COVID-19 vaccination and transmission patterns among pregnant and postnatal women during the fifth wave of COVID-19 in a tertiary hospital in Hong Kong

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A B S T R A C T

Introduction: Vaccination is a key strategy to control the coronavirus disease 2019 (COVID-19) pandemic. Safety concerns strongly influence vaccine hesitancy. Disease transmission during pregnancy could exacerbate risks of preterm birth and perinatal mortality. This study examined patterns of vaccination and transmission among pregnant and postnatal women during the fifth wave of COVID-19 in Hong Kong.

Methods: The Antenatal Record System and Clinical Management System of the Hospital Authority was used to retrieve information concerning the demographic characteristics, vaccination history, COVID-19 status, and obstetric outcomes of women who were booked for delivery at Queen Mary Hospital in Hong Kong and had attended the booking antenatal visit from 1 July 2021 to 30 June 2022.

Results: Among 2396 women in the cohort, 2006 (83.7%), 1843 (76.9%), and 831 (34.7%) had received the first, second, and third doses of COVID-19 vaccine, respectively. Among 1012 women who had received the second dose, 684 (67.6%) women were overdue for their third dose. There were 265 (11.1%) reported COVID-19 cases. Women aged 20 to 29 years had a low vaccination rate but the highest disease rate (19.1%). The disease rate was more than tenfold higher in women who had no (20.3%) or incomplete (18.8%) vaccination, compared with women who had complete vaccination (2.1%; P<0.001).

Conclusion: Acceptance of COVID-19 vaccination was low in pregnant women. Urgent measures are needed to promote vaccination among pregnant women before the next wave of COVID-19.

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New knowledge added by this study

- As of 30 June 2022, only 34.7% of women in Hong Kong had received three doses of coronavirus disease 2019 (COVID-19) vaccine.
- Two-thirds women scheduled for a third dose of COVID-19 vaccine did not receive the booster dose during pregnancy.
- The disease rate was almost ten times higher in women who had no or incomplete vaccination, compared with women who had complete vaccination.
- Women aged 20 to 29 years had a low vaccination rate but the highest disease rate.

Implications for clinical practice or policy

- Pregnant women should receive education concerning the importance and safety of COVID-19 vaccination during pregnancy and breastfeeding.
- Delayed receipt of booster doses increase susceptibility to COVID-19 during future waves.
- A comprehensive programme incorporating pertussis and COVID-19 vaccination for pregnant women should be considered.

第五波新冠肺炎疫情期間香港某公立醫院產科孕婦及產後婦女的新冠疫苗接種及傳播狀況

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引言：疫苗接種是控制新冠疫情大流行的關鍵策略，但安全問題造成疫苗猶豫。懷孕期間的疾病傳播可能會加劇早產和圍產期的死亡風險。本研究調查了香港第五波新冠肺炎疫情期間孕婦和產後婦女的新冠疫苗接種和傳播狀況。

方法：本研究使用醫院管理局的產前紀錄系統及臨床管理系統，檢索於2021年7月1日至2022年6月30日期間在香港瑪麗醫院預約分娩和進行預約產前檢查的孕婦的人口特徵、疫苗接種史、新冠肺炎感染狀況及產後狀況等資料。

結果：在2396名孕婦及產後婦女中，2006名（83.7%）、1843名（76.9%）和831名（34.7%）分別接種了第一劑、第二劑和第三劑新冠疫苗。在已接種第二劑疫苗的1012名婦女中，684名（67.6%）婦女逾期未接種第三劑。研究並發現有265個（11.1%）新冠肺炎病例；20至29歲婦女的疫苗接種率較低，患病率為最高（19.1%）。與完全接種疫苗的婦女（2.1%；P<0.001）相比，未接種疫苗（20.3%）或未完全接種疫苗（18.8%）的婦女的患病率高出近十倍。

結論：孕婦對新冠疫苗接種的接受度較低。在下一波新冠疫情爆發前，需要採取緊急措施促進孕婦接種疫苗。

Introduction

Vaccination is an effective tool to combat the coronavirus disease 2019 (COVID-19) pandemic. Two types of COVID-19 vaccines are used in Hong Kong: the Sinovac-CoronaVac inactivated severe acute respiratory syndrome coronavirus 2 vaccine (Sinovac Biotech Ltd, Beijing, China) and Pfizer BioNTech BNT162b2 (Pfizer Inc, Philadelphia [PA], United States) messenger RNA vaccine began distribution on 26 February 2021 and 10 March 2021, respectively.

