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Willingness to Receive a COVID-19 Vaccine among Pregnant Thai Women during the COVID-19 Pandemic

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ABSTRACT

Objectives: To determine the level of acceptance of COVID-19 vaccine among pregnant women residing in Thailand during the COVID-19 pandemic and assess sociodemographic, medical and informational factors influencing their acceptance.

Materials and Methods: Online and paper-based questionnaires were distributed to pregnant women attending the prenatal care clinic in hospitals located in different regions of Thailand between July and October 2021. Sociodemographic characteristics, perception of risks and knowledge on COVID-19 were collected. Participants were given information on composition, safety and effectiveness, but not the commercial name and manufacturers, of the three currently available COVID-19 vaccines and were asked about their vaccine acceptance. Logistic regression analysis was used to determine factors associated with vaccine acceptance.

Results: A total of 138 women completed the questionnaire. Fifty-nine percent of participants were willing to receive the Thai FDA-approved COVID-19 vaccines. mRNA vaccines (BNT162b2) had the highest acceptance (59.4%) followed by an inactivated (CoronaVac) whole virion vaccine (29.7%) and ChAdOx1-S adenoviral-vectored vaccine (17.4%). The major reason for hesitancy was safety of the mother and fetus. The degree of reliability of COVID-19 vaccine information sources was highest in personal obstetricians and lowest in state media. Pregnant women with adequate knowledge on COVID-19 had higher vaccine acceptance rates. There was no difference in the occupation, education, income, or presence of comorbidities between vaccine acceptance and vaccine hesitancy groups.

Conclusion: Safety was the major reason for vaccine hesitancy, but adequate knowledge on COVID-19 can promote vaccine acceptance in Thailand.

Keywords: acceptance, hesitancy, COVID-19, pregnant women, vaccine.

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การยอมรับวัคซีนป้องกันโรคติดเชื้อไวรัสโคโรนา 2019 ในหญิงตั้งครรภ์ที่อาศัยอยู่ในประเทศไทยช่วงที่มีการระบาดของโรคติดเชื้อไวรัสโคโรนา 2019

พลอยกวิญญ์ ชัยเกียรติ, ฟ้าใส เชี่ยวบางยาง, บุณยวีร์ วงศ์วิเศษสุข, นิชานันท์ เนตตกุล, พริบพราวดาว สุวรรณสิงห์, สุรสิทธิ์ ชัยทองวงศ์วัฒนา, สตีเฟน เคอร์, ณศมน วรรรลภากร

บทคัดย่อ

วัตถุประสงค์*: เพื่อศึกษาอัตราและปัจจัยที่สัมพันธ์กับการยอมรับวัคซีนป้องกันโรคติดเชื้อไวรัสโคโรนา 2019 ในหญิงตั้งครรภ์ที่อาศัยอยู่ในประเทศไทยช่วงที่มีการระบาดของโรคติดเชื้อไวรัสโคโรนา 2019*

วัสดุและวิธีการ*: เป็นการศึกษาที่จุดเวลาใดเวลาหนึ่ง โดยเก็บข้อมูลจากหญิงตั้งครรภ์ที่มารับบริการที่คลินิกฝากครรภ์ ณ โรงพยาบาลต่างๆ ในประเทศไทยระหว่างเดือนกรกฎาคม ถึง ตุลาคม พ.ศ. 2564 ผ่านแบบสอบถามรูปแบบออนไลน์หรือกระดาษ ข้อมูลที่เก็บ ได้แก่ ข้อมูลพื้นฐาน เช่น อายุ อายุครรภ์ รายได้ และ การศึกษา และข้อมูลเกี่ยวกับโรคติดเชื้อไวรัสโคโรนา 2019 เช่นความเสี่ยงของการติดเชื้อ และความรู้เกี่ยวกับตัวโรคและวัคซีนป้องกัน นอกจากนี้แบบสอบถามได้ให้ข้อมูลเกี่ยวกับ ส่วนประกอบ ความปลอดภัย และประสิทธิภาพของวัคซีนป้องกันโรคติดเชื้อไวรัสโคโรนา 2019 จำนวนสามชนิด ที่ใช้ในประเทศไทย ณ เวลานั้น โดยไม่เปิดเผยชื่อและผู้ผลิตและถามผู้เข้าร่วมวิจัย ว่ายอมรับที่จะฉีด วัคซีนชนิดนั้นๆ หรือไม่ และเหตุผลหากไม่แน่ใจหรือไม่ยอมรับ ข้อมูลเหล่านี้ ถูกนำมาวิเคราะห์ เพื่อหาอัตราและปัจจัยที่ส่งผลต่อการยอมรับวัคซีนป้องกันโรคติดเชื้อไวรัสโคโรนา 2019*

