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Characteristics and Factors Associated with SARS-CoV-2 Positivity Among Hospitalized Pregnant and Postpartum Women with Acute Respiratory Febrile Illness in Suzhou, China, 2020–2024

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Abstract

Background/Objectives: To describe SARS-CoV-2 positivity, temporal patterns, and associated factors among pregnant and postpartum women hospitalized with acute respiratory infection or febrile illness (ARFI) in Suzhou, China. Methods: Women who met the ARFI case definition between 2020 and 2024 were included and tested for SARS-CoV-2. Epidemiological and clinical characteristics, disease severity, and outcomes were compared between SARS-CoV-2-positive and non-SARS-CoV-2 ARFI cases. Multivariable logistic regression was used to identify factors associated with SARS-CoV-2 positivity. Results: Among 4219 pregnant and postpartum women hospitalized with ARFI and enrolled in surveillance, 512 (12.1%) tested positive for SARS-CoV-2. After excluding six women with influenza coinfection, the analytic cohort included 512 women who tested positive and 3701 who tested negative. SARS-CoV-2 positivity peaked in December 2022, May–June 2023, and July–August 2024. Among women admitted from December 2022 through December 2024, gestational diabetes mellitus was associated with higher odds of SARS-CoV-2 positivity after adjustment for admission year, vaccination status before admission, and other covariates (aOR 2.21, 95% CI 1.57–3.10). Conclusions: Among pregnant and postpartum women hospitalized with ARFI, gestational diabetes mellitus (GDM) was associated with higher odds of SARS-CoV-2 positivity. These findings support continued active surveillance for respiratory viral infections in this population during the post-emergency phase, with particular attention to women with GDM.

Keywords: pregnancy; postpartum period; SARS-CoV-2; COVID-19; acute respiratory infection; epidemiology

Academic Editor: Omar Cauli

Received: 14 October 2026
Revised: 14 November 2026
Accepted: 17 November 2026
Published: 18 November 2026

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1. Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and is characterized primarily by respiratory manifestations. Since it was first identified in late 2019, COVID-19 has spread

rapidly and developed into a global public health emergency. During sustained transmission, SARS-CoV-2 has continued to evolve. Owing to their enhanced transmissibility and immune-evasive capacity, the Omicron variant and its sublineages gradually became the predominant variants worldwide [1–3]. On 7 December 2022, China issued the "Ten New Measures," marking a major adjustment in its national COVID-19 control strategy, after which routine mass nucleic acid testing was gradually phased out [4]. Against this background, the accumulation of a large susceptible population contributed to rapid community transmission. Pregnant and postpartum women may have experienced increased opportunities for exposure because of their specific physiological status and frequent contact with healthcare services [5,6].

Pregnant and postpartum women constitute a priority population for the prevention and control of respiratory infectious diseases. Pregnancy is accompanied by adaptive changes in the immune, respiratory, and cardiovascular systems, including alterations in cell-mediated immunity, reductions in lung volume secondary to diaphragmatic elevation, and increases in circulating blood volume and cardiovascular workload. These physiological changes may modify host responses to respiratory pathogens [7]. Consequently, acute respiratory infections during pregnancy may be associated with a greater likelihood of severe illness and adverse maternal and neonatal outcomes [8–10]. Previous studies have associated SARS-CoV-2 infection during pregnancy with pregnancy complications, severe disease, and maternal mortality [11–13], although the overall clinical severity and case-fatality rate of COVID-19 have declined relative to the early stages of the pandemic [14]. Nevertheless, immunity acquired through previous infection or vaccination may wane over time, and breakthrough and repeat infections continue to occur [15]. Continued surveillance is therefore warranted to further characterize the epidemiological patterns, clinical manifestations, and associated factors of SARS-CoV-2 infection among pregnant and postpartum women. Such evidence may help identify subgroups requiring closer clinical attention and inform health education, vaccination strategies, and healthcare resource allocation.

As COVID-19 control has shifted toward routine management and recurrent community transmission, patterns of exposure, healthcare-seeking behavior, viral circulation, and clinical management among pregnant and postpartum women may also have changed. Continuous case ascertainment through active surveillance can help characterize the epidemiological and clinical profiles of SARS-CoV-2 infection in hospitalized pregnant and postpartum women. Using a previously established active surveillance system for hospitalizations due to acute respiratory infection or febrile illness (ARFI) among pregnant and postpartum women, we analyzed surveillance data collected in Suzhou between 1 January 2020 and 31 December 2024. This study aimed to characterize SARS-CoV-2 positivity among pregnant and postpartum women hospitalized with ARFI, including their demographic and obstetric characteristics, underlying conditions, temporal patterns, clinical manifestations, disease severity, and antiviral treatment, and to identify factors associated with SARS-CoV-2 positivity within this hospitalized ARFI population.

2. Materials and Methods

2.1. Data Sources and Specimen Collection

Data for this study were obtained from the population-based active surveillance system for hospitalizations due to acute respiratory infection or febrile illness among pregnant and postpartum women, which was established under the leadership of the Suzhou Center for Disease Control and Prevention (Suzhou CDC). During its initial phase, the surveillance system primarily collected information on influenza-associated

hospitalizations among pregnant and postpartum women. SARS-CoV-2 testing was incorporated into the surveillance system in 2020.