According to the World Health Organization, vaccine hesitancy is defined as delaying or refusing vaccination despite the availability of vaccination services.[1] In a study conducted during the third wave of COVID-19 in Hong Kong, the overall vaccine acceptance rate was approximately 37%.[2] Although the subsequent acceptance rate has varied with pandemic progression, confidence in COVID-19 vaccines has remained a key factor in reducing vaccine hesitancy.[3]

Pregnant women were generally excluded from clinical trials focusing on the development, safety, and efficacy of COVID-19 vaccines.[4] When COVID-19 vaccines were introduced in Hong Kong, routine vaccination was not recommended for women who were pregnant or breastfeeding, except when there was a high risk of exposure or complications.[5] The relative lack of data may have contributed to vaccine hesitancy among pregnant women.[6-8] Based on data concerning the efficacy and safety of COVID-19 vaccination in preventing serious illness,[9] COVID-19 vaccination is recommended for people who are pregnant, breastfeeding, planning to become pregnant, or may become pregnant in the future.[10,11]

On 23 April 2021, the Hong Kong College of Obstetricians and Gynaecologists (HKCOG) issued an interim recommendation that pregnant women receive the BioNTech COVID-19 vaccine at the same time as the general population.[12] On 18 February 2022, the Sinovac vaccine was also recommended for use in pregnant women.[12] Furthermore, the recommended interval between the second and third doses of COVID-19 vaccine was shortened from 180 days to 90 days, beginning on 4 March 2022. The vaccine pass policy for entry to specific premises was tightened on 31 May 2022.[13] For persons who were over 18 years old and had no history of infection, a minimal of two doses of vaccination was required. A third dose was required if the second dose was taken over 6 months ago. Starting from 13 June 2022, women attending obstetric clinics were required to provide a negative result proof of a polymerase chain reaction–based nucleic acid test conducted with specimen collected within 48 hours before the visit if they did not fulfil the vaccine pass requirement.[14]

The fifth wave of COVID-19 in Hong Kong has resulted in an overwhelming number of COVID-19 cases. Pregnant women are not automatically protected from COVID-19; indeed, their vaccine hesitancy and low vaccination rate may lead to greater susceptibility. Information concerning the patterns of COVID-19 vaccination and disease transmission among pregnant women in Hong Kong is unavailable. This study examined patterns of vaccination and transmission among pregnant women who were booked for delivery at a tertiary hospital in Hong Kong, with the goal of providing insights into maternal disease characteristics.

Methods

This retrospective review included women who were booked for delivery at Queen Mary Hospital in Hong Kong and had attended the booking antenatal visit from 1 July 2021 to 31 March 2022. Information concerning COVID-19 vaccination history was retrieved from the Clinical Management System of the Hospital Authority, which captured COVID-19 vaccination data from the Department of Health.

Pregnant women were diagnosed with COVID-19 because of symptoms or (in the absence of symptoms) during admission screening. Women diagnosed with COVID-19 through other channels were able to reschedule their appointments. Phone consultations were provided by the obstetric team at Queen Mary Hospital. The clinical details of COVID-19 cases were documented in the

computerised Antenatal Record System. Additionally, antenatal progress notes were updated if a pregnant woman reported a history of COVID-19 during a follow-up visit. Data regarding demographic characteristics, COVID-19 status, and obstetric outcomes were retrieved from the Antenatal Record System.

The vaccinated group comprised women who received at least one dose of any type of COVID-19 vaccine. Vaccination periods were classified as pre-pregnancy, antenatal, and postnatal for women with a known date of delivery, miscarriage, or termination of pregnancy as of 30 June 2022. For women with ongoing pregnancies and unknown obstetric outcomes, the vaccination period was estimated according to the expected date of delivery. Antenatal status was regarded as known ongoing pregnancy before 42 weeks of gestation. A vaccination episode was defined as any episode of COVID-19 vaccination including the first, second, and third doses. The number of days elapsed since vaccination was defined as the interval between the last dose of COVID-19 vaccine and 30 June 2022 for women who had received one or two doses of vaccine. Complete vaccination was regarded as the period between 15 and 90 days after the second dose of COVID-19 vaccine, or 14 days after the third dose of COVID-19 vaccine for women who had never been diagnosed with COVID-19. For women with COVID-19, the date of diagnosis was regarded as the reference point when determining vaccination status.

