Pregnancy and risk of COVID-19: a Norwegian registry-linkage study

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Abstract

Objective: To compare the risk of acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and contact with specialist health-care services for coronavirus disease 2019 (COVID-19) between pregnant and non-pregnant women.

Population or sample: All women ages 15 to 45 living in Norway on March 1st, 2020 (N=1,033,699).

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Methods: We linked information from the national birth, patient, communicable diseases, and education databases using unique national identifiers.
Main outcome measure: We estimated hazard ratios (HR) among pregnant compared to non-pregnant women of having a positive test for SARS-CoV-2, a diagnosis of COVID-19 in specialist healthcare, or hospitalization with COVID-19 using Cox regression. Multivariable analyses adjusted for age, marital status, education, income, country of birth and underlying medical conditions.
Results: Pregnant women were not more likely to be tested for or to a have a positive SARS-CoV-2 test (adjusted HR, 0.99; 95% confidence interval [CI]: 0.92-1.07). Pregnant women had higher risk of hospitalization with COVID-19 (HR, 4.70; 95% CI: 3.51- 6.30), and any type of specialist care for COVID-19 (HR, 3.46; 95% CI: 2.89-4.14). Pregnant women born outside Scandinavia were less likely to be tested, and at higher risk of a positive test (HR, 2.37; 95% CI: 2.51-8.87). Compared to pregnant Scandinavian born women, pregnant women with minority background had a higher risk of hospitalization with COVID-19 (HR, 4.72; 95% CI: 2.51-8.87).
Conclusion: Pregnant women were not more likely to be infected with SARS-CoV-2. Still, pregnant women with COVID-19, especially those born outside of Scandinavia, were more likely to be hospitalized.
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Keywords: pregnancy; COVID-19; SARS-CoV-2.

Tweetable abstract: Pregnant women are at increased risk of hospitalization for COVID-19.

Introduction

It is unclear if pregnant women have an increased risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, but emerging evidence suggest that pregnant women may have a higher risk of severe coronavirus disease 2019 (COVID-19) if infected.[1-4] However, the evidence is not consistent.[5] Most existing studies were from single centers or on hospitalized women with COVID-19, and investigated whether pregnancy increased the risk of severe disease, admission to intensive-care units, mechanical ventilation, and death.[6, 7] Population-based estimates comparing pregnant women compared to non-pregnant women are lacking.

The aim of this study was to compare the risk of acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and contact with specialist health-care services for coronavirus disease 2019 (COVID-19) between pregnant and non-pregnant women. We used data from national health-registries on all women in Norway between 15 and 45 years of age. Notably, Norway has not conducted universal testing of pregnant or delivering women.

Methods

Study population and data sources

We followed all women between 15 and 45 years of age registered in the Norwegian National Population Registry on March 1st, 2020 (n= 1,033,699), until February 28th, 2021. Information on pregnancies and antenatal care visits was obtained from the birth registry, the patient registry (covering specialist/secondary healthcare services), and the general practitioner database (covering general practitioners/primary healthcare services).[8] Information on SARS-CoV-2 tests was provided from the Norwegian Surveillance System for Communicable Diseases, while contacts with specialist healthcare services for suspected and confirmed COVID-19 were obtained from the patient registry. Information on education (highest level attained as of 2019) and household income (in 2018) was from Statistics Norway. Data was linked by using unique personal identification numbers. Data from all registries was provided by the Emergency Preparedness Register for COVID-19 at the Norwegian Institute of Public Health.[9] More information on data sources is available in the supplement. Norwegian legislation does not require consent from individuals to conduct research using the national health registries. Ethical approval was obtained for this study from the Regional Committee of Medical and Health Research Ethics of South/East Norway (reference number 141135).

Definition of completed pregnancies

The birth registry provided data on live births, stillbirths, fetal losses and induced abortions after 12 gestational weeks. Registrations of miscarriages and induced abortions occurring before 12 gestational weeks were obtained from the patient registry and the general practitioner database, as previously described.[10] The diagnostic codes used to define miscarriage and induced abortion are in Table S1. These early miscarriages and induced abortions do not have registrations on gestational length of the pregnancy. Based on the mean gestational length for all induced abortions in Norway in the anonymous abortion registry, and the gestational age distribution of miscarriages from the literature,[11] we assigned these pregnancies a gestational duration of 8 weeks, and in sensitivity analyses a gestational duration of 6 weeks or 10 weeks.

