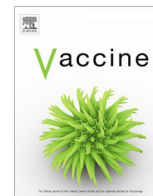




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## Acceptance and willingness to pay for a hypothetical vaccine against monkeypox viral infection among frontline physicians: A cross-sectional study in Indonesia



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### ABSTRACT

**Background:** A clinical trial is ongoing to evaluate the safety and efficacy of a monkeypox vaccine among healthcare workers (HCWs). The critical question that needs to be addressed is whether HCWs are willing to accept and purchase this vaccine. The objective of this study was to evaluate the acceptance and willingness to pay (WTP) for the vaccine among HCWs.

**Methods:** From May to July 2019, a cross-sectional study was conducted among registered general practitioners (GPs) in Indonesia. A contingent valuation method was employed to evaluate the WTP. Besides acceptance and WTP, various explanatory variables were also collected and assessed. A logistic regression and a multivariable linear regression were used to explore the explanatory variables influencing acceptance and WTP, respectively.

**Results:** Among 407 respondents, 391 (96.0%) expressed acceptance of a free vaccination. The mean and median WTP was US\$ 37.0 (95%CI: US\$ 32.76–US\$ 41.23) and US\$ 17.90 (95%CI: US\$ 17.90–US\$ 17.90), respectively. In an unadjusted analysis, those 30 years old or younger had 2.94 times greater odds of vaccine acceptance compared to those who were older (95%CI: 1.07–8.08). Location of alma mater, type of workplace, length of individual medical experience, and monthly income of GPs were all significantly associated with WTP.

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**Conclusion:** Although the vast majority of GPs would accept a freely provided vaccine, they were also somewhat price sensitive. This finding indicates that partial subsidy maybe required to achieve high vaccine coverage, particularly among GPs at community health centres or those with a shorter duration of medical practice.

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## 1. Introduction

Human monkeypox, known simply as monkeypox, is caused by the monkeypox virus (MPXV) and was reported for the first time in Basankusu Territory of the Democratic Republic of Congo (DRC) in 1970 [1]. Monkeypox is an emerging zoonotic infection with sporadic occurrence worldwide [2] and multiple outbreaks have been reported in Western and Central Africa in the recent years [3–5]. MPXV is a double-stranded DNA virus and belongs to the *Orthopoxvirus* genus together with variola virus, the cause of smallpox. The genome of MPXV is 96.3% identical with that of variola virus [6] and cross-neutralizing immune responses have been identified between the infections [7].

While consulting and providing care for patients, frontline health-care workers (HCWs) are at high risk of contracting serious infectious diseases [8,9], including monkeypox [10]. A study in the DRC found that the estimated annual incidence rate for monkeypox among HCWs was 17.4/10,000, which was much higher than in the general population [10]. Outside of Africa, sporadic occurrence of monkeypox has been reported in the US [11,12], UK [13], Israel [14] and recently in Singapore [15]. The increasing number of international air flights could increase the risk of transmission of monkeypox into non-endemic countries, particularly among HCWs. The risks are heightened if physicians have low knowledge and awareness of the disease and therefore apply inadequate infection control measures. In Indonesia, a recent study clearly indicated that the knowledge of monkeypox is low among HCWs in the country [16].

One measure that could be implemented to prevent the occurrence of monkeypox is the use of the smallpox vaccine. Vaccination against smallpox has been proven to be 85% effective in preventing monkeypox infection [17], yet the vaccines have not been widely used for monkeypox prevention due to concerns about adverse events such as risk of autoinoculation to other parts of the body, disseminated infection, postvaccinal encephalitis, or myopericarditis, especially for first and second generation smallpox vaccines [10,18]. Therefore, a new vaccine with a safer profile may be necessary to promote wider acceptance.

The new generation of the vaccine, IMVAMUNE<sup>®</sup>, has been developed with improved safety profiles and a clinical trial is ongoing to evaluate its safety and efficacy in preventing monkeypox among HCWs in the DRC (registered in ClinicalTrials.gov under identifier NCT02977715). The results of the trial are expected by August 2022. To anticipate the adoption of this new monkeypox vaccine, two critical questions need to be addressed: are HCWs willing to (1) accept and (2) purchase the vaccine. Willingness to pay (WTP) studies are one way to evaluate private demand for new vaccines [19–22]. The present study was undertaken to evaluate the acceptance and WTP for a hypothetical monkeypox vaccine among physicians in Indonesia. This information is critical for policy makers to decide the best strategy to implement vaccination programs.