Descriptive statistics were reported. Vaccination rates were calculated according to age-group. Background demographic characteristics were compared between vaccinated and unvaccinated groups. Student's *t* test, analysis of variance, and the Chi squared test were used as appropriate. Regression analyses were conducted to identify factors affecting vaccine acceptance. P values <0.05 were considered statistically significant. Statistical analyses were performed using SPSS software (Windows version 26; IBM Corp, Armonk [NY], United States).

TABLE 1. Background characteristics of women who received antenatal care between 1 July 2021 and 31 March 2022*

	Vaccinated	Unvaccinated	P value
Pregnant women (n=2396)	2006 (83.7%)	390 (16.3%)	
Status on 30 June 2022			
Maternal age, y	34.1 ± 4.0	34.1 ± 4.1	0.98
Ethnicity			<0.001
Chinese	1619 (80.7%)	371 (95.1%)	
Non-Chinese	387 (19.3%)	19 (4.9%)	
Education level			0.012
Tertiary or above	1642 (81.9%)	298 (76.4%)	
Secondary or below	364 (18.1%)	92 (23.6%)	
Employment status			<0.001
Not working	322 (16.1%)	102 (26.2%)	
Working	1684 (83.9%)	288 (73.8%)	
Maternal background characteristics			
Nulliparous	1162 (57.9%)	238 (61.0%)	0.26
Multiple pregnancy	29 (1.4%)	7 (1.8%)	0.44
Assisted reproduction	202 (10.1%)	45 (11.5%)	0.38
Medical or obstetric conditions	351 (17.5%)	90 (23.1%)	0.009
Pertussis vaccination			0.027
Opted in	1532 (76.4%)	282 (72.3%)	
Opted out	69 (3.4%)	24 (6.2%)	
Undecided	405 (20.2%)	84 (21.5%)	
COVID-19 diagnosis	168 (8.4%)	63 (16.2%)	<0.001

Abbreviation: COVID-19 = coronavirus disease 2019

* Data are shown as No. (%) or mean ± standard deviation, unless otherwise specified

Results

Table 1 shows the demographic characteristics of 2396 pregnant women who had attended the booking antenatal visit between 1 July 2021 and 31 March 2022. As of 30 June 2022, 2006 (83.7%), 1843 (76.9%), and 831 (34.7%) women had received the first, second, and third doses of COVID-19 vaccine, respectively. Among the 1843 women who had received two doses of vaccine, 1056 (57.3%) underwent vaccination before pregnancy (Fig 1). Of these 1843 women, 831 received a third dose; the median interval between the second and third doses was 280 days (interquartile range, 239-308). Of the remaining 1012 women who had received only two doses of vaccine, 684 (67.6%) and 504 (49.8%) had already passed the 90-day and 180-day intervals, respectively. Their median number of days elapsed since the last vaccine was 315 (interquartile range, 145-368), which considerably exceeded the recommended 90-day interval.

Only 26.6% (1243/4680) of vaccination episodes occurred during pregnancy. Among women who underwent antenatal vaccination, 65.7% (817/1243) had it during the fifth wave of COVID-19 between January 2022 and June 2022; 65.7% (537/817) of these women received the third dose. The two peaks of vaccination for third dose were observed in early March 2022 and late May 2022 (Fig 2).

The vaccination rate was the lowest among Chinese women (81.4%), but the highest among Caucasian women (96.4%) [Fig 3]. Multivariate analysis showed that active working status (odds ratio [OR]=1.94; 95% confidence interval [CI]=1.47-2.56) was significantly associated with a higher COVID-19 vaccination rate, whereas Chinese ethnicity (OR=0.21; 95% CI=0.13-0.33) and women with obstetric complications (OR=0.72; 95% CI=0.55-0.94) were significantly associated with a lower COVID-19 vaccination rate.