Definition of ongoing pregnancies

We identified ongoing pregnancies using codes for antenatal care visits in the general practitioner database and the patient registry (see Table S2). These antenatal codes capture virtually all pregnancies that eventually will be recorded in the birth registry, as 99.5% of pregnancies in the birth registry had at least one registration of these codes during pregnancy. For a pregnancy to be defined as "ongoing" at the end of the study period, we excluded registrations occurring within the duration of a completed pregnancy. Second, we required that registrations of the antenatal codes were at least 90 days after a completed pregnancy to be counted as a new/currently ongoing pregnancy. Antenatal codes are not registered with a gestational length. Based on the distribution of the first registration of an antenatal code for the already completed pregnancies in the birth registry (Figure S1), we defined the start date of ongoing pregnancies to be 5 weeks (35 days) before the first antenatal consultation, assuming that very few women have an antenatal visit before 5 weeks of pregnancy. In additional analyses we assigned these pregnancies to start 10 weeks before the first visit.

COVID-19

We defined COVID-19 in three ways: 1) a positive test for SARS-CoV-2, 2) any diagnosis of COVID-19 in specialist healthcare, and 3) hospitalization with confirmed COVID-19. Two new ICD-10 codes were implemented at the start of the pandemic: U07.1 "COVID-19 with confirmed virus"; and U07.2 "COVID-19 without confirmed virus". Notably, registration of confirmed COVID-19 (U07.1) requires a positive test for SARS-CoV-2. We used both codes to define specialist diagnosed COVID-19. We assumed that these women had symptoms of COVID-19 which warranted contact with specialist health-care services. We further analyzed hospitalization for confirmed COVID-19 (U07.1) separately.

Pre-existing chronic conditions

We obtained information on a wide range of pre-existing chronic condition defined as risk factors for severe COVID-19.[12] The diagnostic codes we used to define these conditions are shown in Table S3. We required at least two registrations from January 2017 until end of follow-up to qualify as an existing underlying condition.

Statistical analysis

We used Cox proportional hazards models on calendar time to examine separately whether pregnant women had an increased risk of 1) a positive test; 2) a specialist care diagnosis of COVID-19; and 3) hospitalization with confirmed COVID-19. Women were followed from March 1st, 2020, until the event of interest; emigration, death, or reaching February 28th, 2021 without an event was treated as censoring. Pregnancy status was a time-varying exposure, allowing women to contribute both pregnant and non-pregnant follow-up time. We used robust cluster variance estimation with the woman's identification number as the cluster variable. We estimated unadjusted associations, and associations with adjustment for marital status (single, married/cohabitating, or other), educational level (elementary school, high-school, vocational, up to 4 years of higher education, and more than 4 years of higher education), household income (categorized into tertiles), country of birth (Scandinavian countries (Norway, Sweden and Denmark) or non-Scandinavian countries), and chronic conditions. We first analyzed the entire follow-up period, and subsequently analyzed the two main waves of the pandemic in Norway separately (March 1st to June 30th ,2020, and July 1st 2020 to February 28th 2021).[13] We also evaluated if associations differed with pregnancy trimester (1st trimester: ≤83 days; 2nd trimester: 84-195; and 3rd trimester: ≥196 days). As a higher risk of COVID-19 has been reported among non-Scandinavian ethnic groups in Norway,[14] we also examined the risk of COVID-19 separately for Scandinavian and non-Scandinavian born women.

It could be that pregnant women were tested more often, and that milder COVID-19 therefore was detected more often among pregnant women resulting in higher estimates of COVID-19 among pregnant women. We examined whether pregnant women were tested more often than non-pregnant women. Women could have multiple tests during follow-up. We used the Andersen and Gill recurrent events Cox model,[15] where women continued to be a part of the risk set until emigration, death or end of follow-up. To evaluate whether testing in relation to admission to hospital for delivery or miscarriage/abortion was driving the associations, we performed sub-analyses where we excluded tests conducted within three days before or after a

pregnancy ended, and in addition hospitalizations where the end of pregnancy was within a hospital stay for COVID-19. All analyses were conducted in Stata version 16 (Statacorp, Texas).