ผลการศึกษา*: จากผู้เข้าร่วมงานวิจัยทั้งหมด 138 ราย ร้อยละ 59.4 เลือกที่จะรับวัคซีนชนิด mRNA ตามด้วยวัคซีนชนิดเชื้อตายซึ่งมีอัตรายอมรับเท่ากับร้อยละ 29.7 และวัคซีนชนิดมีไวรัสเป็นพาหะร้อยละ 17.4 สาเหตุหลักที่ทำให้เกิดความลังเลใจในการรับวัคซีนคือความกังวลด้านความปลอดภัยต่อมารดาและทารกในครรภ์ แหล่งข้อมูลที่หญิงตั้งครรภ์เชื่อถือมากที่สุดในการตัดสินใจที่จะรับวัคซีนคือสูติแพทย์ผู้ดูแลครรภ์ ส่วนแหล่งข้อมูลที่เชื่อถือน้อยที่สุดคือข้อมูลจากภาครัฐ การที่หญิงตั้งครรภ์มีความรู้พื้นฐานเกี่ยวกับตัวโรคและวัคซีนอย่างเพียงพอ สัมพันธ์กับอัตราการยอมรับวัคซีนที่สูงขึ้น*

***สรุป**: ความกังวลด้านความปลอดภัยของวัคซีนป้องกันโรคติดเชื้อไวรัสโคโรนา 2019 เป็นสาเหตุหลักที่ทำให้เกิดความลังเลใจในการรับวัคซีนในหญิงตั้งครรภ์ที่อาศัยอยู่ในประเทศไทยช่วงที่มีการระบาดของโรคติดเชื้อไวรัสโคโรนา 2019 และการให้ความรู้ที่ถูกต้องอาจช่วยเพิ่มอัตราการยอมรับวัคซีนได้*

***คำสำคัญ**: การยอมรับวัคซีน, หญิงตั้งครรภ์, โรคติดเชื้อไวรัสโคโรนา 2019*

Introduction

Pregnant women infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) are at increased risk for severe morbidity and mortality compared with non-pregnant women of the same age[1,2]. SARS-CoV-2 infection in pregnancy is associated with a higher risk of premature delivery, preeclampsia, stillbirth, intensive care unit admission, invasive ventilation, extracorporeal membrane oxygenation, and death[3-6]. In the early phases of coronavirus disease starting in 2019 (COVID-19) vaccine development, vaccines were tested on healthy adult individuals, not pregnant women or children. Inclusion of pregnant women in the novel COVID-19 vaccine trials would have allowed evaluation of safety and efficacy of vaccines that might reduce maternal morbidity from COVID-19 and improve pregnancy and birth outcomes. However, clinical trials of new vaccines often excluded pregnant individuals for several reasons, including ethical concerns about fetal exposure, actual and perceived regulatory barriers, and liability concerns[7].

During the early COVID-19 pandemic and initial vaccine roll-out, there was limited information on the safety and efficacy of the COVID-19 vaccine in pregnant mothers. This created confusion and concern among pregnant women on whether to receive a vaccine with limited available safety, immunogenicity and efficacy data. A previous survey from 16 countries showed that, given a 90% COVID-19 vaccine efficacy, only 52% of pregnant women indicated they would receive the vaccine. Predictors of vaccine acceptance included confidence in vaccine safety or effectiveness, worrying about COVID-19, personal beliefs, trust of public health guidelines and attitudes towards routine vaccination[8]. A metanalysis conducted in May 2021 reported that the pooled intention rate for receipt of COVID-19 vaccine among pregnant women was 47% (95% confidence interval (CI) 38 – 57%) with substantial variations according to country of residence[9]. The authors also found that uptake of other vaccines (influenza and/or Tetanus-diphtheria and acellular pertussis; TdaP) during pregnancy was associated with higher rates of intention to receive the COVID-19 vaccine (odds ratio (OR) 3.03 (95%CI 1.37 – 6,73)[9]. A Turkish study reported an even lower acceptance rate of 37% among pregnant women[10].

In February 2021, Thailand began importing inactivated COVID-19 vaccine (CoronaVac,®) developed by Sinovac Life Sciences, Beijing, China. This was followed in March 2021 by Oxford/AstraZeneca's Chimpanzee adenovirus Oxford 1 (ChAdOx1)-vectored vaccine, containing spike glycoprotein of SARS-CoV-2 (ChAdOx1-S), which was initially imported from Korea, and later produced locally by Siam Bioscience (Nonthaburi, Thailand). The third available vaccine imported to Thailand in August 2021 was Pfizer/BioNTech's BNT162b2 mRNA vaccine. Although Thailand initially managed to contain the spread of COVID-19, in late May 2021, the readily transmissible delta variant SARS-CoV-2 first found in India was detected domestically. The delta variant spread rapidly in Bangkok and other

provinces, causing a substantial rise in numbers of COVID-19 cases and deaths[11]. In August 2021, there were reports of fatal cases of COVID-19 in Thai pregnant women, all of whom were unvaccinated or incompletely vaccinated[12].