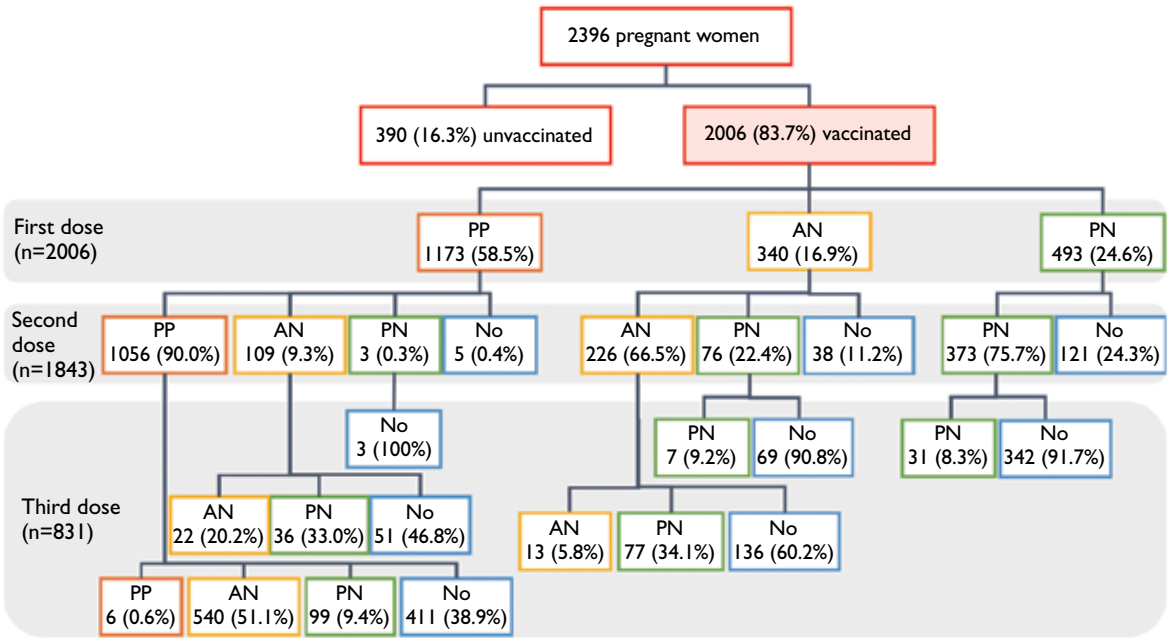

FIG 1. Pattern of coronavirus disease 2019 vaccination episodes according to timing of vaccination*
Abbreviations: AN = antenatal; No = dose not received; PN = postnatal; PP = pre-pregnancy
* Data are shown as No. (%)