Patient and public involvement

No patients were involved directly in the design of the study, recruitment, or conduct of the study because our cohort consisted of normal individuals from the population at large (not patients).

Results

Of the 1,033,699 women included in the study, 101,820 (10%) had been pregnant during the follow-up time. There were 35,915 (4%) who were still pregnant at the end of follow-up (ongoing pregnancies). There was a slightly higher proportion of women born outside of Scandinavia among the pregnant women than among non-pregnant women (Table 1). Fewer pregnant women had chronic underlying risk conditions (Table 1).

Risk of a positive SARS-CoV-2 test

The overall rate of a positive SARS-CoV-2 test among women aged 15-45 years was 5 per 100,000 person-days. The risk of a positive test was similar for pregnant women and non-pregnant women; adjusted HR, 0.99; 95% CI: 0.92-1.07, with similar HRs across all trimesters (Table 2). The estimate was similar for the two waves of the pandemic (first wave, adjusted HR 0.94; 95% CI: 0.76-1.17, and second wave, adjusted HR, 1.00; 95% CI: 0.92-1.08; Table 2). Results were also similar after excluding women with positive tests within three days around the end of pregnancy (Table S4). Women born outside of Scandinavia had an increased risk of a positive test compared to Scandinavian women in general, and even higher risk when pregnant; adjusted HR, 2.37; 95% CI: 1.98-2.84, when compared to Scandinavian pregnant women (Table S5).

Risk of specialist-care diagnosis and hospitalization

The overall rate of a specialist healthcare diagnosis of COVID-19 was 0.3 per 100,000 person days, while the rate of being hospitalized with confirmed COVID-19 was 0.1 per 100,000 person days. Pregnant women had an increased risk of a specialist care diagnosis of COVID-19 (adjusted HR, 3.46; 95% CI: 2.89-4.14), which was similar in both waves of the pandemic (Table 3). The risk appeared to be highest in the third trimester but was attenuated when we excluded pregnancies ending within the same hospital stay as for COVID-19 (Table 3). The increased risk of contact with specialist healthcare services for COVID-19 while pregnant were higher in non-Scandinavian pregnant women (adjusted HR, 7.50; 95% CI: 5.76-9.77), and Scandinavian pregnant women (adjusted HR, 2.66; 95% CI: 2.09-3.39), when compared to Scandinavian women who were not pregnant (Table S6).

Pregnant women had a substantially higher risk of being hospitalized for confirmed COVID-19, adjusted HR, 4.70; 95% CI: 3.51-6.30, in both waves of the pandemic (Table 4). The greatest risk was seen in the third trimester, though the trimester-specific differences were attenuated when we excluded pregnancies ending within the same hospital stay where COVID-19 was diagnosed. Among COVID-19 hospitalized women, the proportion who also had diagnoses of lower respiratory illness (ICD-10 codes J12-J22, J80, J96) was 32% in pregnant and 49% in non-pregnant women. The median number of days in hospital was 2 for pregnant (mean 3.3 days) and 2 for non-pregnant women (mean 3.7 days).

Both being pregnant and being non-Scandinavian increased the risk of hospitalization with confirmed COVID-19, and pregnant non-Scandinavian women were at highest risk of hospitalization with COVID-19 (Table S7).

Likelihood of being tested for SARS-CoV-2

The SARS-CoV-2 testing rate was 310 tests per 100,000 person days. Overall, pregnant women were slightly less likely to be tested for SARS-CoV-2, adjusted HR, 0.90; 95% CI: 0.88-0.91 (Table S8). The rate of testing in pregnant compared to non-pregnant women has been similar or lower after the initial pandemic months (Figure S2). Lowest test rates among pregnant women were seen during third trimester (Table S8). Non-Scandinavian women had lower probability of testing, especially when pregnant, adjusted HR, 0.72; 95% CI: 0.70-0.74, compared to non-pregnant Scandinavian women (Table S9).

In additional analyses we reassigned the gestational duration of pregnancies ending in miscarriages and induced abortions to be 6 and 10 weeks, and ongoing pregnancies to start 10 weeks prior to first antenatal visit instead of 5 weeks; the results were very similar to the main analyses.