## 2. Methods

### 2.1. Ethics approval

The protocol of this study was approved by the Institutional Review Board of the Faculty of Medicine and Health Sciences,

Maulana Malik Ibrahim State Islamic University of Malang, Indonesia (055/EC/KEPK-FKIK/2019), in compliance with national legislation and the Declaration of Helsinki.

### 2.2. Study design

An online-based cross-sectional study was undertaken from 25 May to 25 July 2019. The target population was 50,198 GPs in Indonesia (2019) as registered frontline physicians. Using the conservative assumption that 50% physicians will accept the new vaccine, 382 respondents were required for the minimum sample size, using a confidence interval of 95% and a 5% margin of error. Invitations were sent by email to the members of doctor organizations or groups and were distributed to social media. The survey was estimated to take approximately 7–10 min to be completed.

To evaluate WTP for the monkeypox vaccine, a contingent valuation method was employed. This approach has been used to measure absolute WTP as well as the amount that an individual is willing to pay for a hypothetical vaccine against many infectious diseases [19,23–26].

### 2.3. Study instrument

Closed-ended-questionnaire included questions on sociodemographic status, characteristics of the workplace and the medical professional, knowledge of monkeypox, confidence in clinically managing monkeypox, and acceptance and WTP for a monkeypox vaccine. An expert committee, consisting of a family medicine doctor and two medical microbiologists, evaluated the content validity of the questionnaire. The questionnaire was tested in a pilot study among fifteen physicians and corrections were made accordingly.

### 2.4. Study variables

#### a. Response variables

The response variables in this study were acceptance and WTP for a hypothetical monkeypox vaccine. Before collecting information on acceptance and WTP, respondents were provided with the following information: (a) the case fatality rate of monkeypox was 1–10%; (b) monkeypox vaccine has been developed and clinical trials showed that the vaccine was 100% safe; (c) the vaccine was completely protective against MPXV infection; and (d) it only requires one dose to achieve 100% protection. Participants were then asked to respond the question: “would you be vaccinated with the new vaccine if the government provides the vaccine freely for HCWs?” The possible responses were “yes” or “no”.

To measure the amount of money that participants would be willing to pay for a monkeypox vaccine, a modified double-bounded dichotomous contingent valuation method was employed in which all series questions were closed questions [24]. The first bid was Indonesian Rupiah (IDR) 250,000 (equivalent with US\$ 17.9 using a December 2019 exchange rate). If the participant choose “Yes”, the price doubled until the highest bid: IDR 500,000 (US\$ 35.80), IDR 1 million (US\$ 71.7), or IDR 2 million (US\$ 143.20). If the participant said “No”, it halved till the lowest price: IDR 150,000 (US\$ 10.74), IDR 75,000 (US\$ 5.37), and IDR 25,000 (US\$ 1.79). Accordingly, the highest and the lowest price

provided were IDR 2 million (US\$ 143.20) and IDR 25,000 (US\$ 1.79), respectively.

#### b. Explanatory variables

Six main groups of explanatory variables that would plausibly affect acceptance and WTP on monkeypox vaccine were collected: (a) sociodemographic data (gender, age, educational attainment, type of job, current location, and monthly income); (b) characteristics of workplace (type and location of the workplace); (c) characteristics of the medical professional (alma mater university, length of medical experience and attendance at local, national and international conferences); (d) previous exposure to monkeypox information; (e) knowledge of monkeypox; and (f) confidence in clinically managing monkeypox cases (i.e. diagnosing and treating the monkeypox cases).

For statistical analysis purposes, age was grouped into those 30 years old or younger and those more than 30 years old; educational attainment was dichotomised into medical doctors and medical doctors with an additional (master or doctoral) degree; and type of job was divided into GP and GP with a specialist residency. In addition, the current location of participants was divided into western and central-eastern part of Indonesia; individual monthly income was grouped into less than IDR 5 million (US\$ 356.3) and IDR 5 million or more. Type of workplace was divided into community health center, private clinic, private hospital and public hospital while the location of workplace was divided into three categories: capital city of a district, regency or province. The location of alumni university was divided into those in Java vs non-Java; the length of medical experience divided into less than five year and five year or more. The participants were also asked whether they have attended local, national or international conferences in the last five months; whether they had ever received information about monkeypox during medical education; and whether they had heard about monkeypox prior to the survey.