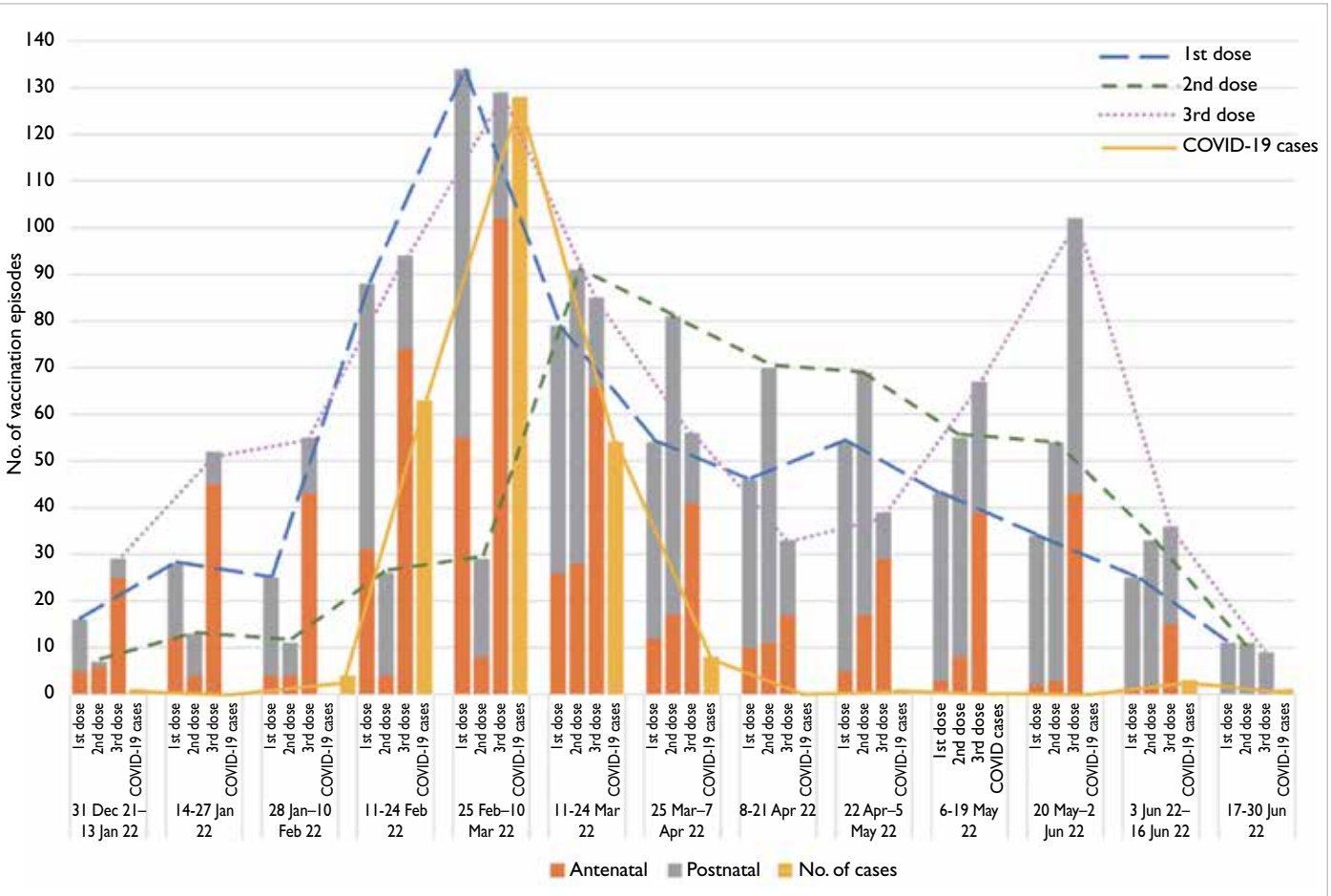

FIG 2. Vaccination episodes during the fifth wave of coronavirus disease 2019 (COVID-19)

In total, there were 265 (11.1%) COVID-19 cases in this cohort; the earliest diagnosis was made on 1 January 2022 during the fifth wave of COVID-19 in Hong Kong (Table 2). The disease rate was more than tenfold higher in women who had no (20.3%) or incomplete (18.8%) vaccination, compared with women who had complete vaccination (2.1%; P<0.001). After exclusion of pregnancies among women aged ≤19 years, there was an insignificant trend of lower vaccination among young women (ie, aged 20-29 years), but their disease rate was the highest (19.1%) [Fig 4].

Among 237 (89.4%) women who had an antenatal diagnosis of COVID-19, 42 (17.7%) required admission for monitoring and 26 (11.0%) delivered in an isolation facility. No women required