With the development of multiple effective vaccines, reducing the global morbidity and mortality of COVID-19 will depend on equitable vaccine distribution and acceptance of COVID-19 vaccination. Since pregnant mothers are often key decision-makers for whether or not they accept vaccinations, it is important to measure the level of vaccine acceptance in this group and understand the reasons contributing to their decision making. Such data can help individual countries prepare for COVID-19 vaccination rollout. In this study, we aimed to determine the level of acceptance of the three COVID-19 vaccines available at the time of the study (CoronaVac, ChAdOx1-S, and BNT162b2) among pregnant women residing in Thailand, and assess sociodemographic, medical and informational factors influencing their acceptance.

Materials and Methods

Study design and data collection

We conducted an anonymous, online and paper-based survey among pregnant women attending antenatal care visits in hospitals or clinics in Thailand between July and October 2021. The online-based survey was distributed by obstetricians throughout Thailand. We assessed COVID-19 vaccine acceptance level, baseline risk and knowledge about COVID-19, trust in COVID-19 information from different media, and attitudes towards vaccine acceptance and hesitancy. This study protocol was approved by the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University (IRB no. 530/64, COA No. 940/2021). This study was conducted according to the Declaration of Helsinki and Good Clinical Practice guidelines. All participants provided consent before filling out the questionnaire. Inclusion criteria were Thai pregnant women aged 18 years or older who could read and write in Thai and provide consent to participate in the study. Exclusion criteria included pregnant women who were unable to provide informed consent or who had a history of or were currently infected with COVID-19.

Sample size and sampling

The sample size was calculated using the formula for a confidence interval around a population proportion[13]. We assumed the COVID-19 vaccine acceptance rate would be approximately 50% among Thai pregnant women attending antenatal clinics. This assumption was based on an acceptance rate of 52% in a previous study[8], and because a rate of 50% gives the maximum sample size for any given level of precision. Enrolling 96 women would allow this rate to be with a precision of approximately ±10%. In this study, we employed convenience sampling, a non-probability sampling technique where participants were selected based on their availability and willingness to participate.

Questionnaire

The questionnaire (Supplementary file 1) used in this study was newly developed for pregnant women in response to the emergence of COVID-19, as there were no existing validated questionnaires at the time the study was conducted. The questions were derived from previously published literature by the same authors[14,15] and relevant literature[8]. Additionally, while the pilot study to pre-test comprehension of the questionnaire and improve the clarity and language included only five pregnant women, thematic sufficiency was achieved, and no further comments or modifications were necessary after the fourth. The pilot test improved the questionnaire by clarifying what “high risk” and “low risk” of contracting COVID-19 mean and by adding a timeframe to assess the risks, which we defined as 3 months. “High risk” refers to situations such as close contact with foreign tourists, being in crowded places, having contact with many people, being front-line healthcare workers, those who must use public transportation, or those unable to work from home. Additionally, we included questions about how many household members were at “high

risk" of contracting COVID-19, as these could influence pregnant women in their decision to get vaccinated.

The questionnaire was structured into four sections covering participants' sociodemographic characteristics, perceived COVID-19 risks and attitudes towards other vaccines, fundamental knowledge about COVID-19 and COVID-19 vaccine, reliability of sources for participants who want to research more about COVID-19 vaccines and acceptance of COVID-19 vaccine. In the fundamental knowledge section, the authors included four Yes/ No/ Unsure questions. Participants who correctly answered at least 3 of 4 questions were classified as having adequate knowledge. Furthermore, there were three specific scenarios on vaccine safety and efficacy provided. Participants were given information on composition, and current safety and effectiveness, of the three available vaccines in Thailand. This information was taken from the available literature[16,17] and a review of COVID-19 vaccines' efficacies and adverse reactions by the CEB COVID-19 evidence team from Ramathibodi Hospital[18]. The commercial name and manufacturers were withheld to decrease the bias caused by the overwhelming discussion about these vaccinations in the Thai media. Participants were given the option to indicate whether they were willing, unsure, or unwilling to receive the vaccines. Those who answered "willing" were defined as individuals who expressed a willingness to receive the vaccine. Those who were unwilling or unsure were also asked to provide reasons for their hesitancy. Vaccine hesitancy is defined as individuals who respond with "unsure" or "unwilling" regarding the vaccine, indicating a delay or refusal to accept the vaccine despite its availability[19]. Conversely, vaccine acceptance refers to the intention to receive the vaccine, as indicated by those who express willingness in our questionnaire. It is important to note that vaccine hesitancy reflects individuals' decision-making process or thought process about the vaccine, irrespective of whether they have actually received it at that time. The first vaccine was an inactivated COVID-19 vaccine; Coronavac (Sinovac Biotech Ltd., People's Republic of China), or Vaccine S[20]. The second vaccine was an adenovirus vector vaccine; ChAdOx1-S/nCoV-19 (University of Oxford - AstraZeneca Plc., United Kingdom), or Vaccine A[16], and the third vaccine was BNT162b2 mRNA vaccine from BioNTech/Pfizer or Vaccine P[17].

