FACTORS ASSOCIATED WITH RECEIPT OF PRENATAL COVID-19 VACCINATION AMONG PREGNANT WOMEN IN TAIWAN

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Abstract. Pregnant women are at increased risk of severe illness from coronavirus disease 2019 (COVID-19) if infected, prompting the World Health Organization (WHO) to recommend vaccination of pregnant women with a COVID-19 vaccine. In this study, we aimed to identify factors significantly associated with accepting or rejecting prenatal COVID-19 vaccination among pregnant women in Taiwan in order to inform efforts to improve vaccination rates in this population. Study subjects consisted of pregnant women receiving prenatal care at any one of three study hospitals in Taiwan during October 2022-February 2023. Inclusion criteria for study subjects were being aged ≥18 years, being pregnant, having no history of a mental health disorder and being willing and able to complete a study questionnaire. The minimum number of subjects calculated to be needed for the study was 500. Each subject was asked to complete a questionnaire asking about subject demographics, subject knowledge about COVID-19 and the COVID-19 vaccine, where they obtained that knowledge, subject attitude about COVID-19 vaccination during pregnancy and their reasons for receiving or refusing the vaccine. Subjects who answered "received vaccination" or "plan to be vaccinated" in response to the question "Would you receive or have you already received the COVID-19 vaccine during this pregnancy?" were considered to have "Received" the vaccine. Subjects who responded "refused vaccination" or "undecided about vaccination" were considered as having "Refused" the vaccine. The questions about attitude were scored and divided into high and low scores. The results of the questionnaire were analyzed by Chi-square tests, *t*-tests, and multivariate logistic regression analysis to determine the factors significantly associated with receiving prenatal COVID-19 vaccination. A total of 594 subjects were included in the study. The mean (±standard deviation) age of study subjects was 31.3 (±5.5) years. 90.7% of subjects were married, 55.7% had a college/university education and 78.8% were employed. 43.0% of subjects were in their third trimester of pregnancy, 50.7% had a planned pregnancy and 78.3% had no history of a miscarriage. 72.4% of subjects had received prenatal

COVID-19 vaccination. On multiple logistic regression analysis, 6 factors were significantly associated with prenatal COVID-19 vaccination: subjects aged ≥40 years were significantly less likely to receive the vaccine than subjects aged <25 years (adjusted odds ratio (aOR) = 0.288, 95% confidence intervals (CI): 0.099-0.837, p=0.022); subjects who reported having good health were significantly more likely to receive the vaccine than subjects reporting poor health (aOR = 4.948, 95% CI: 2.309-10.604, p<0.001); subjects who reported exercising regularly during pregnancy were significantly more likely to receive the vaccine than subjects who said they did not exercise regularly (aOR = 2.843, 95% CI: 1.747-4.627, p<0.001); subjects who reported receiving an annual influenza vaccine during the previous 3 years were significantly more likely to receive prenatal COVID-19 vaccination than subjects who reported not having an influenza vaccine (aOR = 2.707, 95% CI: 1.241-5.906, p=0.012); subjects who received prenatal care at Hospital C were significantly less like to receive the vaccine than subjects who received prenatal care at Hospital A (aOR = 0.251, 95% CI: 0.143-0.441, p<0.001); and subjects who had a high attitude score regarding prenatal COVID-19 vaccination were significantly more likely to receive the vaccine than subjects who had a low attitude score (aOR = 2.673, 95% CI: 1.458-4.899, p=0.001). The main reasons subjects gave for receiving prenatal COVID-19 vaccination were concern about the impact of the pandemic (70.7%) and worry about the complications of COVID-19 (67.4%). The main reason for refusing to receive the vaccine was concern about the safety and side effects of the vaccine (67.1%). In summary, the receipt of prenatal COVID-19 vaccination was associated with younger maternal age, having good self-perceived health, exercising regularly during pregnancy, having previously received influenza vaccination, receiving prenatal care from a hospital promoting prenatal COVID-19 vaccination and having a good attitude about prenatal COVID-19 vaccination. We conclude groups that should be targeted to improve prenatal vaccination rates are older women, the administration of Hospital C, women who had not previously received an influenza vaccine, women who had poor perceived health, women who did not exercise regularly and women with a negative attitude about prenatal vaccination. Further studies are needed to determine what interventions would be best to reach these target groups and to determine if these efforts will result in improved vaccination rates.

Keywords: COVID-19 vaccination, vaccine, knowledge, attitude, pregnant women, health belief model

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) is an infectious respiratory illness caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) (Feng *et al*, 2023). Immune and cardiopulmonary changes during pregnancy increase the risk among pregnant women of developing moderate to severe COVID-19 (Purwono *et al*, 2023; Qeadan *et al*, 2021). Contracting COVID-19 during pregnancy is associated with increased risk for lower birth weight, lower Apgar scores, hyperglycemia and bone marrow dysfunction (Feng *et al*, 2023), raising concerns for both maternal and fetal well-being (Azami *et al*, 2022).

Prenatal COVID-19 vaccination of pregnant women reduces risk for severe COVID-19, results in lower hospitalization rates and lower risk of maternal mortality (Liu *et al*, 2021; Purwono *et al*, 2023; Shimabukuro *et al*, 2021). Prenatal COVID-19 vaccination results in maternal protective antibody production which provides passive immunity to the fetus giving protection during the early neonatal period (Feng *et al*, 2023).

The World Health Organization (WHO) recommends prenatal COVID-19 vaccination (WHO, 2022). A meta-analysis of 16 studies regarding prenatal COVID-19 vaccination that included 19,219 subjects showed a prenatal COVID-19 vaccination rate of 53.4% (Azami *et al*, 2022), lower than 70% rate in the general population, (Wang *et al*, 2021b).

The Taiwan Centers for Disease Control recommends prenatal COVID-19 vaccination during any stage of pregnancy (Shimabukuro *et al*, 2021; Wang *et al*, 2021a). Before 2022, Taiwan experienced a relatively low incidence of COVID-19. However, the emergence of the omicron variant of SARS-CoV-2 led to a nationwide outbreak from April 2022 to March 2023 (Chen *et al*, 2023). As infections surged, public panic boosted vaccination coverage over time (Chen *et al*, 2023; Schaffer DeRoo *et al*, 2020). It is possible prenatal COVID-19 vaccination rates will rise proportionally but there are no published studies of reasons for accepting or rejecting prenatal vaccination in Taiwan.

In this study, we aimed to identify factors significantly associated with accepting or rejecting prenatal COVID-19 vaccination among pregnant women in Taiwan in order to inform efforts to improve vaccination rates in this population.

MATERIALS AND METHODS

Study design and population

We conducted a cross-sectional study among pregnant women attending any one of three study

hospitals during October 2022-February 2023 for prenatal care. Inclusion criteria for study subjects were being aged ≥18 years, being pregnant in any trimester, having no history of mental health disorders and being willing and able to complete a study questionnaire.

The minimum number of study subjects calculated to be needed for this study based on the findings of a previous study (Bujang *et al*, 2018) was 500.

Study questionnaire and definitions

We developed a self-administered questionnaire for this study based on a literature review. The questionnaire, designed to assess knowledge and attitudes about prenatal COVID-19 vaccination, was evaluated by experts and pretested among 20 pregnant women. The Content Validity Index (CVI) was >0.8. The Cronbach's α value for the knowledge evaluation part of the questionnaire was 0.712 and for the attitude part was 0.903.