The surveillance system was linked to the regional health information platform or the hospital information systems of participating healthcare institutions. It covered all healthcare institutions in Suzhou that provided inpatient care for respiratory infections among pregnant and postpartum women. Hospitalization records uploaded daily were screened in real time for either a qualifying admission diagnostic code based on the International Classification of Diseases, 10th Revision (ICD-10), or a temperature meeting the fever threshold within 48 h after admission. The range of ICD-10 codes used for screening was prespecified by an expert panel during the preparatory phase of the surveillance program. All included codes represented symptoms or potential complications related to acute respiratory infections; the complete list of surveillance codes is provided in Appendix A Table A1. The temperature threshold for fever screening was ≥37.3 °C, and screening was restricted to female patients aged 20–49 years.

For patients with acute respiratory infection or febrile illness (ARFI) who met the initial screening criteria, the treating physician assessed pregnancy and postpartum status. Patients who were pregnant or within 2 weeks postpartum were considered eligible for surveillance. All hospitalized pregnant and postpartum patients who met the surveillance case definition were enrolled in the study after providing written informed consent.

Face-to-face interviews were conducted by physicians or nurses at the admitting hospital using a standardized questionnaire. Nasopharyngeal swabs and serum samples were collected within 24 h of enrollment. All specimens were transported within 24 h after collection to the National Influenza Surveillance Network Laboratory at the Suzhou CDC for testing, while the completed questionnaires were submitted to the study team for data entry. Specimens were maintained under refrigerated cold-chain conditions during storage and transportation, in accordance with applicable biosafety requirements for biological specimens. Within 24 h after receipt of the respiratory specimens, the laboratory performed reverse-transcription polymerase chain reaction (RT-PCR) testing for SARS-CoV-2 and influenza viruses.

The study team comprised professionals from disease control and prevention agencies, healthcare institutions, and maternal and child health institutions. Before initiation of the surveillance program, all investigators received standardized training covering study procedures, operational requirements, and relevant precautions. Only personnel who passed the competency assessment were permitted to participate in study activities. Standardized forms were used for specimen collection. During data management and analysis, data were independently entered by two staff members and cross-checked to ensure accuracy. Chest radiography was the principal imaging modality used to diagnose pneumonia.

2.2. Study Population and Case Definitions

Acute respiratory infection or febrile illness (ARFI) was used as the operational framework for identifying potentially eligible hospitalized patients. Acute respiratory infection (ARI) was defined as an acute respiratory illness caused by various pathogens and characterized primarily by symptoms such as cough, sputum production, shortness of breath, sore throat, or rhinorrhea, with an illness duration typically of ≤21 days. The ARFI screening criteria are described in Section 2.1.

Pregnancy trimester was classified according to gestational age: the first trimester was defined as <14 weeks, the second trimester as 14–27 weeks, and the third trimester as ≥28 weeks [16]. Because women in the early postpartum period may also be susceptible to severe acute respiratory infections, women within 2 weeks after delivery were included in the surveillance population.

Influenza-like illness (ILI) was defined as fever, with a body temperature of ≥38 °C, accompanied by either cough or sore throat. Severe acute respiratory infection (SARI) was defined as an acute respiratory infection accompanied by fever (≥38 °C), cough, dyspnea or other respiratory symptoms, and requiring hospitalization or resulting in death.

Based on the RT-PCR results obtained from nasopharyngeal swabs, enrolled patients were categorized into the SARS-CoV-2-positive group and the non-SARS-CoV-2 ARFI group. The primary analyses included a descriptive assessment of the epidemiological and clinical characteristics of SARS-CoV-2-positive patients and comparisons of factors of interest between the SARS-CoV-2-positive and non-SARS-CoV-2 ARFI groups. Patients coinfected with SARS-CoV-2 and influenza virus (n = 6) were excluded from the analysis of factors associated with SARS-CoV-2 positivity.

Clinical outcomes included the patient's vital status at discharge, categorized as alive or dead. Inpatient treatment decisions were made by the treating physicians based on each patient's clinical condition with reference to the national COVID-19 diagnosis and treatment guidelines in effect at the time of care. We described disease severity using recorded indicators, including oxygen therapy, intensive care unit admission, and mechanical ventilation. The surveillance records did not consistently document which laboratory parameters or thresholds were used to assess severity or guide treatment for individual patients.

Pre-admission vaccination was defined as at least one recorded dose before admission. A recorded negative vaccination history was classified as unvaccinated. When the only available last-dose date was later than admission and earlier dose dates were unavailable, pre-admission vaccination status was classified as unknown. Records whether vaccination has been carried out and the time of the last vaccination.

2.3. Statistical Analysis

Information collected included demographic characteristics, such as age, educational attainment, income, and gestational age; pre-existing medical conditions; pregnancy and obstetric history; major clinical symptoms, including fever, sore throat, cough, and shortness of breath; medications and treatments; indicators of disease severity, including oxygen therapy and admission to an intensive care unit; and complications, including pneumonia and respiratory failure.

All statistical analyses were performed using IBM SPSS Statistics version 28.0 and Microsoft Excel. Additional analyses used R version 4.5.1 and Python (statsmodels version 0.14.5 for regression). Continuous variables with non-normal distributions were summarized as medians and interquartile ranges, whereas categorical variables were summarized as counts and percentages.

Spearman's rank correlation analysis was used to assess the correlation between weekly SARS-CoV-2 positivity among hospitalized pregnant and postpartum patients and weekly SARS-CoV-2 positivity among the general population under surveillance at SARI sentinel hospitals. Depending on the distributional normality of the data, continuous variables were compared using analysis of variance or nonparametric tests, as appropriate. Differences in categorical variables were assessed using the chi-square test.