Statistical analysis

Statistical analysis was conducted using Stata 17 (Statacorp, College Station, TX, USA). Continuous data were described by 'willingness to vaccinate' group according to data distribution as mean standard deviation (SD) or median interquartile range (IQR), and formal comparisons made by a t-test or Wilcoxon rank sum test as appropriate. Categorical data were described as frequency (percent), and formal comparisons between groups made using Fisher's exact test. No continuous data was transformed. We used logistic regression to assess associations between individual variables and willingness to receive a COVID-19 vaccine, for variables with p values ≤ 0.15 in two group comparisons. In these models, education was dichotomized as university education or lower. The final multivariable model was selected by the combination of variables which minimized the Akaike information criterion (AIC), and model adequacy was tested using the Hosmer and Lemeshow goodness of fit test. A p value of < 0.05 was considered statistically significant.

Results

Participants' sociodemographic characteristics and vaccine acceptance rates

A total of 146 responses were recorded, with 103 from the online questionnaire and 43 from the paper-based version. However, 8 participants from the online survey declined to participate. Thus, a total of 138 responses from 138 pregnant women were included in this study. Acceptance rate of COVID-19 vaccination during pregnancy was 59.4% (95%CI; 50.7 - 67.7). There were no significant demographic differences between the vaccine

acceptance and vaccine hesitancy groups. Most of the pregnant women who responded to the questionnaire were in their third trimester (61.6%), with no difference in the mean age between the vaccine acceptance and vaccine hesitancy groups (32.4 vs 31.5 years, p = 0.26). Among the 138 respondents, 53.6% had a bachelor's degree, 25.4% had a master's degree or higher, 16% graduated from high school or held an associate's diploma, and 4.4% had a middle school diploma or lower. Most of the enrolled participants (84%) had no co-morbidities. However, 8.0 % (n = 11) had diabetes mellitus, 0.7% had hypertension (n = 1), 0.7% had heart disease (n = 1), and the rest (n = 8) had other comorbidities Human Immunodeficiency Virus (HIV) positive, obesity, lung disease). There was no difference in the occupation, education, income, or presence of comorbidities between vaccine acceptance and vaccine hesitancy groups. Participants' characteristics and demographic data stratified by vaccine acceptance are shown in Table 1.

Table 1. Respondents' socio-demographic and vaccine knowledge adequacy by vaccine acceptance group.

Characteristics	Acceptance (n = 82)	Hesitancy (n = 56)	p value
Mean (SD) age (years)	32.4 (4.1)	31.5 (4.5)	0.26
Median (IQR) gestational age (weeks)	29 (21 – 34)	28 (23 – 36)	0.32
Gestational age (categories)			
0 - 12 wk, n (%)	9 (11.0%)	3 (5.3%)	0.26
13 - 27 wk, n (%)	22 (26.8%)	17 (30.3%)	
28 - 40 wk, n (%)	51 (62.2%)	34 (60.7%)	
Unknown, n (%)	0 (0.0%)	2 (3.6%)	
Occupation, n (%)			0.47
Civil Servant	10 (12.2%)	5 (8.9%)	
Merchant	3 (3.7%)	4 (7.1%)	
State Enterprise	4 (4.9%)	0 (0.0%)	
Freelance	8 (9.8%)	7 (12.5%)	
Office worker	32 (39.0%)	29 (51.8%)	
Personal business	13 (15.8%)	5 (8.9%)	
Unemployed/retired	5 (6.1%)	2 (3.6%)	
Others	7 (8.5%)	4 (7.1%)	
Education, n (%)			0.07
Elementary school	1 (1.2%)	1 (1.8%)	
Middle school	0 (0.0%)	4 (7.1%)	
High school	9 (11.0%)	7 (12.5%)	
Diploma	2 (2.4%)	4 (7.1%)	
Bachelor	46 (56.1%)	28 (50.0%)	
Masters	24 (29.3%)	11 (19.6%)	
No answer	0 (0.0%)	1 (1.8%)	
Income (n)			0.83
≤ 20,000 baht*	13	10	
20,001 - 50,000 baht	23	18	
> 50,000 baht	15	11	
Don't want to answer	31	17	

Table 1. Respondents' socio-demographic and vaccine knowledge adequacy by vaccine acceptance group. (Cont.)