The questionnaire had 5 parts. Part 1 asked about basic demographics: personal information, subject vaccination status and past medical history. Part 2 asked about subject knowledge regarding COVID-19 and the COVID-19 vaccine covering 4 topics: "symptoms and severity", "route of infection", "vaccination timing and recipients" and "vaccine efficacy and protection mechanisms". Possible responses to questions were: "Yes", "No" or "Unknown". A correct answer received 1 point; an incorrect or unknown response received no points. The total score consisted of the sum of the scores for these 21 questions. A higher score indicated a better knowledge of COVID-19 and COVID-19 vaccines. The overall knowledge score was categorized into low and high knowledge groups by dividing the subjects into those with a knowledge score less than then median as having a low knowledge and those with a score above the median as having a high knowledge. Part 3 assessed subject attitudes about COVID-19 vaccination. The framework for this assessment was based on the Health Belief Model (HBM) (Jones and Wallis, 2022; Rosenstock *et al*, 1988). The attitude assessment consisted of the following sections (constructs): "perceived susceptibility", "perceived severity", "perceived benefits of action", "perceived barriers to action", "cues to action" and "self-efficacy" (Dudley *et al*, 2020). Each construct was assessed using 3 questions giving a total of 18 questions for the attitude assessment. Questions were answered using a 5-point Likert scale response, where "1" meant "strongly disagree" and "5" meant "strongly agree". The higher the score the more positive the attitude about prenatal COVID-19 vaccination. The overall attitude score was categorized into three groups (low,

medium and high) by tertiles. Part 4 assessed subject sources of information about COVID-19 vaccination. This consisted of closed-ended questions that allowed for more than one answer. Part 5 assessed the main reasons for receiving/refusing prenatal COVID-19 vaccination using closed-ended questions that allowed for more than one answer.

Data analysis

Subjects were asked the question "Would you receive or have you already received the COVID-19 vaccine during this pregnancy?" Those who answered they "received vaccination" or "planned to be vaccinated" were categorized as having "Received" prenatal COVID-19 vaccination. Those who answered "refused vaccination" or "undecided about vaccination" were categorized as having "Refused" prenatal COVID-19 vaccination.

Frequencies, percentages, means and standard deviations (SD) were used to summarize subject demographic data. Chi-square tests and t-tests, were used to evaluate associations between receiving prenatal COVID-19 vaccination and demographic variables, knowledge about COVID-19 and the COVID-19 vaccine and attitudes about prenatal COVID-19 vaccination. Multiple logistic regression analysis was used to determine factors independently significantly associated with receiving prenatal COVID-19 vaccination giving adjusted odds ratios (aOR) and 95% confidence intervals (CI). A p-value of <0.05 was considered statistically significant. The data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 27.0 (SPSS Inc, Chicago, IL).

We obtained written informed consent from each study subject prior to inclusion in this study. This study received ethical approval from the National Cheng Kung University Institutional Review Board (NCKU HERC-E-111-342-2).

RESULTS

Study subject characteristics

A total of 594 subjects were included in the study. The mean (±SD) age of study subjects was 31.3 (±5.5) (range: 18-46) years. Thirty-four percent of subjects were aged 30-34 years. 90.7% of subjects were married, and 55.7% had a college or university education. 78.8% of subjects were employed. Forty-three percent of subjects were in their third trimester of pregnancy, 50.7% had a planned pregnancy, and 78.3% had no history of a miscarriage. 7.9% of subjects reported having a comorbid condition, with anemia (5.2%) being the most common. 4.4% of subjects reported having a gestational complication, with gestational diabetes (3.2%) being the most common. 16.3%

of subjects had a previous history of influenza (Table 1).

One hundred seventy-seven subjects (29.8%) had previously been vaccinated against influenza: 86 subjects (14.5%) reported receiving annual influenza vaccinations, 33 (5.6%) during the current pregnancy. Ninety-one subjects (15.3%) reported previously receiving occasional influenza vaccinations, 34 (5.7%) during the current pregnancy. A total of 67 subjects (11.3%) had received influenza vaccination during the current pregnancy (Table 1).

Of a total of 594 subjects, 164 (27.6%) were unwilling or undecided about receiving the prenatal COVID-19 vaccine: 155 (26.1%) refused the vaccine and 9 (1.5%) were undecided while 430 subjects (72.4%) received at least one prenatal COVID-19 vaccine dose during pregnancy. Since this study was conducted during the influenza season, we recorded the proportion of subjects who received both prenatal COVID-19 and influenza vaccinations during pregnancy: 55 subjects (9.3%) (Table 1).

Six factors were significantly associated with receiving prenatal COVID-19 vaccination based on the Chi-square test: 1) Maternal age: the proportions of subjects who received prenatal COVID-19 vaccination to those refused vaccination aged <25 years, 25-29 years, 30-34 years, 35-39 years, and ≥40 years were 53:12 (81.5%), 109:51 (68.1%), 153:49 (75.7%), 89:33 (73.0%) and 26:19 (57.8%), respectively (p=0.038); 2) Self-perceived current health condition: the proportions of subjects with poor, fair and good self-perceived health who received prenatal COVID-19 vaccination to those who refused were 18:38 (32.1%), 111:65 (63.1%) and 301:61 (83.1%), respectively (p<0.001); 3) Regular exercise during pregnancy: the proportions of subjects who exercised 0, 1-2, 3-4, and 5-7 days per week who received prenatal COVID-19 vaccination to those who refused were 76:89 (46.1%), 215:43 (83.3%), 110:22 (83.3%) and 29:10 (74.4%), respectively (p<0.001); 4) Health supplements during pregnancy: the proportion of subjects who did not take health supplements during pregnancy who received prenatal COVID-19 vaccination (76:46, 62.3%) was significantly smaller (p=0.005) than the proportion of subjects who did take supplements during pregnancy (354:118, 75.0%); 5) Influenza vaccination history in the previous 3 years: the proportions of subjects who never, uncertain, occasionally and annually received an influenza vaccine who received prenatal COVID-19 vaccination to those who refused were 240:119 (66.9%), 46:12 (79.3%), 69:22 (75.8%) and 75:11 (87.2%), respectively (p=0.001); and 6) Hospital: the proportions of subjects who received their prenatal care at hospitals A, B

Table 1

Demographic variables of study subjects by the receipt of prenatal COVID-19 vaccination

Variable	Total (N = 594)	COVID-19 vaccination		*p*-value
		Received[a] (N = 430)	Refused[a] (N = 164)	
Maternal age, *n* (%)				0.038
<25 years	65 (10.9)	53 (12.3)	12 (7.3)	
25-29 years	160 (26.9)	109 (25.3)	51 (31.1)	
30-34 years	202 (34.0)	153 (35.6)	49 (29.9)	
35-39 years	122 (20.6)	89 (20.7)	33 (20.1)	
≥40 years	45 (7.6)	26 (6.1)	19 (11.6)	
Marital status, *n* (%)				0.185
Unmarried	55 (9.3)	44 (10.2)	11 (6.7)	
Married	539 (90.7)	386 (89.8)	153 (93.3)	
Education level, *n* (%)				0.229
Junior high school	11 (1.9)	6 (1.4)	5 (3.1)	
Senior high school	151 (25.4)	112 (26.1)	39 (23.8)	
Junior college	56 (9.4)	35 (8.1)	21 (12.8)	
University or college	331 (55.7)	246 (57.2)	85 (51.8)	
Graduate institute	45 (7.6)	31 (7.2)	14 (8.5)	

Table 1 (cont)