For the analysis of factors associated with SARS-CoV-2 positivity, directed acyclic graphs (DAGs) were used to identify the minimum sufficient adjustment set. Variables included in this adjustment set were forced into the multivariable logistic regression model. Additional variables showing differences in the preceding chi-square analyses at $p < 0.10$ were also entered into the multivariable logistic regression model. The statistical significance level was set at 0.05.

3. Results

3.1. Study Population and SARS-CoV-2 Positivity

Between January 2020 and December 2024, a total of 4219 pregnant and postpartum women hospitalized with acute respiratory infection or febrile illness (ARFI) were enrolled through the active surveillance system in Suzhou. Of these, 512 tested positive for SARS-CoV-2, yielding an overall positivity rate of 12.1%.

Among the 512 SARS-CoV-2-positive cases, 48 (9.4%) were in the first trimester, 84 (16.4%) were in the second trimester, 364 (71.1%) were in the third trimester, and 16 (3.1%) were postpartum women.

3.2. Epidemiological Characteristics of SARS-CoV-2-Positive Hospitalizations

No laboratory-confirmed SARS-CoV-2-positive cases were identified through the surveillance system between January 2020 and November 2022. The first laboratory-confirmed SARS-CoV-2-positive hospitalization among pregnant and postpartum women was detected in December 2022. The annual numbers of SARS-CoV-2-positive pregnant and postpartum women hospitalized with ARFI were 128 in 2022, 195 in 2023, and 189 in 2024.

Three periods of increased SARS-CoV-2 activity were observed, in late 2022, mid-2023, and mid-2024 (Figure 1).

Figure 1 shows weekly ARFI hospitalization counts and SARS-CoV-2 test positivity. Test positivity increased in late 2022, mid-2023, and mid-2024, with peaks of 90.5% in week 51 of 2022, 75.9% in week 23 of 2023, and 75.0% in week 33 of 2024 (Figure 1).

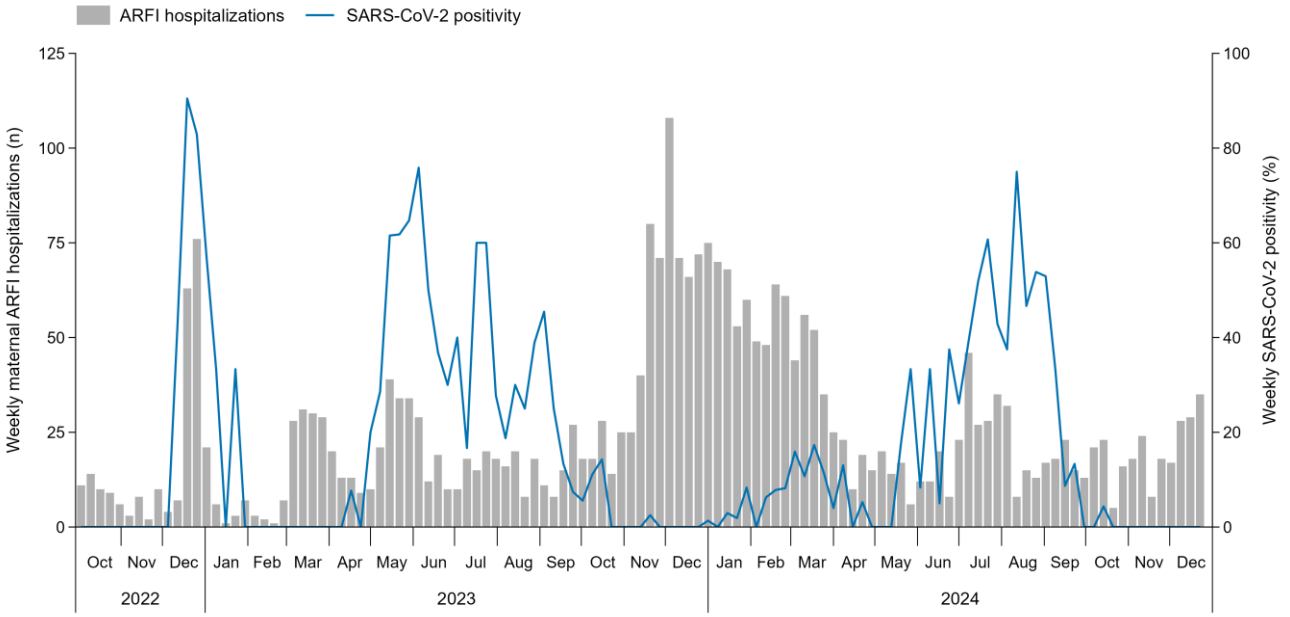


Figure 1. Weekly ARFI hospitalizations and SARS-CoV-2 test positivity among pregnant and postpartum women in Suzhou, China.

3.3. Demographic, Obstetric, and Clinical Characteristics

Of the 512 hospitalized pregnant and postpartum women who tested positive for SARS-CoV-2, 496 were pregnant and 16 were postpartum. The median gestational age at enrollment among pregnant women was 35 weeks.

The participants ranged in age from 20 to 43 years, with a median age of 30 years. A total of 76 women (14.8%) were of advanced maternal age, defined as ≥35 years. Based on prepregnancy body mass index, 26 women (5.1%) were classified as having obesity,

defined as a body mass index of ≥28 kg/m², and 96 (18.8%) were classified as overweight, defined as a body mass index of ≥24 kg/m² (Table 1).

Among SARS-CoV-2-positive women, 9.2% had at least one pre-existing medical condition before hospitalization, with metabolic disorders being the most common category (3.1%). Table 1 shows that 343 of 512 SARS-CoV-2-positive women (67.0%) had a history of COVID-19 vaccination. This percentage refers to prior vaccination irrespective of its timing relative to pregnancy.