To ascertain knowledge of monkeypox, a scale consisting of 21 questions was used. The correct response was given a score of one while zero for an incorrect response. For each respondent, the knowledge level was classified as good and poor based on 80% cut-off (i.e., 17 questions correct). To measure confidence in facing monkeypox cases, participants were asked three questions regarding whether they were confident in diagnosing, treating, and managing the monkeypox cases with their current knowledge and skill and the current facilities of their workplace. Participants were dichotomized as confident and non-confident based on 80% cut-off (i.e. confident for all three questions) of the total confidence score.

### 2.5. Statistical analysis

To assess the relationship between explanatory variables and participants' acceptance for a monkeypox vaccine, a two-step logistic regression was employed. Initially all explanatory variables were analyzed separately, and variables with  $p \leq 0.25$  in this step were included in multivariable analysis. The estimated crude odds ratio (OR) of unadjusted analyses and adjusted OR (aOR) were interpreted in relation to a reference category. Significance was assessed at  $\alpha = 0.05$ .

Explanatory variables influencing participants' WTP were determined using a multivariable linear regression model as described elsewhere [20,22]. Prior to the formal analysis, diagnostic assessments for multicollinearity (by calculating the Variance Inflation Factor (VIF) [27]), heteroscedasticity (using Glejser test [28]) and residual normality (using Kolmogorov-Smirnov test [29]) were conducted. The tests were conducted to check how well the data met assumptions for this multivariable linear regression model. A VIF value of lower than 10 and a tolerance value (1/VIF) of greater than 0.1 were used to define no multicollinearity between

variables. A cut-off point of p-value greater than 0.05 for the other tests (i.e. Glejser test and Kolmogorov-Smirnov test) was applied to indicate no heteroscedasticity and normal distribution of residuals, respectively.

Diagnostic assessments indicated that the WTP raw data violated two assumptions: heteroscedasticity and normality of residuals. The WTP data therefore were transformed using a natural logarithm function (ln) and were re-tested. Assessments of the transformed WTP data indicated better adherence to the aforementioned assumptions (no multicollinearity and data residuals distributed normally, and only one variable had a p-value less than 0.05 for the Glejser test of heteroscedasticity). Therefore, the transformed WTP values were used in the model. All explanatory variables that were significant (p less than 0.05) in the initial model were included in the final model. A reference category (R) was assigned for each association between an explanatory and WTP.

The mean estimated WTP was calculated as  $\text{Exp}(X\hat{\beta} + \hat{\sigma}^2/2)$  where  $\hat{\beta}$  was the estimated regression coefficients (B) and  $\hat{\sigma}^2$  was the mean squared error (MSE) of the model as explained previously [20,22]. All analyses were performed using SPSS software ver. 20.0 (SPSS Inc., Chicago, IL, USA).

## 3. Results

### 3.1. Demographic characteristics

There were 407 out of 510 respondents included in the analysis; data from 103 (20.2%) participants were excluded due to incomplete data. The majority of participants were female (68.6%), aged less than 30 years old (68.6%) and approximately half (51.6%) earned less than IDR 5 million (US\$ 356.3) (Table 1). The vast majority (86.7%) of the respondents were GPs and approximately 5.4% of the participants had an educational attainment of a master's or doctoral degree. Less than a fifth (16.7%) of the participants had ever received information of monkeypox during medical education however 91.9% had heard about monkeypox prior to the survey. This study found that less than 10% of participants (9.3%) had a good knowledge of monkeypox and approximately 10% had a good confidence in management of monkeypox cases based on their current knowledge and skill.