Variable	Total (N = 594)	COVID-19 vaccination		*p*-value
		Received[a] (N = 430)	Refused[a] (N = 164)	
Employment status, *n* (%)				0.471
Unemployed	126 (21.2)	88 (20.5)	38 (23.2)	
Employed	468 (78.8)	342 (79.5)	126 (76.8)	
Civil servant	44 (7.4)	23 (5.3)	21 (12.8)	
Labor	67 (11.3)	43 (10.0)	24 (14.6)	
Merchant	56 (9.4)	41 (9.5)	15 (9.1)	
Health care worker	54 (9.1)	43 (10.0)	11 (6.7)	
Service staff	152 (25.6)	123 (28.6)	29 (17.7)	
Others	95 (16.0)	69 (16.1)	26 (15.9)	
Religion, *n* (%)				0.056
No	336 (56.6)	244 (56.8)	92 (56.1)	
Buddhism	92 (15.5)	75 (17.4)	17 (10.4)	
Taoism	129 (21.7)	90 (20.9)	39 (23.8)	
Christianity	27 (4.5)	17 (4.0)	10 (6.1)	
Catholicism	2 (0.3)	1 (0.2)	1 (0.6)	
I-Kuan Tao	7 (1.2)	3 (0.7)	4 (2.4)	
Islam	1 (0.2)	0 (0.0)	1 (0.6)	

Table 1 (cont)

Variable	Total (N = 594)	COVID-19 vaccination		*p*-value
		Received[a] (N = 430)	Refused[a] (N = 164)	
Trimester of pregnancy, *n* (%)				0.940
1st trimester	113 (19.0)	83 (19.3)	30 (18.3)	
2nd trimester	226 (38.0)	162 (37.7)	64 (39.0)	
3rd trimester	255 (43.0)	185 (43.0)	70 (42.7)	
Planned pregnancy, *n* (%)				0.451
No	293 (49.3)	208 (48.4)	85 (51.8)	
Yes	301 (50.7)	222 (51.6)	79 (48.2)	
Number of miscarriages, *n* (%)				0.514
Never	465 (78.3)	332 (77.2)	133 (81.1)	
1 time	92 (15.5)	72 (16.8)	20 (12.2)	
2 times	24 (4.0)	16 (3.7)	8 (4.9)	
≥3 times	13 (2.2)	10 (2.3)	3 (1.8)	
Frequency of antenatal care, *n* (%)				0.150
Infrequent	4 (0.7)	2 (0.5)	2 (1.2)	
Occasional	10 (1.7)	5 (1.2)	5 (3.1)	
Regular	580 (97.6)	423 (98.3)	157 (95.7)	

Table 1 (cont)

Variable	Total (N = 594)	COVID-19 vaccination		*p*-value
		Received[a] (N = 430)	Refused[a] (N = 164)	
Pregnancy symptoms, *n* (%)				0.064
No	519 (87.4)	369 (85.8)	150 (91.5)	
Yes[b]	75 (12.6)	61 (14.2)	14 (8.5)	
Depression	5 (0.8)	2 (0.5)	3 (1.8)	
Moodiness	14 (2.4)	10 (2.3)	4 (2.4)	
Backache	23 (3.9)	19 (4.4)	4 (2.4)	
Breathlessness	15 (2.5)	13 (3.0)	2 (1.2)	
Food cravings or aversions	27 (4.5)	21 (4.9)	6 (3.7)	
Headache	26 (4.4)	23 (5.3)	3 (1.8)	
Nausea and vomiting	32 (5.4)	26 (6.0)	6 (3.7)	
Fatigue	28 (4.7)	24 (5.6)	4 (2.4)	
Constipation	31 (5.2)	27 (6.3)	4 (2.4)	
Self-perceived current health condition, *n* (%)				<0.001
Poor	56 (9.4)	18 (4.2)	38 (23.2)	
Fair	176 (29.6)	111 (25.8)	65 (39.6)	
Good	362 (61.0)	301 (70.0)	61 (37.2)	

Table 1 (cont)

Variable	Total (N = 594)	COVID-19 vaccination		*p*-value
		Received[a] (N = 430)	Refused[a] (N = 164)	
Drug use during pregnancy, *n* (%)				0.551
No record	8 (1.3)	7 (1.6)	1 (0.6)	
No	399 (67.2)	285 (66.3)	114 (69.5)	
Yes[b]	187 (31.5)	138 (32.1)	49 (29.9)	
Tocolytic drugs	122 (20.5)	91 (21.2)	31 (18.9)	
Painkillers	56 (9.4)	41 (9.5)	15 (9.1)	
Chronic disease medications	10 (1.7)	7 (1.6)	3 (1.8)	
Others	3 (0.5)	2 (0.5)	1 (0.6)	
Regular exercise during pregnancy, *n* (%)				<0.001
Not at all	165 (27.8)	76 (17.7)	89 (54.3)	
1-2 days per week	258 (43.4)	215 (50.0)	43 (26.2)	
3-4 days per week	132 (22.2)	110 (25.6)	22 (13.4)	
5-7 days per week	39 (6.6)	29 (6.7)	10 (6.1)	
Health supplements during pregnancy, *n* (%)				0.005
No	122 (20.5)	76 (17.7)	46 (28.0)	
Yes	472 (79.5)	354 (82.3)	118 (72.0)	

Table 1 (cont)

Variable	Total (N = 594)	COVID-19 vaccination		*p*-value
		Received[a] (N = 430)	Refused[a] (N = 164)	
Dietary control during pregnancy, *n* (%)				0.199
No	476 (80.1)	339 (78.8)	137 (83.5)	
Yes	118 (19.9)	91 (21.2)	27 (16.5)	
Comorbidity, *n* (%)				0.091
No	547 (92.1)	391 (90.9)	156 (95.1)	
Yes[b]	47 (7.9)	39 (9.1)	8 (4.9)	
Heart disease	5 (0.8)	3 (0.7)	2 (1.2)	
Kidney disease	3 (0.5)	3 (0.7)	0 (0.0)	
Liver and gallbladder disease	3 (0.5)	3 (0.7)	0 (0.0)	
Diabetes	3 (0.5)	3 (0.7)	0 (0.0)	
Anemia	31 (5.2)	26 (6.0)	5 (3.0)	
Immunodeficiency	6 (1.0)	4 (0.9)	2 (1.2)	
Gestational complication, *n* (%)				0.233
No	568 (95.6)	413 (96.0)	155 (94.5)	
Gestational diabetes	19 (3.2)	14 (3.3)	5 (3.1)	
Gestational hypertension	7 (1.2)	3 (0.7)	4 (2.4)	

Table 1 (cont)

Variable	Total (N = 594)	COVID-19 vaccination		*p*-value
		Received[a] (N = 430)	Refused[a] (N = 164)	
Previous influenza, *n* (%)				0.170
Unsure	65 (11.0)	49 (11.4)	16 (9.8)	
No	432 (72.7)	304 (70.7)	128 (78.0)	
Yes[b]	97 (16.3)	77 (17.9)	20 (12.2)	
Influenza during last pregnancy	14 (2.4)	14 (3.3)	0 (0.0)	
Influenza outside of pregnancy	83 (14.0)	63 (14.7)	20 (12.2)	
Had complications of influenza	7 (1.2)	6 (1.4)	1 (0.6)	
Previously influenza hospitalization	3 (0.5)	2 (0.5)	1 (0.6)	
Methods used to manage upper respiratory infection symptoms, *n* (%)				0.680
No record	3 (0.5)	3 (0.7)	0 (0.0)	
None	7 (1.2)	6 (1.4)	1 (0.6)	
Methods[b]	584 (98.3)	421 (97.9)	163 (99.4)	
Medications	490 (82.5)	346 (80.5)	144 (87.8)	
Diet and rest	355 (59.8)	256 (59.5)	99 (60.4)	
Exercise	38 (6.4)	30 (7.0)	8 (4.9)	
Folk remedies	9 (1.5)	5 (1.2)	4 (2.4)	
Health supplements	50 (8.4)	36 (8.4)	14 (8.5)	

Table 1 (cont)