The number of pregnancies ranged from one to eight, while the number of previous live births did not exceed four. A total of 280 women (54.7%) were classified as nulliparity.

At admission, 47.5% of the SARS-CoV-2-positive women presented with three or more symptoms. The most frequently reported symptoms were fever (84.0%), cough (60.0%), sore throat (52.3%), and sputum production (35.0%). Overall, 51.6% met the case definition for influenza-like illness.

Table 1. Demographic, obstetric, and clinical characteristics of hospitalized pregnant and postpartum women with SARS-CoV-2 infection.

Variable	First Trimester (*n* = 48)	Second Trimester (*n* = 84)	Third Trimester (*n* = 364)	Postpartum Women (*n* = 16)	Total (*n* = 512)
Age group, *n*(%)					
20–24	10(20.8)	8(9.5)	27(7.4)	2(12.5)	47(9.2)
25–29	16(33.3)	35(41.7)	139(38.2)	6(37.5)	196(38.3)
30–34	16(33.3)	31(36.9)	142(39.0)	4(25.0)	193(37.7)
35–39	5(10.4)	8(9.5)	50(13.7)	4(25.0)	67(13.1)
≥40	1(2.1)	2(2.4)	6(1.6)	0(0.0)	9(1.8)
Prepregnancy BMI category, *n*(%)					
Underweight	10(20.8)	8(9.5)	45(12.4)	1(6.3)	64(12.5)
Normal weight	32(66.7)	56(66.7)	226(62.1)	12(75.0)	326(63.7)
Overweight	5(10.4)	18(21.4)	71(19.5)	2(12.5)	96(18.8)
Obesity	1(2.1)	2(2.4)	22(6.0)	1(6.3)	26(5.1)
At least one underlying condition[a], *n*(%)					
Yes	7(14.6)	7(8.3)	30(8.2)	3(18.8)	47(9.2)
No	41(85.4)	77(91.7)	334(91.8)	13(81.3)	465(90.8)
SARS-CoV-2 vaccination, *n*(%)					
Yes	33(68.8)	52(61.9)	244(67.0)	14(87.5)	343(67.0)
No	15(31.3)	32(38.1)	120(33.0)	2(12.5)	169(33.0)
Gravidity, *n*(%)					
1	18(37.5)	41(48.8)	165(45.3)	7(43.8)	231(45.1)
2	17(35.4)	18(21.4)	82(22.5)	5(31.3)	122(23.8)
3	9(18.8)	14(16.7)	60(16.5)	0(0.0)	83(16.2)
≥4	4(8.3)	11(13.1)	57(15.7)	4(25.0)	76(14.8)
Previous live births, *n*(%)					
0	23(47.9)	48(57.1)	208(57.1)	1(6.3)	280(54.7)
1	21(43.8)	29(34.5)	122(33.5)	10(62.5)	182(35.5)
2	4(8.3)	7(8.3)	32(8.8)	4(25.0)	47(9.2)
≥3	0(0.0)	0(0.0)	2(0.5)	1(6.3)	3(0.6)
Symptoms at admission, *n*(%)					
Fever	40(83.3)	70(83.3)	304(83.5)	16(100.0)	430(84.0)
Sore throat	19(39.6)	50(59.5)	194(53.3)	5(31.3)	268(52.3)
Cough	25(52.1)	60(71.4)	214(58.8)	8(50.0)	307(60.0)
Shortness of breath	4(8.3)	12(14.3)	40(11.0)	0(0.0)	56(10.9)
Chest pain	2(4.2)	6(7.1)	11(3.0)	1(6.3)	20(3.9)
Sputum production	17(35.4)	39(46.4)	118(32.4)	5(31.3)	179(35.0)
Hemoptysis	0(0.0)	1(1.2)	0(0.0)	0(0.0)	1(0.2)
Tachypnea	4(8.3)	8(9.5)	18(4.9)	0(0.0)	30(5.9)

Abnormal findings on lung auscultation	1(2.1)	4(4.8)	12(3.3)	2(12.5)	19(3.7)
≥3 symptoms	19(39.6)	52(61.9)	165(45.3)	7(43.8)	243(47.5)
Influenza-like illness (ILI) symptoms	24(50.0)	42(50.0)	190(52.2)	8(50.0)	264(51.6)
Interventions and outcomes, *n*(%)					
Systemic corticosteroid use	3(6.3)	20(23.8)	89(24.5)	0(0.0)	112(21.9)
Antibiotic use	21(43.8)	50(59.5)	191(52.5)	10(62.5)	272(53.1)
Admission to the intensive care unit (ICU)	0(0.0)	0(0.0)	6(1.6)	0(0.0)	6(1.2)
Oxygen therapy	4(8.3)	26(31.0)	220(60.4)	4(25.0)	254(49.6)
Mechanical ventilation	0(0.0)	1(1.2)	3(0.8)	0(0.0)	4(0.8)
Complications	6(12.5)	9(10.7)	31(8.5)	2(12.5)	48(9.4)
Pneumonia	6(12.5)	8(9.5)	30(8.2)	2(12.5)	46(9.0)
Length of hospital stay, days, median (IQR)	4.0(3.0–6.8)	4.0(3.0–6.0)	4.0(3.0–6.0)	4.0(2.3–6.8)	4.0(3.0–6.0)
Pregnancy status at admission, *n*(%)					
Ongoing pregnancy	42(87.5)	78(92.9)	229(62.9)	0(0.0)	349(68.2)
Delivered	0(0.0)	1(1.2)	135(37.1)	16(100)	152(29.7)
Pregnancy loss	6(12.5)	5(6.0)	0(0.0)	0(0.0)	11(2.1)

[a] Defined as the presence of at least one of the following underlying conditions: chronic pulmonary disease, cardiovascular disease, metabolic disease, chronic kidney disease, chronic liver disease, malignancy, an immune system disorder, or another systemic disease.