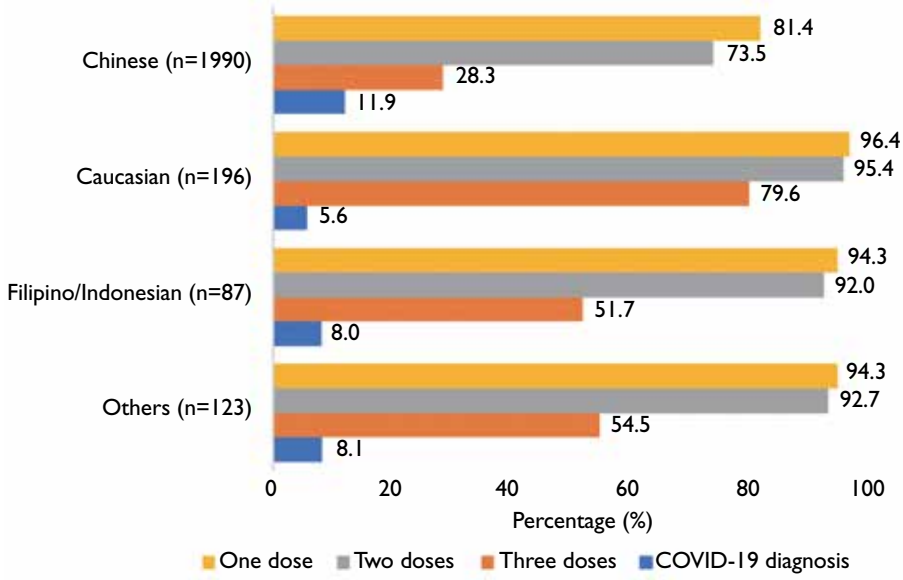

FIG 3. Percentages of coronavirus disease 2019 (COVID-19) vaccination and disease transmission among pregnant women by ethnicity

TABLE 2. Vaccination background and pregnancy outcome among pregnant women with coronavirus disease 2019 (COVID-19)*

	No vaccination	Incomplete vaccination†	Complete vaccination‡	P value
All pregnant women (n=2396)	390 (16.3%)	860 (35.9%)	1146 (47.8%)	
Women with COVID-19 (n=265)	79 (20.3%)	162 (18.8%)	24 (2.1%)	<0.001
Maternal age, y	34.1 ± 0.41	33.5 ± 0.41	34.5 ± 0.39	<0.001
No. of women hospitalised§	13 (16.5%)	25 (15.4%)	4 (16.7%)	0.97
Diagnosed before delivery (n=237)	70 (88.6%)	146 (90.1%)	21 (87.5%)	0.04
Miscarriage/TOP	1 (1.4%)	1 (0.7%)	0	
Ongoing pregnancy	24 (34.3%)	102 (69.9%)	13 (61.9%)	
Delivered	45 (64.3%)	43 (29.4%)	8 (38.1%)	
Isolation facilities	7 (15.6%)	18 (41.9%)	1 (12.5%)	0.01
Caesarean section	16 (35.6%)	11 (25.6%)	3 (37.5%)	0.34
Gestation at diagnosis, wk	31.7 ± 5.3	34.2 ± 7.7	36.9 ± 2.2	0.05
Gestation at delivery, wk	39.1 ± 1.5	38.6 ± 2.0	39.4 ± 0.7	0.29
Birth weight, g	3065.3 ± 376.9	3106.8 ± 465.1	3304.2 ± 324.1	0.43

Abbreviation: TOP = termination of pregnancy

* Data are shown as No. (%) or mean ± standard deviation, unless otherwise specified

† Incomplete vaccination was regarded as women who had received at least one vaccination but not yet fulfilled the criteria for completed vaccination

‡ Complete vaccination was regarded as the period between 15 and 90 days after the second dose of COVID-19 vaccine, or 14 days after the third dose of COVID-19 vaccine for women who had never been diagnosed with COVID-19

§ No critically ill women in the cohort

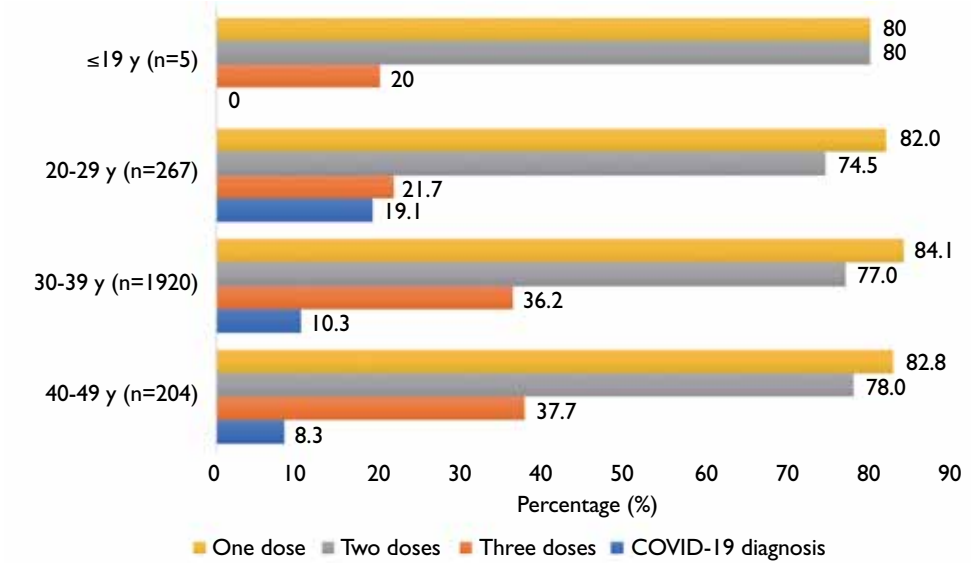

FIG 4. Percentages of coronavirus disease 2019 (COVID-19) vaccination and disease transmission among pregnant women by age

intensive care or oxygen support. There were no adverse maternal outcomes or cases of vertical transmission.