Variable	Total (N = 594)	COVID-19 vaccination		*p*-value
		Received[a] (N = 430)	Refused[a] (N = 164)	
Influenza vaccination history in the previous 3 years, *n* (%)				0.001
None	359 (60.4)	240 (55.8)	119 (72.6)	
Annual vaccination[c]	86 (14.5)	75 (17.4)	11 (6.7)	
Occasional vaccination[d]	91 (15.3)	69 (16.1)	22 (13.4)	
Unsure	58 (9.8)	46 (10.7)	12 (7.3)	
Hospital, *n* (%)				<0.001
A	257 (43.3)	210 (48.8)	47 (28.7)	
B	182 (30.6)	125 (29.1)	57 (34.7)	
C	155 (26.1)	95 (22.1)	60 (36.6)	

[a]Refused subjects consisted of subjects unwilling or undecided about receiving prenatal COVID-19 vaccination while Received subjects consisted of subjects who had completed at least one dose of the prenatal COVID-19 vaccine; [b]Subjects may give more than one answer; [c]Including 33 (5.6%) subjects who received influenza vaccination during the current pregnancy, 28 who "Received" the vaccine and 5 who "Refused" it; [d]Including 34 (5.7%) subjects who received influenza vaccination during this pregnancy, 27 who "Received" the vaccine and 7 who "Refused" it.

A *p*-value of <0.05 was considered statistically significant.

COVID-19: Coronavirus disease 2019

and C who received prenatal COVID-19 vaccination to those who refused were 210:47 (81.7%), 125:57 (68.7%) and 95:60 (61.3%), respectively (p<0.001) (Table 1).

Knowledge about COVID-19 and the prenatal COVID-19 vaccine

The mean ± SD overall knowledge score about COVID-19 and prenatal COVID-19 vaccination among subjects who "Received" prenatal COVID-19 vaccination (14.71 ± 2.80) was significantly greater (p<0.001) than the knowledge score among subjects who "Refused" prenatal COVID-19 vaccination (12.56 ± 3.93). The mean ± SD knowledge score regarding "symptoms and severity" among subjects who "Received" prenatal COVID-19 vaccination (3.65 ± 1.08) was significantly higher (p<0.001) than subjects who "Refused" prenatal COVID-19 vaccination (2.65 ± 1.46). The mean ± SD knowledge score regarding "route of infection" among subjects who "Received" prenatal COVID-19 vaccination (2.19 ± 0.67) was significantly higher (p=0.010) than among subjects who "Refused" prenatal COVID-19 vaccination (2.04 ± 0.64). The mean ± SD knowledge score regarding "vaccination timing and recipients" among subjects who "Received" prenatal COVID-19 vaccine was (4.35 ± 1.12) was significantly higher (p<0.001) than among subjects who "Refused" prenatal COVID-19 vaccination (3.85 ± 1.52). The mean ± SD knowledge score regarding "vaccine efficacy and protection mechanism" among subjects who "Received" prenatal COVID-19 vaccination (4.52 ± 1.20) was significantly higher (p<0.001) than among subjects who "Refused" prenatal COVID-19 vaccination (4.02 ± 1.61) (Tables 2 and 3).

Attitudes about prenatal COVID-19 vaccination

The mean ± SD overall attitude score among subjects who "Received" prenatal COVID-19 vaccination (66.08 ± 8.10) significantly higher (p<0.001) than among subjects who "Refused" prenatal COVID-19 vaccination (58.57 ± 10.11). The mean ± SD attitude score regarding "perceived susceptibility" among subjects who "Received" prenatal vaccination (10.67 ± 1.71) was significantly higher (p=0.001) than among subjects who "Refused" prenatal COVID-19 vaccination (10.14 ± 1.70). The mean ± SD attitude score regarding "perceived benefits of action" among subjects who "Received" prenatal COVID-19 vaccination (11.46 ± 2.11) was significantly higher (p<0.001) than among subjects who "Refused" prenatal COVID-19 vaccination (10.04 ± 2.55). The mean ± SD attitude score regarding "perceived barriers of action" among subjects who "Received" prenatal COVID-19 vaccination (10.73 ± 2.69) was significantly higher (p<0.001) than among subjects who "Refused"

Table 2

Subject knowledge and attitude scores about COVID-19 and prenatal COVID-19 vaccination and receipt of prenatal COVID-19 vaccination

Category	Scores			*p*-value
	Total Mean ± SD	Received Mean ± SD	Refused Mean ± SD	
Overall knowledge score (21 items)	14.12 ± 3.29	14.71 ± 2.80	12.56 ± 3.93	<0.001
Symptoms and severity (6 items)	3.37 ± 1.28	3.65 ± 1.08	2.65 ± 1.46	<0.001
Route of infection (3 items)	2.15 ± 0.66	2.19 ± 0.67	2.04 ± 0.64	0.010
Vaccination timing and recipients (6 items)	4.21 ± 1.26	4.35 ± 1.12	3.85 ± 1.52	<0.001
Vaccine efficacy and protection mechanism (6 items)	4.38 ± 1.34	4.52 ± 1.20	4.02 ± 1.61	<0.001
Overall attitude score (18 items)	64.01 ± 9.32	66.08 ± 8.10	58.57 ± 10.11	<0.001
Perceived susceptibility (3 items)	10.52 ± 1.72	10.67 ± 1.71	10.14 ± 1.70	0.001
Perceived severity (3 items)	11.15 ± 2.25	11.17 ± 2.21	11.10 ± 2.34	0.735
Perceived benefits of action (3 items)	11.07 ± 2.33	11.46 ± 2.11	10.04 ± 2.55	<0.001
Perceived barriers of action (3 items)	10.22 ± 2.87	10.73 ± 2.69	8.88 ± 2.90	<0.001
Cues to action (3 items)	10.93 ± 2.17	11.47 ± 1.84	9.52 ± 2.33	<0.001
Self-efficacy (3 items)	10.12 ± 2.09	10.60 ± 1.85	8.88 ± 2.17	<0.001

Refused subjects consisted of subjects unwilling or undecided about receiving prenatal COVID-19 vaccination while Received subjects consisted of subjects who had completed at least one dose of the prenatal COVID-19 vaccine

A *p*-value of <0.05 was considered statistically significant.

COVID-19: Coronavirus disease 2019; SD: standard deviation

Table 3

Subject knowledge about COVID-19 and prenatal COVID-19 vaccination and receipt of prenatal COVID-19 vaccination

Knowledge[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] *n* (%)	
COVID-19 symptoms and severity				
COVID-19 symptoms are similar to a common cold, having cough, runny nose, fever, headaches and body aches				<0.001
Answered correctly	516 (86.9)	429 (99.8)	87 (53.0)	
Answered incorrectly	78 (13.1)	1 (0.2)	77 (47.0)	
A pregnant woman is at greater risk of severe illness and death due to COVID-19				<0.001
Answered correctly	520 (87.5)	392 (91.2)	128 (78.0)	
Answered incorrectly	74 (12.5)	38 (8.8)	36 (22.0)	
A pregnant woman with COVID-19 may take oral antiviral drugs, such as Paxlovid				<0.001
Answered correctly	232 (39.1)	190 (44.2)	42 (25.6)	
Answered incorrectly	362 (60.9)	240 (55.8)	122 (74.4)	
A pregnant woman with COVID-19 is at greater risk for premature birth, having a low-birth-weight infant and stillbirth				0.798
Answered correctly	390 (65.7)	281 (65.3)	109 (66.5)	
Answered incorrectly	204 (34.3)	149 (34.7)	55 (33.5)	

Table 3 (cont)