3.4. Treatment and Clinical Outcomes

Among SARS-CoV-2-positive women, 6.1% received an antiviral drug during hospitalization. Recorded agents were oseltamivir (n = 26), nirmatrelvir/ritonavir (n = 2), peramivir (n = 1), umifenovir (n = 1), azvudine (n = 1), and simnotrelvir/ritonavir (n = 1). One woman had two agents recorded, so drug-specific counts overlap. Four women in this treated group received a SARS-CoV-2-specific antiviral agent. Antibiotics were administered to 272 women (53.1%) and systemic glucocorticoids to 112 (21.9%) (Table 1).

A total of 254 women (49.6%) received oxygen therapy, 4 (0.8%) underwent mechanical ventilation, and 6 (1.2%) were admitted to an intensive care unit. No in-hospital deaths occurred.

The length of hospital stay ranged from 0 to 67 days, with a median of 4 days. Complications occurred in 48 women (9.4%), with pneumonia being the most frequently documented complication (9.0%).

Among the women who were pregnant at enrollment, 68.2% remained pregnant at discharge, whereas 29.7% had delivered. Women who were no longer pregnant at discharge had either delivered vaginally or by cesarean section or had experienced pregnancy loss, including miscarriage, fetal death, or stillbirth.

Factors Associated with SARS-CoV-2 Positivity Among Women Hospitalized with ARFI

Among the 4219 pregnant and postpartum women hospitalized with ARFI, 512 were SARS-CoV-2 positive. After the exclusion of patients with SARS-CoV-2 and influenza coinfection, 3701 non-SARS-CoV-2 ARFI cases were included as the comparison group.

In univariable analyses, the distribution of SARS-CoV-2 positivity differed significantly according to Suzhou medical insurance coverage, educational attainment, total annual household income, primigravidity, primiparity, gestational diabetes mellitus, and the number of episodes of influenza-like illness during the preceding year (all $p < 0.05$). No statistically significant differences were observed for the remaining characteristics (Table 2).

A directed acyclic graph was constructed using DAGitty version 3.0 to identify a minimally sufficient adjustment set based on prior knowledge. Advanced maternal age and prepregnancy body mass index category were retained in the multivariable logistic regression model, together with variables with a p value <0.10 in the univariable analyses.

In the adjusted analysis, Gestational diabetes mellitus was associated with higher odds of SARS-CoV-2 positivity (aOR, 2.21; 95% CI, 1.57–3.10; $p < 0.001$) (Table 3).

Table 2. Univariable analysis of factors associated with SARS-CoV-2 positivity among pregnant and postpartum women hospitalized with ARFI.

Characteristic	SARS-CoV-2-Positive Group (n = 512)	SARS-CoV-2-Negative Group (n = 3701)	χ^2	p-Value
Pregnancy stage, n(%)			5.324	0.150
First trimester	48(9.4)	354(9.6)		
Second trimester	84(16.4)	603(16.3)		
Third trimester	364(71.1)	2540(68.6)		
Within 2 weeks postpartum	16(3.1)	204(5.5)		
Advanced maternal age (≥35 years), n(%)			0.766	0.381
Yes	76(14.8)	497(13.4)		
No	436(85.2)	3204(86.6)		
Household size, n(%)			2.004	0.157
>3 persons	208(40.6)	1626(43.9)		
≤3 persons	304(59.4)	2075(56.1)		
Prepregnancy BMI category, n(%)			5.258	0.154
Underweight	64(12.5)	390(10.5)		
Normal weight	326(63.7)	2288(61.8)		
Overweight	96(18.8)	760(20.5)		
Obesity	26(5.1)	263(7.1)		
Local insurance coverage, n(%)			3.966	0.046
Yes	400(78.1)	2740(74.0)		
No	112(21.9)	961(26.0)		
Educational attainment, n(%)			8.620	0.013
High school or below	141(27.5)	1208(32.6)		
College diploma	144(28.1)	1088(29.4)		
Bachelor's degree or above	227(44.3)	1405(38.0)		
Annual household income, CNY, n(%)			6.731	0.035
≤100,000	69(13.5)	660(17.8)		
100,000–200,000	294(57.4)	2080(56.2)		
≥200,000	149(29.1)	961(26.0)		
At least one underlying condition, n(%)			0.504	0.478
Yes	47(9.2)	377(10.2)		
No	465(90.8)	3324(89.8)		
Primigravidity, n(%)			3.864	0.049
Yes	231(45.1)	1501(40.6)		
No	281(54.9)	2200(59.4)		
Nulliparity, n(%)			10.686	0.001
Yes	280(54.7)	1739(47.0)		
No	232(45.3)	1962(53.0)		
Nutritional supplement use during pregnancy, n(%)			2.947	0.086
Yes	279(54.5)	1867(50.4)		
No	233(45.5)	1834(49.6)		

