Clinical and Demographic Risk Factors for COVID-19 during Delivery Hospitalizations in New York City

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Abstract

Objective This study was aimed to review 4 weeks of universal novel coronavirus disease 2019 (COVID-19) screening among delivery hospitalizations, at two hospitals in March and April 2020 in New York City, to compare outcomes between patients based on COVID-19 status and to determine whether demographic risk factors and symptoms predicted screening positive for COVID-19.

Study Design This retrospective cohort study evaluated all patients admitted for delivery from March 22 to April 18, 2020, at two New York City hospitals. Obstetrical and neonatal outcomes were collected. The relationship between COVID-19 and demographic, clinical, and maternal and neonatal outcome data was evaluated. Demographic data included the number of COVID-19 cases ascertained by ZIP code of residence. Adjusted logistic regression models were performed to determine predictability of demographic risk factors for COVID-19.

Results Of 454 women delivered, 79 (17%) had COVID-19. Of those, 27.9% ($n = 22$) had symptoms such as cough (13.9%), fever (10.1%), chest pain (5.1%), and myalgia (5.1%). While women with COVID-19 were more likely to live in the ZIP codes quartile with the most cases (47 vs. 41%) and less likely to live in the ZIP code quartile with the fewest cases (6 vs. 14%), these comparisons were not statistically significant ($p = 0.18$). Women with COVID-19 were less likely to have a vaginal delivery (55.2 vs. 51.9%, $p = 0.04$) and had a significantly longer postpartum length of stay with cesarean (2.00 vs. 2.67days, $p < 0.01$). COVID-19 was associated with higher risk for diagnoses of chorioamnionitis and pneumonia and fevers without a focal diagnosis. In adjusted analyses, including demographic factors, logistic regression demonstrated a c-statistic of 0.71 (95% confidence interval [CI]: 0.69, 0.80).

Keywords
- COVID-19
- pregnancy
- COVID-19 symptoms
- COVID-19 screening

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Conclusion COVID-19 symptoms were present in a minority of COVID-19-positive women admitted for delivery. Significant differences in obstetrical outcomes were found. While demographic risk factors demonstrated acceptable discrimination, risk prediction does not capture a significant portion of COVID-19-positive patients.

Key Points

- COVID-19 symptoms were present in a minority of COVID-19-positive women admitted.
- COVID-19 symptomatology did not appear to differ before or after the apex of infection in New York.
- Demographic risk factors are unlikely to capture a significant portion of COVID-19-positive patients.

On January 30, 2020, the World Health Organization declared the novel coronavirus disease 2019 (COVID-19) outbreak as a public health emergency of international concern and on March 11, 2020, declared it as a pandemic.[1] New York City became an international epicenter of the outbreak with an average of >500 deaths per day in New York City from April 3 to April 15, 2020.[1,2] In preparation for clinical resources being allocated to COVID-19 patients, hospitals in New York City limited or discontinued many clinical services. However, some clinical services which could not be deferred, including inpatient obstetrics, continued to be provided at full capacity.

Provision of full obstetric services in the setting of the COVID-19 pandemic involves many challenges including efforts to minimize unprotected exposure of health care staff to asymptomatic or minimally symptomatic patients. Successful identification of patients with asymptomatic COVID-19 infection and application of appropriate measures to prevent transmission may limit infections and absences in the workforce. After initially asymptomatic obstetric patients with COVID-19 infection exposed a large number of health care workers at a tertiary referral hospital in New York City, universal screening for all patients admitted for obstetric indications was initiated on March 22, 2020.[3] With increasing COVID-19 diagnoses across the United States, many other hospitals may face decisions on how to best identify obstetric patients with COVID-19 infections in the setting of local or regional spread of infection.[4,5] Universal screening may be performed but requires significant logistical resources.[6] Given that the outcomes and experience of universal screening at these two hospitals may be informative in developing at protocols, this study reviewed the screening experience at these two hospitals.

Materials and Methods

We sought to review four consecutive weeks of universal COVID-19 screening among delivery hospitalizations and to compare obstetrical and neonatal outcomes between patients who were negative and positive for COVID-19. Therefore, we also wanted to determine to what degree demographic risk factors and symptoms predicted obstetric patients screening positive for COVID-19. Universal COVID-19 screening was initiated for all patients admitted for an obstetric indication starting on March 22, 2020, at two hospitals in New York City: New York-Presbyterian Morgan Stanley Children's Hospital (MSCH), a tertiary referral center performing approximately 4,600 deliveries per year, and New York-Presbyterian/Allen Hospital, a community hospital performing approximately 2,300 deliveries per year. During the study period (April 9, 2020, through the end of the study period), the labor floors of the two hospitals consolidated operations at MSCH to allocate clinical space at the Allen Hospital for nonobstetric patients with COVID-19. Universal screening aimed at improving identification, minimizing exposure, and controlling the spread of infection was initiated after initially asymptomatic obstetric patients with COVID-19 infections exposed numerous health care workers.[3] Use of this data for research purposes was granted by the Columbia University Institutional Review Board (grant no.: AAAS9214).