Knowledge[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] *n* (%)	
The SARS-CoV-2 virus does not pass into breast milk and spread to the infant				<0.001
Answered correctly	155 (26.1)	129 (30.0)	26 (15.9)	
Answered incorrectly	439 (73.9)	301 (70.0)	138 (84.1)	
The SARS-CoV-2 virus may pass through the placenta affecting fetal development				0.040
Answered correctly	190 (32.0)	148 (34.4)	42 (25.6)	
Answered incorrectly	404 (68.0)	282 (65.6)	122 (74.4)	
Route of infection				
COVID-19 is a highly contagious acute respiratory disease				0.596
Answered correctly	576 (97.0)	418 (97.2)	158 (96.3)	
Answered incorrectly	18 (3.0)	12 (2.8)	6 (3.7)	
The risk for contracting COVID-19 is the same for pregnant women as the general population				<0.001
Answered correctly	271 (45.6)	220 (51.2)	51 (31.1)	
Answered incorrectly	323 (54.4)	210 (48.8)	113 (68.9)	
COVID-19 is spread through respiratory droplets; wearing masks, social distancing and hand-washing can lower the risk of infection but not eliminate it				0.197
Answered correctly	430 (72.4)	305 (70.9)	125 (76.2)	
Answered incorrectly	164 (27.6)	125 (29.1)	39 (23.8)	

Table 3 (cont)

Knowledge[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] *n* (%)	
Vaccination timing and recipients				
The government of Taiwan has prioritized pregnant women for receiving a publicly funded COVID-19 vaccine				0.001
Answered correctly	493 (83.0)	371 (86.3)	122 (74.4)	
Answered incorrectly	101 (17.0)	59 (13.7)	42 (25.6)	
Women planning to become pregnant should receive a COVID-19 vaccine before pregnancy				<0.001
Answered correctly	525 (88.4)	397 (92.3)	128 (78.0)	
Answered incorrectly	69 (11.6)	33 (7.7)	36 (22.0)	
Pregnant women can receive the COVID-19 vaccine at any time during pregnancy				0.140
Answered correctly	308 (51.9)	231 (53.7)	77 (47.0)	
Answered incorrectly	286 (48.1)	199 (46.3)	87 (53.0)	
Children may receive the COVID-19 vaccine after age six months				0.566
Answered correctly	362 (60.9)	259 (60.2)	103 (62.8)	
Answered incorrectly	232 (39.1)	171 (39.8)	61 (37.2)	
The COVID-19 vaccine given to pregnant women is not a live virus vaccine so there is no risk of contracting COVID-19 from the vaccine				0.078
Answered correctly	259 (43.6)	197 (45.8)	62 (37.8)	
Answered incorrectly	335 (56.4)	233 (54.2)	102 (62.2)	

Table 3 (cont)

Knowledge[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] *n* (%)	
Family members caring for newborns should receive the COVID-19 vaccine to protect the newborn				<0.001
Answered correctly	556 (93.6)	416 (96.7)	140 (85.4)	
Answered incorrectly	38 (6.4)	14 (3.3)	24 (14.6)	
Vaccine efficacy and mechanisms of action				
Receiving the COVID-19 vaccine can reduce the risk of developing moderate to severe COVID-19				<0.001
Answered correctly	527 (88.7)	399 (92.8)	128 (78.0)	
Answered incorrectly	67 (11.3)	31 (7.2)	36 (22.0)	
The antibodies generated by a pregnant woman after receiving a COVID-19 vaccine can be transmitted to the fetus through the placenta				0.003
Answered correctly	458 (77.1)	345 (80.2)	113 (68.9)	
Answered incorrectly	136 (22.9)	85 (19.8)	51 (31.1)	
It is possible to contract COVID-19 even after being vaccinated with the COVID-19 vaccine				0.091
Answered correctly	559 (94.1)	409 (95.1)	150 (91.5)	
Answered incorrectly	35 (5.9)	21 (4.9)	14 (8.5)	
The adverse events of the COVID-19 vaccine in a pregnant woman are generally similar to those observed in the general population				0.090
Answered correctly	243 (41.0)	185 (43.0)	58 (35.4)	
Answered incorrectly	351 (59.0)	245 (57.0)	106 (64.6)	

Table 3 (cont)

Knowledge[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] *n* (%)	
The COVID-19 vaccine does not prevent the common cold				0.262
Answered correctly	366 (61.6)	259 (60.2)	107 (65.2)	
Answered incorrectly	228 (38.4)	171 (39.8)	57 (34.8)	
Receiving the COVID-19 vaccine during pregnancy does not increase the risk of fetal anomalies, miscarriage, stillbirth, premature delivery or pregnancy complications				<0.001
Answered correctly	449 (75.6)	345 (80.2)	104 (63.4)	
Answered incorrectly	145 (24.4)	85 (19.8)	60 (36.6)	

[a]Subjects answered whether the statements were true or false; [b]Refused subjects were subjects unwilling or undecided about receiving prenatal COVID-19 vaccination while Received subjects were subjects who had received at least one dose of prenatal COVID-19 vaccination

A *p*-value of <0.05 was considered statistically significant.

COVID-19: Coronavirus disease-2019; SARS-CoV-2: Severe acute respiratory syndrome coronavirus-2

prenatal COVID-19 vaccination (8.88 ± 2.90). The mean ± SD attitude score regarding "cues to action" among subjects who "Received" prenatal COVID-19 vaccination (11.47 ± 1.84) was significantly higher (p<0.001) than among subjects who "Refused" prenatal COVID-19 vaccination (9.52 ± 2.33). The mean ± SD attitude score regarding "self-efficacy" among subjects who "Received" prenatal COVID-19 vaccination (10.60 ± 1.85) was significantly higher (p<0.001) than among subjects who "Refused" prenatal COVID-19 vaccination (8.88 ± 2.17). There was no significant difference (p=0.735) in the attitude scores regarding "perceived severity" between those who "Received" and those who "Refused" prenatal COVID-19 vaccination (Tables 2 and 4).

Independent factors significantly associated with receiving prenatal COVID-19 vaccination

On multiple logistic regression analysis, six factors were significantly associated with receiving prenatal COVID-19 vaccination: subjects aged ≥40 years were significantly less likely to receive prenatal COVID-19 vaccination than subjects aged <25 years (adjusted odds ratio (aOR) = 0.288, 95% confidence intervals (CI): 0.099-0.837, p=0.022); subjects who reported having good health were significantly more likely to receive prenatal COVID-19 vaccination than subjects reporting poor health (aOR = 4.948, 95% CI: 2.309-10.604, p<0.001); subjects who reported exercising regularly during pregnancy were significantly more likely to receive prenatal COVID-19 vaccination than subjects who said they did not exercise regularly (aOR = 2.843, 95% CI: 1.747-4.627, p<0.001); subjects who reported receiving annual influenza vaccination during the previous 3 years were significantly more likely to receive prenatal COVID-19 vaccination than subjects who reported not receiving annual influenza vaccination (aOR = 2.707, 95% CI: 1.241-5.906, p=0.012); subjects who received prenatal care at Hospital C were significantly less like to receive prenatal COVID-19 vaccination than subjects who received prenatal care at Hospital A (aOR = 0.251, 95% CI: 0.143-0.441, p<0.001); and subjects who had a high attitude score regarding prenatal COVID-19 vaccination were significantly more likely to receive prenatal COVID-19 vaccination than subjects who had a low attitude score (aOR = 2.673, 95% CI: 1.458-4.899, p=0.001) (Table 5).