Medication use during pregnancy, *n*(%)			0.443	0.506
Yes	108(21.1)	829(22.4)		
No	404(78.9)	2872(77.6)		
Gestational diabetes mellitus, *n*(%)			20.747	<0.001
Yes	78(15.2)	329(8.9)		
No	434(84.8)	3372(91.1)		
Gestational hypertension, *n*(%)			1.481	0.224
Yes	6(1.2)	72(1.9)		
No	506(98.8)	3629(98.1)		
Number of ILI episodes in the previous year, *n*(%)			3.952	0.047
≥1	166(32.4)	1043(28.2)		
0	346(67.6)	2658(71.8)		
Contact with a person with ILI within 2 weeks before illness onset, *n*(%)			3.460	0.063
Yes	71(13.9)	410(11.1)		
No	441(86.1)	3291(88.9)		
ZAntibiotic use, *n*(%)			50.229	<0.001
Yes	272 (53.1)	2548 (68.8)		
No	240 (46.9)	1153 (31.2)		
Glucocorticoid use, *n*(%)			3.613	0.057
Yes	112 (21.9)	680 (18.4)		
No	400 (78.1)	3021 (81.6)		

Table 3. Multivariable analysis of factors associated with SARS-CoV-2 positivity among pregnant and postpartum women hospitalized with ARFI.

Variable	aOR(95%CI)	*p*-Value
Advanced maternal age		
Yes	0.97(0.70–1.34)	0.862
No	1.00	
Prepregnancy BMI category		
Underweight	1.23 (0.89–1.71)	0.200
Normal weight	1.00	
Overweight	0.94 (0.71–1.24)	0.662
Obesity	0.75 (0.47–1.20)	0.231
basic medical insurance coverage		
Yes	0.99 (0.75–1.30)	0.936
No	1.00	
Educational attainment		
High school or below	1.00	
College diploma	0.87 (0.65–1.18)	0.375
Bachelor's degree or above	1.28 (0.95–1.72)	0.107
Annual household income, CNY		
≤100,000	1.08 (0.78–1.50)	0.644
100,000–200,000	1.00	
≥200,000	1.05 (0.82–1.35)	0.698
Primigravidity		
Yes	1.08 (0.81–1.44)	0.596
No	1.00	
Primiparity		
Yes	1.10 (0.82–1.47)	0.513
No	1.00	
Nutritional supplement use during pregnancy		
Yes	1.25 (1.00–1.56)	0.047
No	1.00	

Gestational diabetes mellitus		
Yes	2.21 (1.57–3.10)	<0.001
No	1.00	
Number of ILI episodes in the previous year		
≥1	0.92 (0.73–1.15)	0.469
0	1.00	
Contact with a person with ILI within 2 weeks before illness onset		
Yes	1.11 (0.82–1.51)	0.495
No	1.00	
COVID-19 vaccination before admission		0.019
Yes	0.76(0.60–0.96)	
No	1.00	

3.5. Sensitivity Analyses

Sensitivity analyses used the same 2951 pregnant and postpartum women hospitalized with ARFI from December 2022 through December 2024 (Table S1). Model A included the baseline covariates, including educational attainment. Model B additionally adjusted for admission year, and Model C further included COVID-19 vaccination before admission.

For gestational diabetes mellitus, the aOR decreased from 2.90 (95% CI 2.15–3.91) in Model A to 2.20 (95% CI 1.57–3.09) after adjustment for admission year in Model B. The estimate was similar after vaccination status was added in Model C (aOR 2.21, 95% CI 1.57–3.10). For women with no previous live births, the 95% CIs included 1 in all three models. In Model C, receipt of at least one documented COVID-19 vaccine dose before admission was associated with lower odds of SARS-CoV-2 positivity (aOR 0.76, 95% CI 0.60–0.96, $p = 0.019$).

4. Discussion

This study yielded several principal findings. Among pregnant and postpartum women hospitalized with acute respiratory infection or febrile illness (ARFI), the overall SARS-CoV-2 positivity rate was 12.1%. After SARS-CoV-2 was first detected through the surveillance system in December 2022, three prominent peaks were observed. After adjusting for the year of hospitalization, vaccination and other covariates, gestational diabetes mellitus (GDM) was still associated with an increased risk of SARS-CoV-2 positivity during hospitalization for acute respiratory infections or febrile illnesses among pregnant women and postpartum women.

Previous studies have reported estimates of SARS-CoV-2 infection among pregnant populations ranging from 3% to 20% [17,18]. The positivity rate observed in the present study, 12.1% (512/4219), was slightly higher than those reported in Houston, USA (8%) [19], northern Mexico (11.2%) [20], and Mozambique (9.2%) [21], but substantially lower than the 66.9% positivity reported among pregnant women in Hunan Province, China, following the adjustment of national COVID-19 control measures [22]. These differences likely reflect variations in study populations, surveillance periods, testing strategies, and case-ascertainment methods. The present study was restricted to pregnant and postpartum women who were hospitalized with ARFI and underwent RT-PCR testing for SARS-CoV-2. Both test-positive and test-negative patients were included. It therefore excluded outpatients, individuals who did not seek medical care, and symptomatic patients who did not undergo testing. This relatively restrictive case definition may partly explain the lower positivity rate compared with studies that included broader populations or relied on less restrictive diagnostic criteria.