#### Table 1

### 3.2. Acceptance for a monkeypox vaccine and associated factors

In this study, 391 (96.0%) of the respondents expressed their acceptance for a hypothetical monkeypox vaccine. In the unadjusted analysis, age group was the only explanatory variable associated with acceptance (Table 1). Those who were 30 years old or younger had 2.94 times greater odds of accepting the monkeypox vaccine compared to those older than 30 years (95%CI: 1.07–8.08,  $p = 0.037$ ). The adjusted analysis indicated no explanatory variable significantly associated with acceptance.

### 3.3. WTP for a monkeypox vaccine and associated factors

Of the 407 participants who completed the survey, 3.9% (16/407) indicated they would not be vaccinated even if the vaccine was provided freely by government; an additional 10.3% (42/407) of participants stated that they would be vaccinated only if the vaccine was freely provided. Therefore, only 356 (87.4%) of respondents were willing to pay for a vaccine and included in the WTP analysis. Among those who were willing to pay for the vaccine, 89.7% of them willing to pay if the vaccine price was US \$ 1.79 and this decreased to 77.9%, 70.8% and 33.7% as the vaccine price increased to US\$ 10.74, US\$ 17.90, and US\$ 35.80, respec-

**Table 1**  
Unadjusted and adjusted logistic regression analyses showing factors associated with acceptance of a monkeypox vaccine among general practitioners in Indonesia ( $n = 407$ ).

Variable	$n$ (%)	Accept $n$ (%)	Unadjusted		Adjusted	
			OR (95% CI)	$p$ -value	OR (95% CI)	$p$ -value
Location of alma mater university						
Sumatra and others (Reference, $R$ )	350 (86.0)	335 (95.7)	1			
Java	57 (14.0)	56 (98.2)	0.38 (0.33–19.36)	0.378		
Location						
Western Indonesia ( $R$ )	285 (70.0)	275 (96.5)	1			
Central and Eastern Indonesia	122 (30.0)	116 (95.1)	0.70 (0.25–1.98)	0.505		
Gender						
Female ( $R$ )	279 (68.6)	267 (95.7)	1			
Male	128 (31.4)	124 (96.9)	1.39 (0.44–4.41)	0.572		
Age group						
>30 years ( $R$ )	128 (31.4)	119 (93.0)	1		1	
30 years or less	279 (68.6)	272 (97.5)	2.94 (1.07–8.08)	0.037	2.19 (0.33–14.64)	0.418
Education						
General practitioner (GP) ( $R$ )	385 (94.6)	370 (96.1)	1			
GP with master's or doctoral degree	22 (5.4)	21 (95.5)	0.85 (0.11–6.76)	0.879		
Type of job						
GP ( $R$ )	353 (86.7)	341 (96.6)	1		1	
Residency	54 (13.3)	50 (92.6)	0.44 (0.14–1.42)	0.169	0.60 (0.17–2.04)	0.408
Type of workplace						
Community health center ( $R$ )	102 (25.1)	97 (95.1)	1			
Private clinic	90 (22.1)	85 (94.4)	0.88 (0.25–3.13)	0.839		
Private hospital	68 (16.7)	68 (100.0)	$8 \times 10^7$ (0.00–)	0.997		
Public hospital	147 (36.1)	141 (95.9)	1.21 (0.36–4.08)	0.757		
Location of workplace						
District ( $R$ )	129 (31.7)	124 (96.1)	1			
Regency	152 (37.3)	146 (96.1)	0.98 (0.29–3.29)	0.975		
Province	126 (31.0)	121 (96.0)	0.98 (0.28–3.46)	0.970		
Attended a province-level conference						
No ( $R$ )	136 (33.4)	133 (97.8)	1		1	
Yes	271 (66.6)	258 (95.2)	0.45 (0.13–1.60)	0.216	0.55 (0.15–2.08)	0.379
Attended a national-level conference						
No ( $R$ )	256 (62.9)	244 (95.3)	1			
Yes	151 (37.1)	147 (97.4)	1.81 (0.57–5.71)	0.313		
Attended an international-level conference						
No ( $R$ )	338 (95.3)	372 (95.9)	1			
Yes	19 (4.7)	19 (100.0)	$7 \times 10^7$ (0.00–)	0.998		
Medical practice experience (years)						
Less than 5 ( $R$ )	294 (72.2)	286 (97.3)	1		1	
5 years or more	113 (27.8)	105 (92.9)	0.37 (0.13–1.00)	0.051	0.81 (0.12–5.39)	0.830
Ever received information about human monkeypox during medical education						
Never ( $R$ )	339 (83.3)	324 (95.6)	1			
Yes	68 (16.7)	67 (98.5)	3.10 (0.40–23.89)	0.277		
Monthly income (Indonesian Rupiah)						
<5 million ( $R$ )	210 (51.6)	201 (95.7)	1			
$\geq 5$ million	197 (48.4)	190 (96.4)	1.22 (0.44–3.33)	0.704		
Ever heard about human monkeypox before						
Never ( $R$ )	33 (8.1)	32 (97.0)	1			
Yes	374 (91.9)	359 (96.0)	0.75 (0.10–5.85)	0.782		
Knowledge of monkeypox						
Poor ( $R$ )	369 (90.7)	356 (96.5)	1		1	
Good	38 (9.3)	35 (92.1)	0.43 (0.12–1.57)	0.199	0.34 (0.09–1.29)	0.111
Confidence in clinical management of monkeypox						
Poor ( $R$ )	365 (89.7)	350 (95.9)	1			
Good	42 (10.3)	41 (97.6)	1.76 (0.23–13.65)	0.590		