Discussion

Main findings

We found no overall increased risk of a positive SARS-CoV-2 test among pregnant women compared to non-pregnant women. However, pregnant women were at a substantially increased risk of receiving specialist healthcare and also hospitalization. Women born outside of Scandinavia were less likely to be tested, and at a particularly higher risk of being hospitalized for COVID-19 when pregnant compared to Scandinavian born women.

Strengths and limitations

This study is unique in its size as it included all women of reproductive age in Norway, with the ability to compare the pregnant with the non-pregnant population of similar age. We were also able to examine whether differences in testing behavior were likely to influence results, which was not found to be the case.

A limitation of registry studies is that health definitions rely on registrations from contact with healthcare. Norway has not conducted universal testing of pregnant or delivering women. Testing was therefore by indication on either having symptoms of COVID-19, due to workplace testing or having been exposed to someone who has tested positive for SARS-CoV-2. Asymptomatic individuals, or those with very mild symptoms, were unlikely to get tested. Test capacity for SARS-CoV-2 and healthcare availability for those with milder COVID-19 symptoms have also varied through the pandemic. In the initial phase, testing was limited, and testing for Covid-19 was prioritized to those with severe symptoms or underlying risk conditions. Our results indicated that pregnant women were slightly more likely to be tested in the initial phase than non-pregnant women, but after the initial months when testing capacity increased, pregnant women were slightly less likely to be tested. Still, results stratified according to the two main waves of the pandemic in Norway yielded similar estimates, supporting that test availability was unlikely to explain our findings. The association with being tested while pregnant may not be generalizable to other countries with different testing strategies. We were not able to evaluate

256 other measures of severity such admission to intensive-care unit due to small numbers (15
257 events in the age group of interest).
258
259 Identifying ongoing pregnancies and early terminations through healthcare contacts is also prone
260 to misclassification. Towards the end of the follow up period we were less likely to capture
261 ongoing pregnancies that will end in miscarriage or induced abortions. Only 44.2% of
262 miscarriages and induced abortions had a prior antenatal code. This could have resulted in
263 underestimation of the number of pregnant women and attenuation of associations. Since
264 antenatal visits are without information on gestational length information, we defined pregnancy
265 start date and durations for ongoing pregnancies and early abortions based on known
266 distributions. We chose a strict approach in the main analyses to minimize misclassification of
267 "non pregnant" days as "pregnant", which likely resulted in some true "pregnant" days counted
268 as "non-pregnant" days. However, several sensitivity analyses with other assumptions of
269 gestational lengths for these pregnancies yielded very similar results, indicating little impact on
270 associations. Another limitation was that we could not adjust for some potential confounding
271 factors, such as crowded living conditions, body-mass index or smoking. We were not able to
272 look at other measures of severity such as admission to intensive-care unit due to small numbers.
273 Even though we were able to study all women of reproductive age in Norway, our findings might
274 not be generalizable outside of Scandinavia or other European countries with universal health-
275 care coverage.
276
277 *Interpretation*
278 Women born outside of Scandinavia were less likely to be tested, and at a particularly higher risk
279 of being hospitalized for COVID-19 when pregnant compared to Scandinavian born women. An
280 increased risk of COVID-19 among ethnic minorities has been reported in several countries,[16, 17]
281 including Norway.[13] This has been attributed to crowded households and more service related
282 professions with personal contact. We observed a less testing among both pregnant and non-
283 pregnant women born outside of Scandinavia. A higher threshold for testing may have resulted
284 in more severe illness before seeking healthcare, which is supported by our findings of increased

risk of specialist care and hospitalizations than Scandinavian born women. Routine testing of minority women in connection with antenatal care could reduce these differences.