Sources of information about prenatal COVID-19 vaccination

The most common sources subjects reported receiving information about prenatal COVID-19 vaccination were: physicians (37%), hospital posters or advertisements (36.5%), TV news (34.8%), official government websites

Table 4

Subject responses regarding attitude about prenatal COVID-19 vaccination by receipt of prenatal COVID-19 vaccination

Responses[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] (N = 164)	
Perceived susceptibility				
Pregnant women have a higher risk of contracting COVID-19 than the general population				0.012
Strongly agree	49 (8.2)	39 (9.1)	10 (6.1)	
Agree	223 (37.6)	167 (38.8)	56 (34.1)	
Neutral	97 (16.3)	57 (13.3)	40 (24.4)	
Disagree	162 (27.3)	124 (28.8)	38 (23.2)	
Strongly disagree	63 (10.6)	43 (10.0)	20 (12.2)	
There is still a risk of contracting COVID-19 even when I have proper protective measures in place				0.007
Strongly agree	68 (11.4)	57 (13.3)	11 (6.7)	
Agree	259 (43.6)	198 (46.0)	61 (37.2)	
Neutral	162 (27.3)	109 (25.4)	53 (32.3)	
Disagree	92 (15.5)	59 (13.7)	33 (20.1)	
Strongly disagree	13 (2.2)	7 (1.6)	6 (3.7)	

Table 4 (cont)

Responses[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] (N = 164)	
Infants are more susceptible to contracting COVID-19 than older children				0.336
Strongly agree	168 (28.3)	131 (30.5)	37 (22.6)	
Agree	313 (52.7)	221 (51.4)	92 (56.1)	
Neutral	63 (10.6)	42 (9.8)	21 (12.8)	
Disagree	45 (7.6)	32 (7.4)	13 (7.9)	
Strongly disagree	5 (0.8)	4 (0.9)	1 (0.6)	
Perceived severity				
Pregnant women who contract COVID-19 may experience severe illness and sequelae				0.338
Strongly agree	110 (18.5)	83 (19.3)	27 (16.5)	
Agree	314 (52.9)	224 (52.1)	90 (54.9)	
Neutral	89 (15.0)	63 (14.7)	26 (15.8)	
Disagree	74 (12.5)	57 (13.2)	17 (10.4)	
Strongly disagree	7 (1.1)	3 (0.7)	4 (2.4)	
Pregnant women who contract COVID-19 are more likely to have a risk of premature birth				0.079
Strongly agree	116 (19.5)	81 (18.8)	35 (21.3)	
Agree	273 (46.0)	186 (43.2)	87 (53.1)	
Neutral	119 (20.0)	96 (22.3)	23 (14.0)	
Disagree	76 (12.8)	59 (13.7)	17 (10.4)	
Strongly disagree	10 (1.7)	8 (1.9)	2 (1.2)	

Table 4 (cont)

Responses[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] (N = 164)	
I am anxious about the impact of the COVID-19 pandemic and its future progression				0.044
Strongly agree	123 (20.7)	95 (22.1)	28 (17.1)	
Agree	251 (42.3)	190 (44.2)	61 (37.2)	
Neutral	153 (25.8)	101 (23.5)	52 (31.7)	
Disagree	58 (9.8)	40 (9.3)	18 (11.0)	
Strongly disagree	9 (1.4)	4 (0.9)	5 (3.0)	
Perceived benefits of action				
Receiving the COVID-19 vaccine can reduce the risk of complications and long-term outcomes caused by the disease				<0.001
Strongly agree	102 (17.2)	84 (19.5)	18 (11.0)	
Agree	286 (48.1)	220 (51.2)	66 (40.2)	
Neutral	126 (21.2)	80 (18.6)	46 (28.1)	
Disagree	73 (12.3)	44 (10.2)	29 (17.7)	
Strongly disagree	7 (1.2)	2 (0.5)	5 (3.0)	
Receiving the COVID-19 vaccine can reduce the risk of my infant developing severe COVID-19				<0.001
Strongly agree	96 (16.2)	82 (19.1)	14 (8.5)	
Agree	248 (41.8)	193 (44.9)	55 (33.5)	
Neutral	158 (26.5)	102 (23.7)	56 (34.2)	
Disagree	79 (13.3)	46 (10.7)	33 (20.1)	
Strongly disagree	13 (2.2)	7 (1.6)	6 (3.7)	

Table 4 (cont)

Responses[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] (N = 164)	
Receiving the COVID-19 vaccine can protect myself, my fetus, and my newborn, giving me peace of mind				<0.001
Strongly agree	126 (21.2)	104 (24.2)	22 (13.4)	
Agree	298 (50.2)	235 (54.7)	63 (38.4)	
Neutral	116 (19.5)	68 (15.8)	48 (29.3)	
Disagree	48 (8.1)	23 (5.3)	25 (15.2)	
Strongly disagree	6 (1.0)	0 (0.0)	6 (3.7)	
Perceived barriers of action				
I should get the COVID-19 vaccine even if there are concerns about adverse events				<0.001
Strongly agree	78 (13.1)	72 (16.7)	6 (3.7)	
Agree	264 (44.4)	209 (48.6)	55 (33.5)	
Neutral	151 (25.4)	97 (22.6)	54 (32.9)	
Disagree	82 (13.8)	43 (10.0)	39 (23.8)	
Strongly disagree	19 (3.2)	9 (2.1)	10 (6.1)	
I am confident about the safety of the COVID-19 vaccine				<0.001
Strongly agree	76 (12.8)	66 (15.4)	10 (6.1)	
Agree	230 (38.7)	187 (43.5)	43 (26.2)	
Neutral	175 (29.5)	117 (27.2)	58 (35.4)	
Disagree	94 (15.8)	50 (11.6)	44 (26.8)	
Strongly disagree	19 (3.2)	10 (2.3)	9 (5.5)	

Table 4 (cont)

Responses[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] (N = 164)	
Receiving the COVID-19 vaccine during pregnancy will not affect the development of my fetus				<0.001
Strongly agree	70 (11.8)	60 (13.9)	10 (6.1)	
Agree	231 (38.9)	188 (43.7)	43 (26.2)	
Neutral	148 (24.9)	103 (24.0)	45 (27.4)	
Disagree	112 (18.9)	61 (14.2)	51 (31.1)	
Strongly disagree	33 (5.5)	18 (4.2)	15 (9.2)	
Cues to action				
I should receive the COVID-19 vaccine, even if family members, friends or I have had negative experience it or expressed opposition to it				<0.001
Strongly agree	104 (17.5)	90 (20.9)	14 (8.5)	
Agree	229 (38.6)	192 (44.7)	37 (22.6)	
Neutral	130 (21.9)	85 (19.8)	45 (27.4)	
Disagree	105 (17.7)	56 (13.0)	49 (29.9)	
Strongly disagree	26 (4.3)	7 (1.6)	19 (11.6)	

Table 4 (cont)

Responses[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] (N = 164)	
I will receive the COVID-19 vaccine based on the advice of officials on the Taiwan National Epidemic Prevention Team				<0.001
Strongly agree	87 (14.6)	72 (16.7)	15 (9.1)	
Agree	249 (42.0)	211 (49.1)	38 (23.2)	
Neutral	192 (32.3)	117 (27.2)	75 (45.7)	
Disagree	56 (9.4)	28 (6.5)	28 (17.1)	
Strongly disagree	10 (1.7)	2 (0.5)	8 (4.9)	
If a healthcare provider explains the risks and benefits of the COVID-19 vaccine, I am more likely to receive it				<0.001
Strongly agree	108 (18.2)	90 (20.9)	18 (11.0)	
Agree	328 (55.2)	264 (61.4)	64 (39.0)	
Neutral	136 (22.9)	68 (15.8)	68 (41.5)	
Disagree	18 (3.0)	7 (1.6)	11 (6.7)	
Strongly disagree	4 (0.7)	1 (0.2)	3 (1.8)	

Table 4 (cont)