tively. At the highest vaccine price, US\$ 143.20, only 40 (9.8%) of the participants agreed to pay for the vaccine. The mean and median WTP was US\$ 37.0 (95% CI: US\$ 32.76– US\$ 41.23) and US\$ 17.90 (95% CI: US\$ 17.90–US\$ 17.90), respectively.

The initial linear regression model indicated that the location of alma mater university, type of workplace, length of medical practice experience, and monthly income were all significantly associated with the WTP (Table 2). In the final model, all of those explanatory variables were associated with the WTP significantly (Table 3). Participants who graduated from universities in Java (compared to those who graduated from Sumatra and other islands) and who were working in public hospitals (compared to those in community health centers) had a higher WTP of approximately US\$ 2.43 and US\$ 2.44, respectively. In addition, GPs who

had medical experience more than five years and those who earned more than US\$ 356.3 also had a higher WTP of approximately US\$ 3.12 and US\$ 2.18 compared to those who had medical experience less than five years and who had monthly income less than US\$ 356.3, respectively.

Table 2 & Table 3

#### 4. Discussion

Several studies in Indonesia have been conducted to assess acceptance and WTP for different vaccines [20–22,26,30,31]. This is the first study that we know of that assesses acceptance and WTP for a monkeypox vaccine not only in Indonesia but in the

**Table 2**  
Initial multivariable linear regression model showing factors associated with the willingness to pay for a monkeypox vaccine among general practitioners in Indonesia ( $n = 365$ ).