In line with some previous studies,[1, 4, 6] although not all,[5] our results support that pregnant women may experience more severe symptoms as part of COVID-19, however, our results may also reflect a lower threshold for hospitalization of pregnant women with COVID-19 than non-pregnant women. In our study, we could only look at hospitalization as a marker of severity. Notably, prior studies did not compare pregnant and non-pregnant women in the general population. Among hospitalized women, others have found that pregnant women have an increased risk of intensive care and death when compared to non-pregnant women.[1, 6] A recent meta-analysis of 123,176 non-pregnant and 10,000 pregnant women reported a higher case-fatality rate in pregnant women.[7] As pregnant women may be more likely to be admitted to hospitals than non-pregnant women with similar symptoms, restricting studies to women hospitalized with COVID-19 may complicate interpretation of results. We found a higher risk of hospitalization when pregnant, but a similar duration of the hospital stays and slightly lower proportion with co-registrations of lower respiratory illness, compared to non-pregnant women. This may suggest that, in Norway, when hospitalized, there is no substantial difference in severity of disease in pregnant women, although more detailed data is needed to address this.

Even though several studies conclude that pregnant women are at higher risk of severe COVID-19,[2] and of adverse pregnancy outcomes in women with COVID-19,[6, 18] vaccination of pregnant women against COVID-19 is currently debated.[19-22] COVID-19 vaccines have not been tested in pregnant women, and pregnant women are in general not recommended vaccination but to be evaluated on an individual basis.[23, 24] We found that pregnant women were not at higher risk of SARS-CoV2 infection per se, however, our results support the current evidence that there may be an increased risk of hospitalization when infected during pregnancy. Protecting pregnant women against COVID-19 is therefore important, and there is an urgent need to address vaccine safety in pregnancy.

Conclusions

In this large nationwide registry study, pregnant women were not at higher risk of SARS-CoV-2 infection, but pregnancy increased the risk of receiving specialist care and hospitalization for COVID-19 compared to non-pregnant women of the same age. Pregnant women born outside of Scandinavia were of a particular increased risk, and increased surveillance in this group is warranted. The increased risk of hospitalization for COVID-19 support the need for vaccination of pregnant women.

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Data availability statement: Data are available by applying the Norwegian registry owners: https://helsedata.no/soknadsveiledning/. The data are not publicly available due to privacy and ethical restrictions.

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Legends

Table 1. Distribution of characteristics among 1,033,699 ages 15 to 45 in Norway who were pregnant between March 1st, 2020 and February 28th, 2021.

Table 2. Hazard ratio of a positive SARS-CoV-2 test during pregnancy among 1,033,698 women in Norway between 15 and 45 years of age.

Table 3. Hazard ratio of a COVID-19 diagnosis in specialist healthcare services for pregnant women among 1,033,696 women between 15 and 45 years of age in Norway.

Table 4. Hazard Ratio of Hospitalization (Event) with Confirmed COVID-19 for Pregnant Women among 1,033,699 Women Between 15 and 45 Years of Age.

427 **Table 1. Distribution of characteristics among 1,033,699 ages 15 to 45 in Norway who were**
428 **pregnant between March 1st, 2020 and February 28th, 2021.**

Characteristics	Women who were pregnant (n=102,820)	Women who were not pregnant (n=930,879)
Age at start of follow-up, mean (SD)	30.8 (5.1)	30.2 (8.8)
Country of birth, no. (%)		
Norway	73,936 (71.9)	705,553 (75.8)
Another Scandinavian country	2,026 (2.0)	14,186 (1.5)
Outside of Scandinavia	26,528 (25.8)	208,193 (22.4)
Unknown	330 (0.3)	2,947 (0.3)
Marital status, no. (%)		
Single	59,163 (57.5)	636,473 (68.4)
Married/registered partner	39,520 (38.4)	241,090 (25.9)
Other	4,137 (4.0)	53,316 (5.7)
Educational level, no. (%)		
Elementary school	16,243 (15.8)	221,684 (23.8)
Highschool	19,416 (18.9)	230,053 (24.7)
Vocational	1,566 (1.5)	13,955 (1.5)
Up to 4 years of university	37,289 (36.3)	272,101 (29.2)
More than 4 years of university	20,049 (19.5)	102,543 (11.0)