This retrospective cohort analyzed all patients admitted for delivery at MSCH and the Allen Hospital for a 4-week period from March 22 to April 18th, 2020. This study period began before and continued past the apex of infections, hospitalizations, and deaths from COVID-19 in New York City.[7] No patients admitted for delivery were excluded from this study. Results from the first 2 weeks of this screening have been briefly reported.[2] Screening for COVID-19 was performed using viral severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) polymerase chain reaction (PCR) nasopharyngeal collected by physicians or nurse practitioners either (1) on admission in an obstetrical triage unit or (2) at a dedicated preadmission testing site less than 24 hours prior to admission. Patients with unknown or positive COVID-19 screening status were placed on droplet and contact precautions with use of personal protective equipment during both vaginal and cesarean delivery. Patients negative for COVID-19 were treated with standard precautions including hospital policy requiring all hospital employees and patients to wear at minimum surgical masks for all patient interactions. While COIVD-19 status influenced infection prevention and control procedures, obstetrical practice was not changed. Specifically, timing of delivery and management of common obstetrical conditions (preterm rupture of membranes, preterm labor, nonreassuring fetal status, etc.) followed our standard practices.

The primary objectives of this study compare obstetrical and neonatal outcomes between patients who were negative and positive for COVID-19. Secondary objectives were to determine demographic risk factors for COVID-19 and to what degree they accounted for a positive COVID-19 diagnosis during the delivery hospitalization. Additionally we sought to determine whether (1) the proportion of patients screening positive for COVID-19 changed by study week, and (2) whether significant symptoms and findings including upper respiratory infection symptoms, fever, hypoxia, and leukopenia changed significantly by study week among patients with COVID-19. We hypothesized that earlier in the study period patients would be more likely to be asymptomatic and not have significant findings and that later in the study period, as patients would have on average been more likely to have been exposed to the virus for longer time periods, symptoms would be more common.

A range of demographic and clinical characteristics were evaluated. Demographic data included maternal race (non-Hispanic black, non-Hispanic white, Hispanic, Asian or Pacific Islander, other, and unknown), body mass index (<25, 25–<30, 30–<35, and ≥35 kg/m^2), payer (commercial, Medicaid, and other or unknown), maternal age in years (<25, 25–34, 35–39, and 40years or older), and COVID-19 cases by patient home address ZIP code as of May 14, 2020, stratified into quartiles (22–480, >480–823, >823–1,440, and >1440–4,082 cases per ZIP code) based on data from the New York City Department of Department of Health and Mental Hygiene.[8] Clinical characteristics included gestational age at screening, parity, medical comorbidities, previous cesarean, multifetal gestation, tobacco use, potential COVID-19 exposure risk factors (including recent travel and exposure to a presumed COVID-19 infection with 14 days), and whether the patient was a health care worker.

Chart review was performed to determine whether patients had significant symptoms on presentation for delivery hospitalization including sore throat, reported fever, cough, chest pain, dyspnea, ageusia or hypogeusia, chills, myalgias, rhinorrhea, nausea or vomiting, headache, abdominal pain, diarrhea, malaise, and rigor. Significant clinical and laboratory findings assessed on presentation included fever (≥38.0 °C), pulse oximetry oxygen saturation ≤95%, and leukocyte count ≤6,000/uL. Delivery characteristics were analyzed comparing women with and without COVID-19 including delivery indication, mode of delivery, postpartum length of stay, gestational age at delivery, receipt of antenatal steroids, hypertensive disorders of pregnancy, infectious diagnoses, and lowest oxygen saturation during the delivery hospitalization. Neonatal outcomes evaluated included Apgar's score ≤5 at 1 and 5 minutes, arterial and venous cord pH of ≤7.10, birth weight <2,500 g, disposition to the well-baby nursery versus neonatal intensive care unit (NICU), length of stay, and neonatal death. The proportion of deliveries, by quartile, for women with and without COVID-19 that contributed to the cohort by date was determined.