Variable	Unstandardized coefficients				US-\$ estimate			P-value
	B	95% CI of B		SE	Mean	95% CI		
		Lower	Upper			Lower	Upper	
Intercept	2.525	1.887	3.163	0.325	21.156	19.144	23.169	<0.001
Location of alma mater university ( <i>Sumatra and others</i> )								
Java	0.446	0.076	0.815	0.189	2.645	0.633	4.658	0.019
Current location ( <i>Western Indonesia</i> )								
Central and Eastern Indonesia	-0.111	-0.404	0.182	0.149	1.516	-0.496	3.528	0.458
Gender ( <i>Female</i> )								
Male	-0.091	-0.331	0.149	0.123	1.546	-0.466	3.559	0.457
Age group ( <i>More than 30 years</i> )								
30 years or less	0.392	-0.049	0.833	0.225	2.506	0.494	4.519	0.083
Education ( <i>General practitioner (GP)</i> )								
GP with master's or doctoral degree	-0.464	-1.003	0.076	0.275	1.065	-0.947	3.078	0.093
Type of job ( <i>GP</i> )								
Residency	-0.005	-0.383	0.374	0.193	1.686	-0.327	3.698	0.980
Type of workplace ( <i>Community health center</i> )								
Private clinic	0.004	-0.344	0.352	0.177	1.701	-0.312	3.713	0.982
Private hospital	0.274	-0.129	0.677	0.206	2.228	0.216	4.241	0.183
Public hospital	0.417	0.049	0.785	0.188	2.570	0.557	4.582	0.027
Location of workplace ( <i>District</i> )								
Regency	-0.034	-0.354	0.286	0.163	1.637	-0.375	3.650	0.835
Province	-0.229	-0.565	0.107	0.172	1.347	-0.665	3.360	0.183
Attended a province-level conference ( <i>No</i> )								
Yes	-0.018	-0.260	0.225	0.124	1.664	-0.348	3.677	0.887
Attended a national-level conference ( <i>No</i> )								
Yes	0.087	-0.164	0.338	0.128	1.848	-0.165	3.860	0.498
Attended an international-level conference ( <i>No</i> )								
Yes	0.339	-0.231	0.910	0.291	2.378	0.366	4.391	0.245
Medical practice experience ( <i>Less than 5 year</i> )								
Five year or more	0.580	0.121	1.039	0.234	3.025	1.013	5.038	0.014
Ever received information of human monkeypox during medical education ( <i>Never</i> )								
Yes	0.155	-0.134	0.443	0.147	1.977	-0.035	3.990	0.294
Monthly income ( <i>Less than 5 million Indonesian Rupiah</i> )								
$\geq 5$ million Indonesian Rupiah	0.307	0.075	0.539	0.118	2.302	0.290	4.315	0.010
Ever heard about human monkeypox before ( <i>Never</i> )								
Yes	-0.167	-0.568	0.234	0.205	1.434	-0.579	3.446	0.416
Knowledge of monkeypox ( <i>Poor</i> )								
Good	-0.320	-0.686	0.045	0.186	1.230	-0.783	3.242	0.087
Confidence ( <i>Poor</i> )								
Good	0.182	-0.189	0.553	0.189	2.032	0.020	4.045	0.337
MSE	1.054							
F-value ( $P = 0.002$ )	2.277							
R <sup>2</sup>	0.117							

**Table 3**  
Final multivariable linear regression model showing factors associated with the willingness to pay for a monkeypox vaccine among general practitioners in Indonesia ( $n = 365$ ).

Variable	Unstandardized coefficients				US-\$ estimate			p-value
	B	95% CI of B		SE	Mean	95% CI		
		Lower	Upper			Lower	Upper	
Intercept	2.367	1.893	2.840	0.242	18.024	16.016	20.032	<0.001
Location of alma mater university ( <i>Sumatra and others</i> )								
Java	0.366	0.061	0.671	0.156	2.437	0.429	4.445	0.019
Age group ( <i>More than 30 years</i> )								
30 years or less	0.394	-0.038	0.826	0.220	2.506	0.498	4.514	0.075
Education ( <i>General practitioner only</i> )								
GP with master's or doctoral degree	-0.432	-0.943	0.079	0.261	1.097	-0.911	3.105	0.098
Type of workplace ( <i>Community health center</i> )								
Private clinic	-0.037	-0.356	0.282	0.163	1.629	-0.379	3.637	0.819
Private hospital	0.232	-0.112	0.576	0.176	2.132	0.124	4.140	0.187
Public hospital	0.368	0.091	0.645	0.141	2.442	0.434	4.450	0.010
Medical practice experience ( <i>Less than 5 year</i> )								
Five year or more	0.614	0.163	1.065	0.230	3.124	1.116	5.132	0.008
Monthly income ( <i>&lt;5 million Indonesian Rupiah</i> )								
$\geq 5$ million Indonesian Rupiah	0.257	0.038	0.475	0.112	2.185	0.177	4.193	0.022
Knowledge of monkeypox ( <i>Poor</i> )								
Good	-0.322	-0.681	0.038	0.183	1.225	-0.783	3.233	0.080
MSE	1.050							
F-value ( $P < 0.001$ )	4.032							
R <sup>2</sup>	0.093							



world, and is particularly relevant because a monkeypox vaccine trial is ongoing among HCWs in the DRC. This study sought to fill our knowledge gap on how well this monkeypox vaccine would be received among HCWs in Indonesia and how much they would be willing to pay for vaccination.