Discussion

Coronavirus disease 2019 vaccination

To our knowledge, this is the first report of the low COVID-19 vaccination rate (83.7%) among pregnant women in Hong Kong. This rate is considerably lower than the single-dose rate among the general public (92.7%) that was reported on the government's vaccination dashboard on the final day of the study period (ie, 30 June 2022).[15] Furthermore, the disease rate was more than threefold higher in women who had no or incomplete vaccination, compared with women who had complete vaccination.

Pregnant women are considered a vulnerable group. The substantial increase in the disease rate, combined with a lower vaccination rate, among women aged 20 to 29 years is particularly concerning. A case of COVID-19 during pregnancy can lead to adverse obstetric outcomes, including increased risks of preterm delivery, growth restriction, and stillbirth.[16] In addition to the effectiveness of vaccination in terms of reducing severe complications, the transplacental transfer of immunoglobulins after maternal vaccination might provide infants with protection against COVID-19.[10,16-18]

Vaccine hesitancy

Vaccine hesitancy is a potential public health problem.[19] The five psychological antecedents of vaccination are confidence, complacency, constraints, calculation, and collective responsibility.[20,21] Acceptance of COVID-19 vaccination has varied among countries, with the highest rates reported in India, the Philippines, and Latin America.[22] In the present study, Chinese women had a lower vaccination rate, compared with their non-Chinese counterparts.

The COVID-19 pandemic has contributed to a decrease in vaccine hesitancy.[23] In May 2021, a systemic review showed that an estimated 47% of pregnant women worldwide intended to undergo COVID-19 vaccination.[24]

Communities generally become more complacent when the number of disease cases is low, suggesting that the perceived risk of disease transmission is minimal. This phenomenon was evident in Hong Kong across several waves of COVID-19 transmission.[15] The vaccination rate increased during the fifth wave of COVID-19 when there was an exponential surge in the number of disease cases. A similar pattern was observed in the present study, such that two-thirds of the antenatal vaccination episodes occurred during the fifth wave of COVID-19 in Hong Kong.

Despite this relative surge in vaccination, around two-thirds of women eligible for the third dose did not receive it during pregnancy. This delay poses a major threat because the protective effect of the previous two doses may have dissipated. Importantly, although the rate of vaccination was higher in the antenatal group than the postnatal

group, most women in the antenatal group had undergone vaccination before pregnancy. Thus, they may have a higher risk of serious adverse effects from COVID-19 if they become ill in the peripartum period. After exclusion of the small number of pregnant women aged ≤19 years, vaccination rates were consistently low among pregnant women of all ages. Pregnant women may have a higher risk of disease transmission in future waves of COVID-19; at the end of the present study, only one-third of pregnant women in this cohort had received three doses of vaccine.

Lack of confidence has been identified as the main factor consistently associated with lower COVID-19 vaccine hesitancy.[3] The implementation of the stringent vaccine pass policy had driven another peak of vaccination in late May 2022. However, nearly half of the women who had received two doses of vaccine were indeed overdue for the third dose, and hence did not fulfil the vaccine pass for entrance to specific premises or could not attend obstetric clinics without undergoing nucleic acid testing. This group of vaccine had received COVID-19 vaccine before but had it mostly before pregnancy. Pregnancy could represent the key hindrance for their vaccination in the antenatal period. Government policy might not be adequate enough for promoting vaccination in pregnant women. Concern about possible harmful side-effects was the top reason for reluctance; confidence in COVID-19 vaccine safety and efficacy was the main predictor of acceptance, particularly in the pregnant population.[8,22] In a Japanese cohort, concerns about potential effects on the fetus and breastfeeding were the main reasons for low COVID-19 vaccination acceptance.[25] These findings highlight the need to distribute correct information and provide sufficient education to address concerns among women of reproductive age. In particular, antenatal women should receive additional information concerning vaccine safety during pregnancy.