Unknown	8,257 (8.0)	90,543 (9.7)
Household income, no. (%)		
1st tertile (≤ 500,730 NOK)	30,241 (29.4)	304,914 (32.8)
2nd tertile (500,731 to 846,668 NOK)	41,219 (40.1)	293,937 (31.6)
3rd tertile (> 846,668 NOK)	28,081 (27.3)	307,073 (33.0)
Unknown	3,279 (3.2)	24,955 (2.7)
Chronic conditions, no. (%)		
Diabetes	1,203 (1.2)	10,365 (1.1)
Cerebrovascular disease	104 (0.1)	1,339 (0.1)
Other chronic cardiovascular disorders	823 (0.8)	6,783 (0.7)
Immune deficiency	37 (0.04)	453 (0.05)
Reduced immune function due to medications	1,566 (1.5)	14,713 (1.6)
Chronic lung disease	3,505 (3.4)	36,953 (4.0)
Neurological disorders	93 (0.1)	2,263 (0.2)
Kidney failure	27 (0.03)	507 (0.05)
Organ transplant	21 (0.02)	628 (0.07)
Hematological cancer	95 (0.1)	1,036 (0.1)
Other types of cancer	94 (0.1)	2,405 (0.3)

429

Table 2. Hazard ratio of a positive SARS-CoV-2 test during pregnancy among 1,033,698[*] women in Norway between 15 and 45 years of age.

Follow-up period	Pregnancy status	Follow-up time in days	No. of positive tests	Hazard Ratio (95% CI)	
				Unadjusted	Adjusted[†]
Complete follow-up[‡]	Non-pregnant	356,383,248	16,364	1.00	1.00
	Pregnant	15,481,516	708	0.98 (0.91-1.05)	0.99 (0.92-1.07)
	1st trimester	5,454,096	256	0.97 (0.86-1.10)	0.98 (0.87-1.11)
	2nd trimester	5,787,833	271	0.99 (0.88-1.12)	1.01 (0.90-1.14)
	3rd trimester	4,239,587	181	0.96 (0.83-1.11)	0.97 (0.84-1.13)
Wave 1[§]	Non-pregnant	119,435,417	1977	1.00	1.00
	Pregnant	5,198,569	87	1.01 (0.82-1.26)	0.94 (0.76-1.17)
	1st trimester	1,746,753	24	0.87 (0.58-1.30)	0.81 (0.54-1.21)
	2nd trimester	1,941,362	35	1.05 (0.75-1.46)	0.97 (0.69-1.36)
	3rd trimester	1,510,454	28	1.13 (0.78-1.65)	1.05 (0.72-1.53)
Wave 2[‖]	Non-pregnant	236,947,831	14,387	1.00	1.00
	Pregnant	10,282,947	621	0.97 (0.90-1.05)	1.00 (0.92-1.08)

1st trimester	3,707,343	232	0.98 (0.86-1.12)	1.01 (0.88-1.15)
2nd trimester	3,846,471	236	0.99 (0.87-1.12)	1.02 (0.90-1.16)
3rd trimester	2,729,133	153	0.93 (0.79-1.09)	0.96 (0.82-1.12)

*Excluded one person that tested positive before March 1st, 2020.

†Adjusted for age as a linear and squared term, country of birth, marital status, education, household income, diabetes, cerebrovascular disease, other cardiovascular disorders, immune-deficiency, chronic lung disease, reduced immune function, neurological disorders, kidney failure, organ transplant, hematological cancer, and other types of cancer.

‡March 1st, 2020 to February 28th, 2021

§March 1st, 2020 to June 30th, 2020

||July 1st, 2020 to February 28th, 2021

Table 3. Hazard ratio of a COVID-19 diagnosis in specialist healthcare services for pregnant women among 1,033,696[*] women between 15 and 45 years of age in Norway.

Follow-up period	Pregnancy status	Follow-up time in days	All events			Excluding events where the end of pregnancy occurred within the hospital stay for COVID-19	
			No. of events	Hazard Ratio (95% CI)		No. of events	Hazard Ratio (95% CI)
				Unadjusted	Adjusted[†]		Adjusted [†]
Complete follow-up[‡]	Non-pregnant	358,063,481	900	1.00	1.00	900	1.00
	Pregnant	15,549,308	144	3.66 (3.07-4.36)	3.46 (2.89-4.14)	87	2.11 (1.68-2.64)
	1st trimester	5,479,349	36	2.63 (1.89-3.68)	2.48 (1.77-3.47)	24	1.67 (1.11-2.51)
	2nd trimester	5,813,675	28	1.86 (1.28-2.71)	1.76 (1.20-2.57)	27	1.71 (1.16-2.51)
	3rd trimester	4,256,284	80	7.53 (6.00-9.47)	7.16 (5.68-9.01)	36	3.25 (2.33-4.54)
Wave 1[§]	Non-pregnant	119,573,874	291	1.00	1.00	291	1.00
	Pregnant	5,203,614	50	3.96 (2.93-5.34)	3.32 (2.42-4.54)	29	1.91 (1.29-2.82)
	1st trimester	1,748,663	12	2.93 (1.65-5.21)	2.49 (1.39-4.46)	7	1.44 (0.68-3.07)
	2nd trimester	1,943,283	7	1.43 (0.68-3.03)	1.20 (0.56-2.55)	7	1.19 (0.56-2.52)