Our data indicate that more than 95% of the GPs are willing to accept the vaccine if it is freely provided by government. The median WTP was US\$ 37.0 which is lower than WTP for a human papillomavirus (HPV) (US\$ 49.3) [32] and dengue vaccine (US\$ 67.4) [24] but it is higher than Ebola (US\$ 2.08) [33] and Zika vaccine (US\$ 13.1) [20]. In this study, although no variable was identified to be significantly associated with vaccine acceptance, four predictors of WTP were identified: location of alma mater university, type of workplace, the length of individual had medical experience, and monthly income. This study indicates that vaccine price is not a major obstacle to implementing a vaccination program among medical doctors in Indonesia since vast majority (70.8%) of the participants are willing to pay for the vaccine as long as the vaccine price is around US\$ 17.90. If the vaccine price rises to US\$ 35.80, only around a third of the respondents were willing to pay.

In line with this observation that higher vaccine prices yield lower willingness to be vaccinated, this study found that those who have a higher income are willing to spend more money for the monkeypox vaccine even though monthly income has no association with vaccine acceptance. This is consistent with many previous studies that have demonstrated that income or economic status is a robust predictor of WTP [20,25,26,34–37], although a few studies found no association [22,38,39]. Altogether these studies suggest that if the market price of the vaccine is more expensive than US\$ 35.80, a partial subsidy maybe be required to achieve adequate vaccine coverage.

Besides monthly income, those who have had a longer medical practice also had better support for the monkeypox vaccination. This finding could derive from two possibilities: (1) older GPs have a better attitude towards vaccination or (2) GPs with a longer practice have had more experience dealing with severe cases of disease or seeing the benefits of vaccines at firsthand. Future studies could better elucidate the mechanism by which length of medical practice affects WTP. Regardless, any program introducing a monkeypox vaccine should consider the possibility of more difficulties in reaching GPs with a shorter practice.

Additionally, the present study found that GPs who graduated from universities in Java had a higher WTP compared to their counterparts who graduated from non-Java universities. A previous study found that in unadjusted analysis that GPs who graduated from universities located in Java had better knowledge compared those from Sumatra or other islands [16]. Some of the highest ranked universities in Indonesia are located on Java, and it is the political, cultural, and economic centre of the country. Therefore, individuals educated in Java may have received a higher quality education or may have been exposed to certain cultural characteristics. Nevertheless, in our analyses, we did not find knowledge to be a robust predictor for WTP for a monkeypox vaccine. This finding is in contrast to previous studies that do suggest that a good knowledge of a disease is associated with WTP for the vaccine against that disease [22,26,36,40]. Other studies have found no relationship between knowledge and WTP, however [34,37,41]. Therefore, there must be some characteristics that differentiate GPs who graduated from Java vs other islands. This finding also points to future programs which can differentially target physicians based on where they received medical education. Similarly, since individuals who worked in community health centers were not willing to pay as much money for a vaccine as those in public hospitals, they could be targeted for certain subsidies, particularly as these community health centers are the first location that individuals with a sickness may visit [42].

There are some limitations of this study. Respondents' preferences in a study may differ from a real-life situation. Additionally, the study referenced a hypothetical vaccine, and so the physicians would not have had any previous experience dealing with the specific monkeypox vaccine. We note that our description of the vaccine (100% safe and effective) is simplistic and a less-than-perfect vaccine would likely result in lower acceptance and WTP. Social desirability bias is inevitable in a WTP study in which participants might tend to give favorable answer; this bias is minimized through the mode of collection which does not involve a face-to-face interaction. As stated in the previous studies [16,43], there is also potential for selection bias by geography in this study since some localities in Indonesia have better internet access than others.

## 5. Conclusion

Acceptance of the monkeypox vaccine among frontline physicians in Indonesia is relatively high, more than 95%, if the vaccine is provided freely. Factors like age may affect acceptance of the vaccine, and characteristics like longer medical practice, higher income, graduating from Java, and working in public hospitals were all associated with greater WTP. Any program that seeks to roll-out the vaccine among HCWs in Indonesia should consider our results for WTP, in which median WTP was US\$ 17.90 and only about a third of respondents were WTP when the vaccine price was US\$35.80. If monkeypox were to spread into Indonesia, protecting frontline HCWs will be extremely important, and a monkeypox vaccine would be one way to limit the spread of the disease, but only if the vaccine is widely received in this population.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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