Vaccination promotion

A study in Hong Kong showed that recommendations from the government constituted the strongest factor driving COVID-19 vaccine acceptance.[2] Education about the safety and benefit of vaccination is also important.[7] Webinars would be useful in efforts to educate the general public. Within the hospital setting, vaccination teams comprising obstetricians and midwives could allay concerns and dispel myths about vaccination among working staff at all levels; this approach could provide useful information for pregnant and breastfeeding women. There is also a need to combat physician hesitancy in recommending COVID-19 vaccination for pregnant women.[26] To address this need, the HKCOG revised its recommendations on 3 March 2022 to indicate that women who are planning to become pregnant, are pregnant, or are breastfeeding should undergo COVID-19 vaccination along with the general population.[12] A corresponding educational video to promote COVID-19 vaccination was made available on 5 March 2022.[12]

Possible interventions to promote vaccination in Hong Kong include the provision of vaccines at convenient venues and the involvement of healthcare professionals in information dissemination.[27] During the fifth wave of COVID-19, pregnant women were proactively asked to consider COVID-19 vaccination when they attended obstetric clinics. Leaflets were distributed with information about the HKCOG recommendations, as well as community vaccination sites. The establishment of a pathway specifically for pregnant women, which reduced their waiting time in vaccine clinics, also helped to increase the vaccination rate. Moreover, vaccination was provided to women in the maternity wards of some hospitals and women attending antenatal clinics in Maternal and Child Health Centres. All of these measures helped reduce vaccine hesitancy in pregnant women.[28]

In Hong Kong, a pertussis vaccination programme for pregnant women was launched on 2 July 2020.[29] The programme was incorporated into antenatal care, such that all pregnant women received counselling concerning the rationale for vaccination; the vaccine was administered during obstetric follow-up. To facilitate vaccine availability in our hospital, all women were asked to indicate their preference concerning pertussis vaccination during the first antenatal visit. It may be useful to incorporate COVID-19 vaccination into the maternal immunisation programme.

Strengths

This study had some notable strengths. The results of the present large cohort study provide clinicians and policymakers with key insights concerning the COVID-19 vaccination rate among pregnant women in Hong Kong. The study period was designed to include both antenatal and postnatal periods for a better understanding of vaccination behaviour among women in each period. A real-time collection method was adopted to capture COVID-19 vaccination records from the Clinical Management System, thereby ensuring data reliability.

Limitations

Nevertheless, this study had some limitations. A small number of women who underwent COVID-19 vaccination outside Hong Kong were not automatically identified in the system; however, they were included in the cohort if their vaccination history had been documented in antenatal records. Because rapid antigen self-tests were acceptable for diagnosis in

Hong Kong beginning on 26 February 2022, the number of recorded COVID-19 cases in our cohort might have been lower than the actual number of cases if patients did not report positive COVID-19 test results to our department. Finally, this study did not explore whether the generally more cautious approach of pregnant women, in terms of avoiding all types of diseases, might contribute to a lower disease rate compared with the general public.

Conclusion

The rate of COVID-19 vaccination was low among pregnant and postnatal women in Hong Kong in early 2022. Pregnant women had a high risk of disease transmission because many of them had not received the third dose of COVID-19 vaccine. Urgent measures are needed to promote vaccination among pregnant women before future waves of COVID-19. In particular, women should receive information concerning vaccine safety to avoid unnecessary delays related to pregnancy.

Author contributions

Concept or design: PW Hui, DTY Chan.
Acquisition of data: All authors.
Analysis or interpretation of data: PW Hui.
Drafting of the manuscript: PW Hui, LM Yeung, JKY Ko, THT Lai, MTY Seto.
Critical revision of the manuscript for important intellectual content: All authors.

All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have disclosed no conflicts of interest.

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Declaration

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Ethics approval

Ethics approval was obtained from the Institutional Review Board of The University of Hong Kong/Hospital Authority Hong Kong West Cluster (Ref No.: UW 22-205). Informed patient consent has been waived by the Board due to the retrospective nature of the research.

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