	3rd trimester	1,511,668	31	8.50 (5.87-12.30)	7.06 (4.81-10.35)	15	3.38 (1.99-5.72)
Wave 2[‖]	Non-pregnant	238,489,607	609	1.00	1.00	609	1.00
	Pregnant	10,345,694	94	3.52 (2.83-4.37)	3.53 (2.83-4.40)	58	2.21 (1.69-2.91)
	1st trimester	3,730,686	24	2.51 (1.67-3.77)	2.50 (1.65-3.78)	17	1.80 (1.11-2.92)
	2nd trimester	3,870,392	21	2.06 (1.34-3.19)	2.08 (1.34-3.23)	20	2.01 (1.28-3.15)
	3rd trimester	2,744,616	49	7.03 (5.26-9.41)	7.09 (5.30-9.47)	21	3.09 (2.00-4.76)

*Excluded three people in contact with specialist healthcare services for suspected or confirmed COVID-19 disease before March 1st, 2020.

†Adjusted for age as a linear and squared term, country of birth, marital status, education, household income, diabetes, cerebrovascular disease, other cardiovascular disorders, immune-deficiency, chronic lung disease, reduced immune function, neurological disorders, kidney failure, organ transplant, hematological cancer, and other types of cancer.

‡March 1st, 2020 to February 28th, 2021

§March 1st, 2020 to June 30th, 2020

‖ July 1st, 2020 to February 28th, 2021

Table 4. Hazard Ratio of Hospitalization (Event) with Confirmed COVID-19 for Pregnant Women among 1,033,699 Women Between 15 and 45 Years of Age.

Follow-up period	Pregnancy status	Follow-up time in days	All Events			Excluding events where the end of pregnancy occurred within the hospital stay for COVID-19	
			No. of events	Hazard Ratio (95% CI)		No. of events	Hazard Ratio (95% CI)
				Unadjusted	Adjusted *		Adjusted *
Complete follow-up†	Non-pregnant	358,173,181	289	1.00	1.00	289	1.00
	Pregnant	15,559,886	53	4.19 (3.12-5.61)	4.70 (3.51-6.30)	24	2.21 (1.45-3.37)
	1st trimester	5,482,901	8	1.81 (0.89-3.66)	2.00 (0.99-4.06)	6	1.55 (0.69-3.49)
	2nd trimester	5,817,698	11	2.27 (1.25-4.15)	2.58 (1.41-4.72)	10	2.44 (1.30-4.59)
	3rd trimester	4,259,287	34	10.01 (7.01-14.27)	11.37 (7.97-16.21)	8	2.78 (1.37-5.65)
Wave 1‡	Non-pregnant	119,591,018	88	1.00	1.00	88	1.00
	Pregnant	5,205,118	15	3.93 (2.27-6.80)	4.17 (2.37-7.31)	6	1.70 (0.73-3.97)
Wave 2§	Non-pregnant	238,582,163	201	1.00	1.00	201	1.00

Pregnant	10,354,768	38	4.30 (3.04-6.08)	4.96 (3.52-6.98)	18	2.45 (1.51-3.98)

*Adjusted for age as a linear and squared term, country of birth, marital status, education, household income, diabetes, cerebrovascular disease, other cardiovascular disorders, immune-deficiency, chronic lung disease, reduced immune function, neurological disorders, kidney failure, organ transplant, hematological cancer, and other types of cancer.

†March 1st, 2020 to February 28th, 2021

‡March 1st, 2020 to June 30th, 2020

§July 1st, 2020 to February 28th, 2021