Responses[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] (N = 164)	
Self-efficacy				
I would encourage family members caring for an infant to receive the COVID-19 vaccine to protect themselves and the infant				<0.001
Strongly agree	141 (23.7)	120 (27.9)	21 (12.8)	
Agree	295 (49.7)	235 (54.6)	60 (36.6)	
Neutral	126 (21.2)	67 (15.6)	59 (36.0)	
Disagree	27 (4.5)	8 (1.9)	19 (11.6)	
Strongly disagree	5 (0.9)	0 (0.0)	5 (3.0)	
I am confident in the safety of the COVID-19 vaccine and I have no concerns about it harming the fetus or doubts about its efficacy				0.025
Strongly agree	27 (4.5)	26 (6.0)	1 (0.6)	
Agree	106 (17.8)	82 (19.1)	24 (14.6)	
Neutral	140 (23.6)	100 (23.3)	40 (24.4)	
Disagree	237 (39.9)	166 (38.6)	71 (43.3)	
Strongly disagree	84 (14.2)	56 (13.0)	28 (17.1)	

Table 4 (cont)

Responses[a]	Total (N = 594)	COVID-19 Vaccination		*p*-value
		Received[b] (N = 430)	Refused[b] (N = 164)	
I am willing to receive the COVID-19 vaccine regardless of the incidence of COVID-19 among pregnant women				<0.001
Strongly agree	100 (16.8)	85 (19.8)	15 (9.1)	
Agree	257 (43.3)	224 (52.1)	33 (20.1)	
Neutral	164 (27.6)	94 (21.8)	70 (42.7)	
Disagree	62 (10.4)	24 (5.6)	38 (23.2)	
Strongly disagree	11 (1.9)	3 (0.7)	8 (4.9)	

[a]Study subject response regarding statements; [b]Refused subjects were subjects unwilling or undecided about receiving prenatal COVID-19 vaccination while Received subjects were subjects who had received at least one dose of prenatal COVID-19 vaccination

A *p*-value of <0.05 was considered statistically significant.

COVID-19: Coronavirus disease-2019; SARS-CoV-2: Severe acute respiratory syndrome coronavirus-2

Table 5

Demographics, knowledge and attitudes about COVID-19 and prenatal COVID-19 vaccination and its association with receipt of prenatal COVID-19 vaccination

Variables	Number (N = 594)	Univariate analysis		Multivariate analysis	
		cOR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Maternal age					
<25 years	65	Reference	0.043	Reference	0.204
25-29 years	160	0.484 (0.238-0.984)	0.045	0.470 (0.205-1.076)	0.074
30-34 years	202	0.707 (0.350-1.430)	0.335	0.590 (0.261-1.334)	0.205
35-39 years	122	0.611 (0.290-1.284)	0.193	0.522 (0.214-1.275)	0.154
≥40 years	45	0.310 (0.131-0.733)	0.008	0.288 (0.099-0.837)	0.022
Self-perceived current health condition					
Poor	56	Reference	<0.001	Reference	<0.001
Fair	176	3.605 (1.903-6.830)	<0.001	2.660 (1.239-5.711)	0.012
Good	362	10.417 (5.578-19.456)	<0.001	4.948 (2.309-10.604)	<0.001
Regular exercise during pregnancy					
No	165	Reference	---	Reference	---
Yes	429	5.527 (3.725-8.202)	<0.001	2.843 (1.747-4.627)	<0.001
Use of health supplements during pregnancy					
No	122	Reference	---	Reference	---
Yes	472	1.816 (1.192-2.767)	0.006	1.488 (0.876-2.528)	0.142

Table 5 (cont)

Variables	Number (N = 594)	Univariate analysis		Multivariate analysis	
		cOR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Influenza vaccination history in the previous 3 years					
None	359	Reference	0.001	Reference	0.040
Annual vaccination	86	3.381 (1.730-6.606)	<0.001	2.707 (1.241-5.906)	0.012
Occasional vaccination	91	1.555 (0.917-2.636)	0.101	1.383 (0.745-2.569)	0.305
Unsure	58	1.901 (0.970-3.723)	0.061	1.907 (0.881-4.128)	0.102
Hospital					
A	257	Reference	<0.001	Reference	<0.001
B	182	0.491 (0.314-0.766)	0.002	0.602 (0.353-1.027)	0.063
C	155	0.354 (0.225-0.557)	<0.001	0.251 (0.143-0.441)	<0.001
Overall knowledge score					
Low (0-14 points)	308	Reference	---	Reference	---
High (15-21 points)	286	2.571 (1.759-3.759)	<0.001	1.624 (0.984-2.681)	0.058

Table 5 (cont)

Variables	Number (N = 594)	Univariate analysis		Multivariate analysis	
		cOR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Overall attitude score					
Low (20-60 points)	197	Reference	<0.001	Reference	0.001
Medium (61-67 points)	191	3.339 (2.141-5.207)	<0.001	2.329 (1.379-3.935)	0.002
High (68-90 points)	206	5.570 (3.440-9.020)	<0.001	2.673 (1.458-4.899)	0.001
			Omnibus test	χ^2 / *df*	*p*-value
				176.014 / 16	<0.001
			Hosmer and Lemeshow goodness of fit test	χ^2 / *df*	*p*-value
				12.097 / 8	0.147

A *p*-value of <0.05 was considered statistically significant.

aOR: adjusted odds ratios; CI: confidence intervals; cOR: crude odds ratio; COVID-19: Coronavirus disease 2019; *df*: degree of freedom

(33.5%), prenatal health education (31.1%), and online social media (30.5%) (Table 6).

Further analysis of the differences among the three hospitals revealed 52.1% of subjects who attended Hospital A for prenatal care, received information about prenatal COVID-19 vaccination from their physicians, versus 25.3% of subjects who attended B and 25.8% who attended Hospital C (p<0.001). 42.8% of subjects who attended Hospital A for prenatal care saw advertisements or posters regarding COVID-19 and prenatal COVID-19 vaccination, versus 33.5% of subjects who attended Hospital B and 29.7% of subjects who attended Hospital C (p=0.016).

Reasons given for receiving/refusing prenatal COVID-19 vaccination

The most common reason given by subjects for receiving prenatal

Table 6

Sources of information about COVID-19 vaccination among study subjects (N = 594)

Source of information about COVID-19 vaccination	Frequency *n* (%)
Physicians	220 (37.0)
Hospital posters or advertisements	217 (36.5)
TV news reports	207 (34.8)
Official websites	199 (33.5)
Prenatal health education	185 (31.1)
Online social media	181 (30.5)
Family members or friends	139 (23.4)
News conference of Central Epidemic Command Center	66 (15.3)
Maternal health handbooks	41 (6.9)
Newspapers or magazines	30 (5.1)
Radio programs	7 (1.2)

Note: Subjects may give more than one answer.

COVID-19: Coronavirus disease 2019

COVID-19 vaccination was concern about the impact of the COVID-19 pandemic on their daily life, (70.7%) followed by concern about the complications of COVID-19 (67.4%) (Table 7).

The most common reason given for refusing prenatal COVID-19 vaccination was worry about adverse effects of the vaccine (overall 67.1%; 78.9% of subjects aged ≥40 years, 60.6% aged 35-39 years, 67.3% aged 30-34 years, 66.7% aged 25-29 years and 66.7% aged <25 years). The second most common reason given for refusing prenatal COVID-19 vaccination was hearing negative reports and comments about prenatal COVID-19 vaccination (28.7%). The third most common reason given for refusing prenatal COVID-19 vaccination was not having sufficient knowledge about the vaccine (23.2%) (Table 8).