Characteristics	Acceptance (n = 82)	Hesitancy (n = 56)	p value
Significant comorbidities, n (%)			0.41
None	66 (80.5%)	50 (89.3%)	
Diabetes mellitus	8 (9.8%)	3 (5.4%)	
Heart disease	1 (1.2%)	0 (0.0%)	
Hypertension	0 (0.0%)	1 (1.8%)	
Others	6 (7.3%)	2 (3.6%)	
Don't want to answer	1 (1.2%)	0 (0%)	
Perceived risk of COVID-19 infection, n (%)			0.41
Low	62 (75.6%)	43 (76.8%)	
High	17 (20.7%)	13 (23.2%)	
Don't want to answer	3 (3.7%)	0 (0.0%)	
Number of household members, n (%)			0.34
1-2	25 (30.5%)	19 (33.9%)	
3	15 (18.3%)	7 (12.5%)	
4 or more	42 (51.2%)	29 (51.8%)	
Don't want to answer	0 (0.0%)	1 (1.8%)	
Number of household members (Including participants) at high risk of COVID-19 infection, n (%)			0.21
0	4 (4.9%)	2 (3.6%)	
1	38 (46.3%)	28 (50.0%)	
2	25 (30.5%)	18 (32.1%)	
3 or more	14 (17.1%)	4 (7.1%)	
Don't want to answer	1 (1.2%)	4 (7.1%)	
Friends, family/ or colleagues have contracted COVID-19, n (%)			0.93
Yes	25 (30.5%)	16 (28.6%)	
No	56 (68.3%)	39 (69.6%)	
Don't want to answer	1 (1.2%)	1 (1.8%)	
Friends, family, or colleagues have received a COVID-19 vaccine, n (%)			0.15
Yes	69 (84.1%)	40 (71.4%)	
No	12 (14.6%)	15 (26.8%)	
Don't want to answer	1 (1.2%)	1 (1.8%)	
Respondent has received other vaccines during pregnancy, n (%)			0.68
Yes	65 (79.3%)	42 (75.0%)	
No	17 (20.7%)	14 (25.0%)	
Adequate vaccine knowledge, n (%)			0.001
Yes	72 (87.8%)	35 (62.5%)	
No	10 (12.2%)	21 (37.5%)	

* 1 USD = approximately 33.5 baht. The minimum daily wage is 313-336 baht per day.

Perception of COVID-19 risks, attitudes towards other vaccines and fundamental knowledge on COVID-19 and COVID-19 vaccine.

A total of 105/138 (76.1%) participants reported themselves as having "low risk" of contracting COVID-19. There was no difference in the percentages of perceived low risk between vaccine acceptance and vaccine hesitancy groups (75.6% vs 76.8%, p = 0.41). However, 17.1% of the vaccine acceptance group had 3 or more family members at high risk of contracting COVID-19, compared to only 7.1% in the vaccine hesitancy group, although this did not reach statistical significance. There was no difference in the percentages of participants who had a family member, friends, work colleagues or relatives who contracted COVID-19 between vaccine acceptance and vaccine hesitancy groups (30.5% vs 28.6%, p = 0.93). Most participants (79.0%) reported that their family, friends, or colleagues have been vaccinated with COVID-19 vaccine, and most had (77.5%) had received other vaccines during pregnancy. There was no difference in the percentages of participants who had previously received other vaccines, such as influenza, pertussis, and tetanus, between the vaccine acceptance and vaccine hesitancy groups.

Regarding the fundamental knowledge on COVID-19 and COVID-19 vaccines, 77.5% of the participants (n = 107) had adequate knowledge. Factors associated with COVID-19 acceptance during pregnancy at p < 0.15 are shown in Table 2. In the multivariable analysis, after adjustment for university education or lower, the only significant association with willingness to vaccinate was adequate knowledge on COVID-19 and vaccine (adjusted OR 4.03, 95%CI 1.69 - 9.61, p = 0.002). While university education was not a significant association, the adjusted odds ratio for this variable was 1.91, and the 95%CI were predominantly consistent with higher willingness to be vaccinated. The Hosmer and Lemeshow goodness of fit p value was 0.25, indicating adequate model fit.

Table 2. Univariable and multivariable logistic regression model of factors associated with willingness to receive the Thai FDA approved COVID-19 vaccine.