Regarding temporal patterns, SARS-CoV-2-positive cases were first identified in the Suzhou surveillance system for ARFI hospitalizations among pregnant and postpartum women in December 2022. Thereafter, SARS-CoV-2 activity occurred in distinct waves, with peaks in epidemiological week 51 of 2022, week 23 of 2023, and week 33 of 2024. No stable seasonal pattern was observed. Community-based sentinel surveillance in China similarly documented a rapid increase in SARS-CoV-2 infections following the optimization of national prevention and control measures in December 2022, with the first major epidemic peak occurring in late December 2022 [23]. This timing was broadly consistent with the first peak identified in the present study. Previous respiratory infectious disease surveillance studies conducted in Zhejiang and Guangdong have shown that sentinel surveillance data can be used to characterize temporal changes in the activity of respiratory pathogens [24,25]. This finding suggests that ARFI surveillance among hospitalized pregnant and postpartum women may, to some extent, reflect changes in the intensity of local SARS-CoV-2 circulation. The changes in the circulating variants may also have contributed to these patterns. However, due to the inability to obtain the viral sequences at the participant level and the local variant data during the same period, it is difficult to attribute these peaks to specific variants.

Most SARS-CoV-2-positive women in this study were aged 25–34 years, and the majority were in the third trimester of pregnancy. The age distribution was broadly consistent with findings from Osaka, Japan, where COVID-19 cases among pregnant women were concentrated in the principal reproductive age groups [26]. The high proportion of third-trimester cases in the present study may partly reflect increased contact with healthcare services during late pregnancy, including antenatal examinations, preparation for delivery, perinatal assessment, and hospitalization. Women in the third trimester may therefore have had more opportunities to undergo pathogen testing and to be included in the hospital-based ARFI surveillance system.

Fever, cough, and sore throat were the most frequently reported symptoms at admission, and approximately half of the SARS-CoV-2-positive cases met the clinical definition of influenza-like illness. These findings indicate that the clinical presentation remained predominantly respiratory. Previous systematic reviews and multinational cohort studies have reported that SARS-CoV-2 infection during pregnancy may be associated with severe maternal illness, preterm birth, and adverse maternal and neonatal outcomes, although the magnitude and consistency of these associations have varied across regions and study designs [27,28]. Several early studies from China reported that the clinical manifestations of COVID-19 in pregnant women were generally similar to those in nonpregnant women and that most cases were mild or moderate [29–31]. In the present study, the proportions of intensive care unit admission, mechanical ventilation, pneumonia, and complications were relatively low, broadly consistent with findings from several studies conducted in Asian populations. In this study, among the female patients diagnosed with SARS-CoV-2, only 31 cases (6.1%) received antiviral treatment during their hospitalization. Among them, 4 cases received specific drugs targeting SARS-CoV-2. These data are merely descriptive information and the sample size is insufficient, making it impossible to conduct a meaningful assessment of the treatment effect.

Among pregnant women and postpartum women hospitalized due to ARFI, after adjusting for time, vaccination status and other covariates, GDM remained highly associated with a higher rate of SARS-CoV-2 positivity. The adjusted odds ratio (aOR) was 2.21 (95% CI 1.57–3.10) (Tables 3 and S1). In the same analysis, being vaccinated with a recorded COVID-19 vaccine at least once before admission was associated with a lower probability of SARS-CoV-2 positivity in the hospitalized ARFI cohort (aOR 0.76, 95% CI 0.60–0.96, $p = 0.019$). However, the vaccine analysis used binary indicators to measure the recorded vaccination status before admission, without differentiating the number of

doses, nor considering the time since the last dose. This made it impossible to estimate the variant-specific association, thus requiring cautious interpretation of the association with vaccination.

The association observed for gestational diabetes mellitus (GDM) was directionally consistent with a previous cohort study that proposed metabolic alterations as a possible explanation [32]. Healthcare-related factors may also contribute to this finding. Women with GDM may have more frequent healthcare contact, closer clinical monitoring, and different thresholds for hospital admission than women without GDM. These differences could increase opportunities for SARS-CoV-2 testing and affect which women enter hospital-based ARFI surveillance, potentially introducing surveillance or detection bias. Although testing followed a standardized protocol after enrollment, differences in healthcare contact and admission before enrollment may still influence case ascertainment. Further studies incorporating healthcare utilization and admission data could help clarify the observed association.

The present study had several strengths. First, the active surveillance system continuously captured ARFI hospitalizations among pregnant and postpartum women over a 5-year period from 2020 to 2024. This system provided pregnancy-specific surveillance information that is not routinely recorded in conventional respiratory infectious disease surveillance systems. Second, a directed acyclic graph was used to identify a minimally sufficient adjustment set, thereby reducing the likelihood of inappropriate covariate adjustment. Third, sensitivity analyses using sequentially adjusted covariate sets and E-value analyses were performed to assess the robustness of the observed associations.

Several limitations should also be considered. First, this was a cross-sectional analysis restricted to hospitalized pregnant and postpartum women with ARFI. The estimated associations therefore represent the relative odds of SARS-CoV-2 positivity within this hospitalized ARFI population rather than the risk of infection among pregnant and postpartum women in the general population. Eligibility depended on hospitalization and meeting the ARFI surveillance criteria, and enrollment required informed consent. Selection through these processes may have influenced the observed associations; the estimates cannot be assumed to apply to women with asymptomatic infection or mild illness who were not hospitalized. Second, the study was conducted in Suzhou, a city with relatively well-resourced healthcare services. Differences in healthcare access, referral pathways, admission thresholds, and testing practices across regions may influence the characteristics of women included in hospital-based surveillance. The applicability of these findings to other settings should therefore be considered in relation to their local healthcare and surveillance systems.

The findings also have implications for public health surveillance. Conventional influenza sentinel surveillance is commonly conducted in respiratory or internal medicine departments and does not routinely document pregnancy status. As a result, surveillance information on respiratory infections among pregnant and postpartum women remains limited. The active surveillance system used in this study continuously documented SARS-CoV-2 activity among pregnant and postpartum women hospitalized with ARFI from 2020 to 2024 and may provide a feasible framework for continued monitoring of respiratory viral infections in this population during the post-pandemic period. Continued surveillance and timely clinical evaluation may facilitate appropriate resource allocation and improve the management of maternal respiratory infections.