Table 7

Main reasons for receiving prenatal COVID-19 vaccination (N = 430)

Main reason	Frequency *n* (%)
Impact of serious COVID-19 pandemic on daily life	304 (70.7)
Concerns about potential complications of COVID-19	290 (67.4)
Protection of the mother and infant from COVID-19 disease	205 (47.7)
Concerns about SARS-CoV-2 virus transmission to the fetus	204 (47.4)
Support for public health policies	151 (35.1)
Healthcare provider recommendations	76 (17.7)
Family member recommendations	45 (10.4)
Availability and accessibility of prenatal COVID-19 vaccination	37 (8.6)
Confidence in the safety of prenatal COVID-19 vaccination	28 (6.5)
Friend recommendations	18 (4.2)

Note: Subjects may give more than one answer.

COVID-19: Coronavirus disease 2019; SARS-CoV-2: Severe acute respiratory syndrome coronavirus-2

Table 8

Main reasons for refusing prenatal COVID-19 vaccination among study subjects (N = 164)

Main reason	Frequency *n* (%)
Concerns about potential adverse events and safety of prenatal COVID-19 vaccination	110 (67.1)
Impact of negative reports on COVID-19 vaccines in the news	47 (28.7)
Lack of understanding about prenatal COVID-19 vaccination	38 (23.2)
Confidence in self-protection against contracting COVID-19	23 (14.0)
Lack of confidence in the efficacy of prenatal COVID-19 vaccination	12 (7.3)
No assessment or guidance from healthcare providers about prenatal COVID-19 vaccination	12 (7.3)
Previous experience with vaccine side effects	10 (6.1)
Family member opposition	9 (5.5)
Poor health or illness	7 (4.3)
Fear of needles	3 (1.8)

Note: Subjects may give more than one answer.

COVID-19: Coronavirus disease 2019

DISCUSSION

As far as we know, this is the first study regarding prenatal COVID-19 vaccination in Taiwan. The prenatal COVID-19 vaccination rate among study subjects was 72.4%, lower than the 90% rate reported in the general population in Taiwan (Chen *et al*, 2023). Taiwan's prenatal COVID-19 vaccination rate was higher than the global estimated average of 53.46%, as revealed by a meta-analysis of 16 articles involving 19,219 pregnant women worldwide (Azami *et al*, 2022). This higher rate might be due to Taiwan's past history with the severe acute respiratory syndrome (SARS) outbreak in 2003 and the H1N1 pandemic in 2009, which fostered a strong interest in self-protection and epidemic prevention in the Taiwanese population (Yen *et al*, 2021; Skjefte *et al*, 2021).

In our study, subjects aged ≥40 years were significantly less likely to receive prenatal COVID-19 vaccination than subjects aged <25 years. This suggests older pregnant women may be more concerned about the vaccine's impact on their health and the health of the fetus (Jones and Wallis, 2022). Since older pregnant women are at higher risk for complications due to COVID-19 during pregnancy (Qeadan *et al*, 2021; Zambrano *et al*, 2020), this concern among older subjects needs to be addressed to improve vaccination rates in this age group.

In our study, subjects with perceived good health were significantly more likely to receive prenatal COVID-19 vaccination than subjects with perceived poor health, similar to the findings of a study from Canada where the subjects were more concerned about the risks than the benefits of the vaccine due to their overall poor health (Guay *et al*, 2022). It is important to address this concern as those with poor health are at greater risk of complications due to COVID-19 than those with good health (Genovese *et al*, 2023; Xu *et al*, 2021).

In our study, subjects who exercised regularly during pregnancy were significantly more likely to receive prenatal COVID-19 vaccination than subjects who did not. Those who exercise regularly during pregnancy may be more health conscious, wanting to protect themselves and their fetus (Hallam *et al*, 2022).

In our study, subjects who regularly received influenza vaccination during the previous 3 years were significantly more likely to receive prenatal COVID-19 vaccination than those who did not, similar to the findings of previous studies from the United States (Battarbee *et al*, 2022; Razzaghi *et al*, 2022). 14.5% of our subjects reported receiving annual influenza vaccinations, 15.3% reported receiving occasional influenza vaccinations and 11.3% reported receiving an influenza vaccination during the current pregnancy. These percentages are much lower than the 60% influenza vaccination rate among pregnant women prior to the COVID-19 pandemic (Chang *et al*, 2019). A previous study from the United States, reported the prenatal influenza vaccination rate in 2019 was 83% and during the COVID-19 pandemic was 40% (Perelman *et al*, 2023). In our study, 9.3% of subjects had received both prenatal COVID-19 and influenza vaccinations, similar to low rates reported in studies from Korea (16.5%) (Kim and Kim, 2023), Italy (16.8%) (Genovese *et al*, 2023) and Turkey (20.7%) (Goncu Ayhan *et al*, 2021). Efforts aimed at improving both influenza and COVID-19 vaccination

rates need to determine the reasons for these low rates and address them to improve prenatal vaccination rates of both these vaccines.

In our study, subjects receiving prenatal care at Hospital A had higher prenatal COVID-19 vaccination rates than subjects attending Hospitals B and C. Those attending Hospital A were more likely to receiving information about COVID-19 and prenatal COVID-19 vaccination and more likely to see advertisements about prenatal COVID-19 vaccination than subjects attending Hospitals B and C. These data show the importance of healthcare providers' influence on pregnant women's vaccination decisions (Binger *et al*, 2023; Genovese *et al*, 2023) and suggests the need to target hospital administrations for improving prenatal COVID-19 vaccination promotion in the study population.

In our study, subjects who received prenatal COVID-19 vaccination had higher mean knowledge scores than those who refused it. This suggests pregnant women who refuse prenatal COVID-19 vaccination likely have a poorer knowledge about COVID-19 and prenatal COVID-19 vaccination. In our study, 23.2% of subjects stated their reason for refusing of prenatal COVID-19 vaccination was insufficient knowledge about the vaccine. Previous studies from China and Malaysia reported improving pregnant women's knowledge about COVID-19 and prenatal COVID-19 vaccination increased vaccination rates (Kalok *et al*, 2023; Tao *et al*, 2021). This suggests it is important to improve pregnant women's knowledge about prenatal COVID-19 vaccination is important to improve vaccination rates.

In our study, subjects with a positive attitude about prenatal COVID-19 vaccination were significantly more likely to be vaccinated than those with a negative attitude, similar to previous studies from China and the United States (Jones and Wallis, 2022; Tao *et al*, 2021). Among the attitude study areas, "perceived severity" was had the strongest association with receiving prenatal COVID-19 vaccination suggesting concern about disease severity was important in subject decision making and may suggest a way to improve vaccination rates in the study population by educating about the risk for severe disease due to COVID-19 during pregnancy (Razzaghi *et al*, 2022; Tao *et al*, 2021).

In summary, receiving prenatal COVID-19 vaccination among our study subjects was associated with younger maternal age, having good self-perceived health, exercising regularly during pregnancy, having

received influenza vaccination, getting prenatal care from a hospital promoting prenatal vaccination, having a better knowledge about COVID-19 and prenatal COVID-19 vaccination and having a good attitude about prenatal COVID-19 vaccination. We conclude some groups should be targeted to improve prenatal vaccination rates including older women, the administration of Hospital C, women who have not previously received influenza vaccination, women who have poor perceived health, women who do not exercise regularly, women with a poor knowledge about COVID-19 and prenatal COVID-19 vaccination and women with a negative attitude about prenatal vaccination. Further studies are needed to determine what interventions would be best to reach these target groups and to determine if these efforts will result in improved vaccination rates.

ACKNOWLEDGEMENTS

We appreciate all the subjects for their participation in our study.

CONFLICT OF INTEREST DISCLOSURE

The authors declare that there is no conflict of interest.

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