Categorical variables were compared with the Chi-square test or Fisher's exact test as appropriate. The Cochran–Armitage test for trend was used to compare outcomes by week. An adjusted multivariable logistic regression model with COVID-19, as the outcome was constructed from demographic variables, was statistically significant or otherwise considered to be of importance. This model included days from the first diagnosed case in New York City (March 1, 2020). To make the model more parsimonious, some categorical variables were collapsed into fewer categories than in the univariable analysis. The c-statistic or area under the curve (AUC) from the receiver operating characteristic (ROC) curve of the logistic regression model was used to examine the predictability of the selected factors (►**Fig. 1**). The ability to distinguish was calculated to evaluate the predictability of selected covariates on COVID-19 infection compared with chance alone (c-statistic of model with one or more variables − c-statistic of null model) / (c-statistic of null model). Bootstrapping based on 50 random samples with replacement was used to calculate 95% confidence intervals (CIs) for c-statistics and the ability to distinguish.[9] This model was performed with the entire population and then, as a sensitivity analysis, repeated excluding patients who had symptoms and significant findings (fever, pulse oximetry oxygen saturation ≤95%, and leukocyte count ≤6,000/uL) on presentation. The study was not powered for individual outcomes and the sample size was determined by based on analyzing cases during the apex of infections diagnosed in New York City. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

Results

Over the study period of March 22, 2020, to April 18, 2020, 454 women admitted for delivery at the two hospitals were

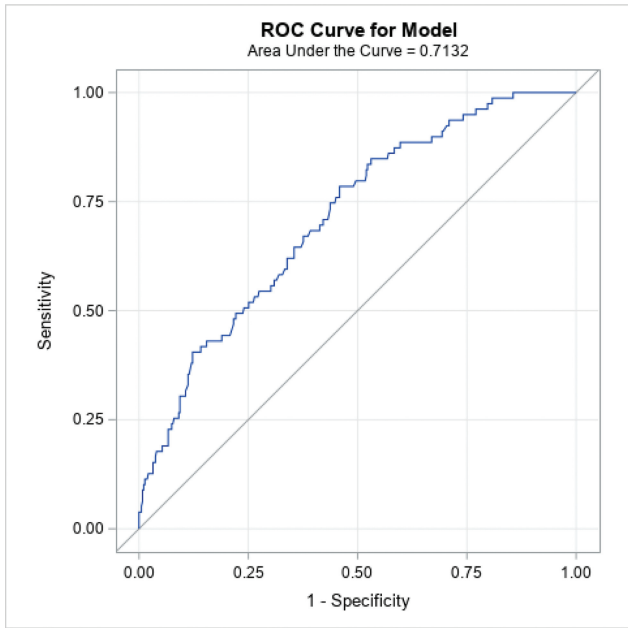

Fig. 1 Receiver operating characteristic (ROC) curve for the adjusted model. The area under the curve (AUC; 95 confidence interval [CI]) of the ROC curve was 0.713 (0.688, 0.797). The 95% CI was calculated by bootstrapping. The ability of differentiation was 42.6% (37.6, 59.4%).