Characteristics	Univariable		Multivariable	
	OR (95%CI)	p value	aOR (95%CI)	p value
University education vs high school or lower	2.39 (1.03 - 5.57)	0.04	1.91 (0.78 - 4.7)	0.16
Know someone vaccinated against COVID-19	1.91 (0.85 - 4.31)	0.12		
Vaccine knowledge adequate (vs inadequate)	4.3 (1.8 - 10.2)	0.001	4.03 (1.69 - 9.61)	0.002

FDA: Food and Drug Administration, COVID-19: Coronavirus Disease 2019, OR: odds ratio, aOR: adjusted odds ratio.

Acceptance of each type of COVID-19 vaccine and reasons for vaccine hesitancy

Based on information on the composition, safety, and effectiveness of each vaccine type, the mRNA vaccine (BNT162b2) had the highest acceptance (59.4%) followed by the inactivated (CoronaVac) whole virion vaccine (29.7%) and the ChAdOx1-S adenoviral-vectored vaccine (17.4%). Fig. 1 illustrates the distribution of reasons pregnant women may have concerns or hesitations about receiving different types of COVID-19 vaccines. In Fig. 1, the most common reason for hesitancy across all vaccine types was concern that both the pregnant woman and the fetus would experience adverse effects from the COVID-19 vaccine. Other major reasons included "prefer receiving a safer vaccine",

"prefer receiving a more effective vaccine", "want to wait for more evidence to confirm safety of the vaccine in pregnant women" and "does not trust information from governmental organization".

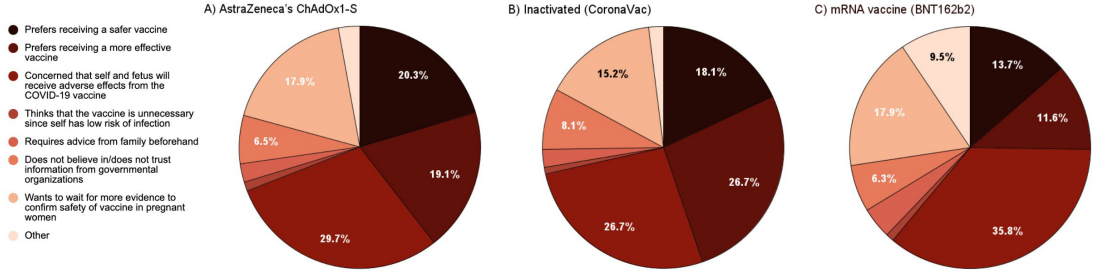

Fig. 1. The major reasons for unwillingness or hesitancy to receive A) an adenoviral-vectored vaccine B) an inactivated vaccine C) an mRNA vaccine.

Reliability of sources if participants want to research more about COVID-19 vaccine.

Pregnant women were asked to rank the sources that they trust the most when seeking information about COVID-19 vaccines. Fig. 2 illustrates the perceived reliability of various information sources, as rated by the respondents. The sources provided in the questionnaire included the government's "THAI ROO SOO COVID" facebook and twitter, the government's coronavirus disease management center on the television, guidance from the Ministry of Public Health, Thailand, acquaintance and family members, personal obstetricians, and online platforms such as social media and websites. The rankings ranged from "not reliable at all" (1) to "strongly reliable" (4). According to this study, the degree of reliability of COVID-19 vaccine information sources was rated highest for personal obstetricians, with 65.2% of respondents ranking this source as "strongly reliable." Conversely, the government's coronavirus disease management center on television was rated the lowest in reliability.