5. Conclusions

Based on the active surveillance system for ARFI hospitalizations among pregnant and postpartum women in Suzhou, this study characterized the epidemiological patterns,

clinical manifestations, and factors associated with SARS-CoV-2 positivity from 2020 to 2024. Active surveillance in Suzhou identified three peaks in SARS-CoV-2 positivity among pregnant and postpartum women hospitalized with ARFI during 2020–2024. Gestational diabetes mellitus were associated with higher odds of SARS-CoV-2 positivity within this hospitalized ARFI population. Continued active surveillance, with particular attention to women with GDM, can help characterize respiratory virus activity and inform clinical assessment and resource planning.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/diseases14110430/s1: Table S1: Sensitivity Calendar-time and vaccination sensitivity analyses; Table S2: Inpatient treatment use in the contemporaneous and influenza subgroup comparisons; Table S3: Antiviral prescriptions in SARS-CoV-2-positive women.

Author Contributions: Conceptualization, S.S. and L.C.; methodology, W.H.; formal analysis, S.S.; investigation, L.C., N.D. and W.H.; data curation, L.J. and Y.Z.; writing—original draft preparation, S.S.; writing—review and editing, L.C.; supervision, L.C.; project administration, Y.Z. and L.C. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Cooperative Agreement Number (5U011P001106) funded by the United States Centers for Disease Control and Prevention,as well as by The 27th Batch of Science and Technology Development Plan (Social Development Science and Technology Innovation) of Suzhou in 2022 (2022SS14).

Institutional Review Board Statement: This research was approved by the Ethics Review Committee of the Chinese Center for Disease Control and Prevention. The approval number is 202014-01-02. Approval date: 2 September 2020. All paper and electronic materials were managed by designated personnel in a specialized manner. The relevant responsible persons assumed the legal obligation of information confidentiality, and all materials were archived and preserved in accordance with the management norms for scientific and technological archives.

Informed Consent Statement: Informed consent was obtained from all the subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to ethical reasons.

Acknowledgments: We would like to thank all the involved participants and physicians in each hospital and the Suzhou Center for Disease Control and Prevention for their contribution to this study.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. ICD-10 codes used for COVID-19 and influenza surveillance.

ICD-10 Code	Disease/Condition
A41	Other sepsis
B34	Viral infection of unspecified site
B95.3	Streptococcus pneumoniae as the cause of diseases classified elsewhere
B96.0	Mycoplasma pneumoniae as the cause of diseases classified elsewhere
B96.1	Klebsiella pneumoniae as the cause of diseases classified elsewhere
B96.3	Haemophilus influenzae as the cause of diseases classified elsewhere
B97.0	Adenovirus as the cause of diseases classified elsewhere
B97.2	Coronavirus as the cause of diseases classified elsewhere
B97.3	Retrovirus as the cause of diseases classified elsewhere
B97.4	Respiratory syncytial virus as the cause of diseases classified elsewhere

B97.8	Other viral agents as the cause of diseases classified elsewhere
B99.x01	Infectious fever
J00	Acute nasopharyngitis (common cold)
J01	Acute sinusitis
J02	Acute pharyngitis
J03	Acute tonsillitis
J04	Acute laryngitis and tracheitis
J05	Acute obstructive laryngitis (croup) and epiglottitis
J06	Acute upper respiratory infections of multiple and unspecified sites
J09	Influenza due to identified zoonotic or pandemic influenza virus
J10	Influenza due to identified seasonal influenza virus
J11	Influenza, virus not identified
J12	Viral pneumonia, not elsewhere classified
J13	Pneumonia due to Streptococcus pneumoniae
J14	Pneumonia due to Haemophilus influenzae
J15	Bacterial pneumonia, not elsewhere classified
J16	Pneumonia due to other infectious organisms, not elsewhere classified
J17	Pneumonia in diseases classified elsewhere
J18	Pneumonia, organism unspecified
J20	Acute bronchitis
J21	Acute bronchiolitis
J22	Unspecified acute lower respiratory infection
J35	Chronic diseases of tonsils and adenoids
J36	Peritonsillar abscess
J39	Other diseases of upper respiratory tract
J40	Bronchitis, not specified as acute or chronic
J45	Asthma
J46	Status asthmaticus
J80	Acute respiratory distress syndrome
J81	Pulmonary edema
J84	Other interstitial pulmonary diseases
J86.9	Pyothorax without fistula
J90	Pleural effusion, not elsewhere classified
J96	Respiratory failure, not elsewhere classified
J98	Other respiratory disorders
O75.1	Shock during or following labor and delivery
O75.2	Pyrexia during labor, not elsewhere classified
O86.4	Pyrexia of unknown origin following delivery
O98.5	Other viral diseases complicating pregnancy, childbirth and the puerperium
O98.8	Other maternal infectious and parasitic diseases complicating pregnancy, childbirth and the puerperium
O99.5	Diseases of the respiratory system complicating pregnancy, childbirth and the puerperium
R04	Hemorrhage from respiratory passages
R05	Cough
R06	Abnormalities of breathing
R07	Pain in throat and chest
R09	Other symptoms and signs involving the circulatory and respiratory systems
R50	Fever of other and unknown origin
R57.9	Shock, unspecified
R65	Systemic inflammatory response syndrome
R68.8	Other specified general symptoms and signs

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