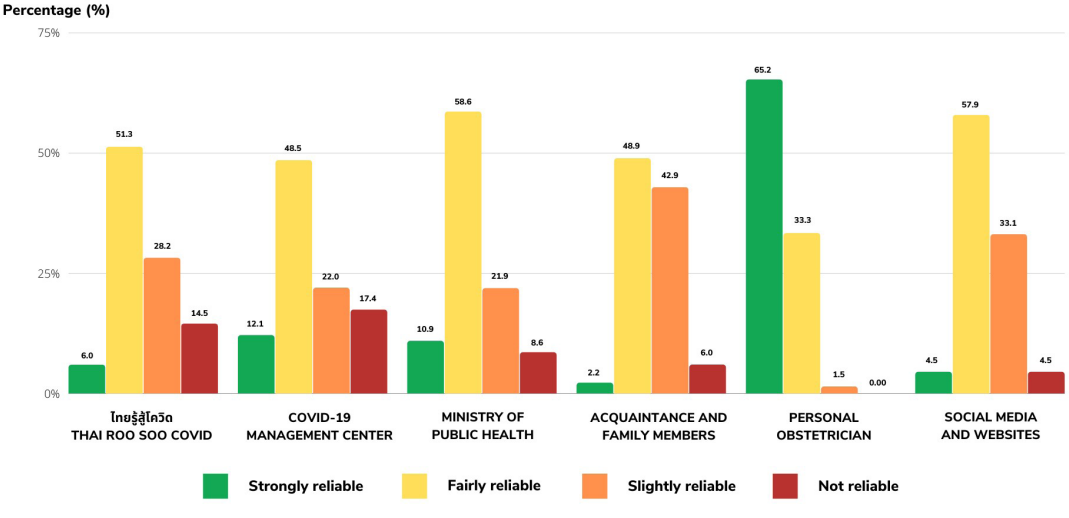

Fig. 2. Reliability of COVID-19 information sources ranging from strongly reliable (green), fairly reliable (yellow), slightly reliable (orange) and non-reliable (red).

Discussion

Vaccine confidence is increasingly recognized as an important element in determining the success of vaccine uptake in regions where vaccine accessibility is optimal. As of August 2021 when this study was conducted, Thailand has secured inactivated vaccine, adenoviral-vectored vaccine and mRNA vaccines. In this study, we found 59% of pregnant women who participated were willing to receive any of the Thai-FDA approved COVID-19 vaccines. The vaccine acceptance rate in this cohort was higher than other previous studies, which reported an acceptance rate between 37-53%[8-10, 21-22]. We hypothesized that geographic variation may influence COVID-19 vaccination acceptance rates among pregnant women. For instance, a survey by Skjefte et al[8] in 16 countries found higher acceptance levels in the tropical regions such as Philippines, India, and Latin America, and lower levels in the temperate region such as US, Australia, and Russia. Nirunrungruang et al conducted a prospective study in rural Chiang Mai, Thailand, one year after our study, reporting even lower vaccine acceptance rates (17%) among pregnant women[23]. This contrasts with the higher acceptance rates found in our study, which involved participants mainly from Bangkok, the country's urban center. This suggests that cultural and regional factors significantly impact vaccine acceptance. Another consideration is the potential selection bias in our study. As this study used convenience sampling, participants likely to get vaccinated may have been more willing to respond to the questionnaire, while those who hesitated may not have responded, potentially leading to an overestimation of acceptance rates. Therefore, the actual COVID-19 vaccine acceptance rate among pregnant women in Thailand may be low, highlighting the need for an intervention strategy to promote acceptance.

As per vaccine type, the mRNA vaccine had the highest acceptance rate, probably due to the high efficacy in preventing mild and moderate symptoms of COVID-19 (95% for mRNA vaccine as compared to 84% for inactivated and 79% for adenoviral-vectored vaccines). Besides, at the time the questionnaire was administered, the mRNA vaccine was the only vaccine that had been used in pregnant women with preliminary data showing that there were no reports of higher adverse events following vaccination. The most common reason for vaccine hesitancy was safety of maternal and the fetus, which was similar to the previous studies on COVID-19 vaccine acceptance during pregnancy in the US and Turkey, and Chiang Mai, Thailand[10,21,23]. Other common reasons for vaccine hesitancy found in this study were "prefer receiving more effective vaccine", "wait for more evidence to confirm safety of the vaccine in pregnant women" and "does not trust information from governmental organization". These findings aligned with the scoping review of global COVID-19 vaccine hesitancy by Casubhoy et al[24], who reviewed 44 articles on attitudes toward COVID-19 vaccination among pregnant women and found that the primary reason for vaccine hesitancy was a lack of confidence in vaccine safety and fear of unknown side effects. Other factors influencing hesitancy according to Casubhoy et al included lack of access to reliable information about the vaccine and mistrust of the vaccine and medical professionals[24].

This study also found that adequate knowledge on COVID-19 and vaccine was the only factor significantly associated with willingness to vaccinate, after adjusting for education level. A study on influenza vaccine acceptance in Thai pregnant women also found that women in the influenza vaccine acceptance group scored higher in knowledge on influenza and vaccine (83.2% vs 73.9%) than those in the hesitancy group[13]. Similarly, a study on pertussis vaccine acceptance in Thai pregnant women also found that knowing the disease could improve the intention to receive pertussis vaccine during pregnancy[14].

Educational levels have been shown to be associated with increased rates of COVID-19 vaccine acceptance in a study of the Thai elderly population.[25] Although education level was not significant in our multivariable model, including it as an explanatory variable resulted in a better model fit,

and the adjusted odds ratio and 95%CI for university education were consistent with an increased willingness to vaccinate. A systematic review and meta-analysis in the United States found that pregnant women with college or higher education were significantly more likely to accept the COVID-19 vaccine, with an odds ratio of 3.25 (95% CI 2.53 - 4.17[26]. Additionally, predictors of COVID-19 vaccine acceptance have been shown to be related to attitudes towards routine vaccine[8]. A metanalysis showed that uptake of other vaccines (influenza and/or Tetanus-diphtheria and acellular pertussis; TdaP) during pregnancy was associated with higher rate of intent to receive the COVID-19 vaccine[9, 26, 27]. Women with higher levels of education may be more likely to make more informed and evidence-based decisions about their health.

In terms of resources for Thai pregnant women to consult with regarding the COVID-19 and vaccine, personal obstetricians ranked first with highest reliability. These findings were consistent with the previous studies on pertussis and influenza vaccines in Thailand, Hong Kong and United Kingdom which reported that recommendation of vaccine by healthcare providers greatly improved the acceptance rate[13-14, 28-29]. For the least reliability resources, this study showed the lack of confidence in the state media including social medias, television, and websites. Several aspects of government communication may have contributed to the lack of confidence, including a lack of transparency about vaccine options and perceived favoritism toward certain manufacturers. A study among Thai seniors found that high vaccine hesitancy was linked to a lack of confidence in the healthcare system's ability to treat COVID-19, distrust in certain vaccine manufacturers, and being offered a vaccine from an unexpected manufacturer[25]. Limited information on available vaccine options from the governmental organization could influence public willingness to get vaccinated. This finding suggest that it is important for the government to build trust in the public to improve the vaccine acceptance among the population. Strategies to build trust include enhancing transparency by providing clear, detailed information about the vaccines, addressing public concerns and misconceptions, and actively engaging with the community to bridge the gap between the government and the public. Our study could place more emphasis on the practical guidelines for educational campaigns to enhance vaccine acceptancy in Thai pregnant women. Unified information dissemination across Thailand is crucial for improving public understanding. Consistent online health literacy promotion could accelerate COVID-19 vaccine acceptance. Educational campaigns should address vaccine safety in pregnant women and the risks of severe complications due to COVID-19 without vaccination. Community leaders and health professionals can engage with the public to answer common questions, address concerns, and dispel misconceptions about COVID-19 and vaccines.

Our study has some limitations. First, this was a pilot study to determine vaccine acceptance in pregnant women, who are a high-risk group for adverse outcomes after contracting COVID-19[30], and the sample size was small. This could affect the representativeness of results to a broader population and limit the ability to detect accurate trends or patterns in vaccine acceptance or hesitancy. Second, most of the pregnant women who responded to this questionnaire resided in Bangkok, which may limit the generalizability of the results. Since the study relied on a convenience sample and most of the respondents were from Bangkok, the findings may be specific to this particular group and may not be applicable to a broader or different population, such as women living in remote or rural areas. Third, a small number of women declined to answer some questions, although these questions regarded sociodemographic characteristics, not vaccine acceptance. This could introduce bias and underrepresent certain views and characteristics, particularly from sociodemographic groups with a low response rate. Future studies should clearly explain the importance of these questions and provide assurances of confidentiality to encourage participation. Fourth, the number of new cases per

day, as well as the efficacy and safety data of COVID-19 vaccines against newly emerged SARS-CoV-2 variants, could change overtime. This constantly evolving data could ultimately shift vaccine hesitancy rates, therefore potentially skewing the results. These factors could influence the vaccination decisions and should be assessed in a timely manner. Future studies should use longitudinal designs to regularly update vaccine efficacy and safety information, including follow-up surveys to track changes in perceptions and hesitancy. Time-dependent factors, such as new COVID-19 variants or updated vaccine evidence, should be communicated to the public, with studies capturing these changes over time. Additional qualitative research could provide deeper insights into vaccine hesitancy. Expanding sample sizes by recruiting from multiple sites or extending study duration can improve participant numbers. Combining questionnaires with interviews in a mixed-methods approach could enhance understanding of vaccine hesitancy and increase study representativeness and statistical power. Lastly, the associations observed in our study are from an observational study and therefore subject to unobserved confounding.

Conclusion

Through the newly developed questionnaires which aim to obtain comprehensive relevant information and analyze all possible barriers in a Thai context, this study pinpointed modifiable barriers to COVID-19 vaccination in pregnant individuals including inadequate knowledge on COVID-19 disease and vaccines, and mistrust in the government media. To enhance vaccine acceptance, public health interventions should focus on vaccine safety and the risks of severe COVID-19 complications without vaccination. The government should build public trust and engage with the public through community leaders and health professionals to address questions, concerns, and misconceptions. These efforts are crucial for increasing vaccine coverage among Thai pregnant women.

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Potential conflicts of interest

The authors declare no conflicts of interest.

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