Table 1 Demographics of the study population by week of delivery

Characteristic	All patients (March 22–April 19)	Week 1 (March 22–March 28)	Week 2 (March 29–April 4)	Week 3 (April 5–April 11)	Week 4 (April 12–April 19)	*p*-Value
All patients	454 (100)	106 (23.4)	112 (24.7)	123 (27.1)	113 (24.9)	N/A
COVID-19 infection present	79 (17.4)	16 (15.1)	20 (17.9)	28 (22.8)	15 (13.3)	0.24
Gestational age at testing in weeks (mean)	$39^{0/7}$	$39^{0/7}$	$38^{6/7}$	$38^{6/7}$	$39^{0/7}$	0.27
< 34	25 (5.5)	3 (2.8)	9 (8.0)	8 (6.5)	5 (4.4)	0.58
34–37	32 (7.1)	4 (3.8)	8 (7.1)	9 (7.3)	11 (9.7)	
37– < 39	142 (31.3)	30 (28.3)	37 (33.0)	43 (35.0)	32 (28.3)	
39– < 41	244 (53.7)	65 (61.3)	56 (50.0)	61 (49.6)	62 (54.9)	
41 or greater	11 (2.4)	4 (3.8)	2 (1.8)	2 (1.6)	3 (2.7)	
Maternal age in years (mean)	30.4	32.0	29.8	30.8	29.4	0.05
< 25	75 (16.5)	15 (14.2)	8 (7.1)	25 (20.3)	27 (23.9)	0.02
25–34	252 (55.5)	54 (50.9)	73 (65.2)	64 (52.0)	61 (54.0)	
35–39	87 (19.2)	23 (21.7)	25 (22.3)	23 (18.7)	16 (14.2)	
40 or older	40 (8.8)	14 (13.2)	6 (5.4)	11 (8.9)	9 (8.0)	
Race						0.36
Asian	26 (5.7)	5 (4.7)	9 (7.3)	9 (7.3)	3 (2.7)	
Native Hawaiian/ Pacific Islander	3 (0.7)	1 (1.0)	1 (0.9)	0 (0.0)	1 (0.9)	
Black	73 (16.1)	14 (13.2)	26 (23.2)	16 (13.0)	17 (15.0)	
White	169 (37.2)	46 (43.4)	37 (33.0)	44 (35.8)	42 (37.2)	
Unknown	183 (40.3)	40 (37.7)	39 (34.8)	54 (43.9)	50 (44.3)	
Ethnicity						0.96
Not Hispanic	141 (31.1)	34 (32.1)	30 (26.8)	40 (32.5)	37 (32.7)	
Hispanic	249 (54.9)	58 (54.7)	64 (57.1)	67 (54.5)	60 (53.1)	
Unknown	64 (14.1)	14 (13.2)	18 (16.1)	16 (13.0)	16 (14.2)	
Insurance						0.20
Private	193 (43.5)	55 (51.9)	44 (39.3)	54 (43.9)	40 (35.4)	
Medicaid	251 (55.3)	49 (46.2)	64 (57.1)	68 (55.3)	70 (62.0)	
Missing	10 (2.2)	2 (1.9)	4 (3.6)	1 (0.8)	3 (2.7)	
Body mass index in kg/m^2 (mean)	29.8	28.9	30.3	29.7	31.2	0.03
< 25	79 (17.4)	23 (21.7)	23 (20.5)	19 (15.5)	14 (12.4)	0.06
25– < 30	160 (35.2)	44 (41.5)	32 (28.6)	45 (36.6)	39 (34.5)	
30– < 35	139 (30.6)	24 (22.6)	44 (39.3)	37 (30.1)	34 (30.1)	
≥35	76 (16.7)	15 (14.2)	13 (11.6)	22 (17.9)	26 (23.0)	
Parity						0.94
0	202 (44.5)	48 (45.3)	49 (43.8)	54 (43.9)	51 (45.1)	
1	147 (32.4)	35 (33.0)	37 (33.0)	43 (35.0)	32 (28.3)	
≥2	105 (23.1)	23 (21.7)	26 (23.2)	26 (21.1)	30 (26.6)	
Medical conditions						
≥1 medical condition	169 (37.1)	42 (39.6)	41 (36.6)	52 (42.3)	34 (30.1)	0.25
Asthma	58 (12.8)	15 (14.2)	11 (9.8)	16 (13.0)	16 (14.2)	0.74
Chronic hypertension	34 (7.5)	7 (6.6)	8 (7.1)	7 (5.7)	12 (10.6)	0.51
Gestational diabetes	41 (9.0)	11 (10.4)	8 (7.1)	15 (12.2)	7 (6.2)	0.34

Table 1 (*Continued*)

Characteristic	All patients (March 22–April 19)	Week 1 (March 22–March 28)	Week 2 (March 29–April 4)	Week 3 (April 5–April 11)	Week 4 (April 12–April 19)	*p*-Value
Pregestational diabetes	1 (0.2)	0 (0.0)	0 (0.0)	1 (0.8)	0 (0.0)	0.44
Anemia	58 (12.8)	14 (13.2)	18 (16.1)	17 (13.8)	9 (8.0)	0.31
Sickle cell disease	3 (0.7)	0 (0.0)	2 (1.8)	1 (0.8)	0 (0.0)	0.30
HIV	2 (0.4)	0 (0.0)	1 (0.9)	1 (0.8)	0 (0.0)	0.60
Hepatitis B or hepatitis C	1 (0.2)	0 (0.0)	0 (0.0)	1 (0.8)	0 (0.0)	0.44
Abnormal placentation	4 (0.9)	0 (0.0)	1 (0.9)	3 (2.4)	0 (0.0)	0.15
Previous cesarean	102 (22.5)	22 (20.8)	23 (20.4)	28 (22.8)	29 (25.7)	0.78
Multifetal gestation	10 (2.2)	1 (0.9)	3 (2.7)	5 (4.1)	1 (0.9)	0.29
Tobacco use	24 (5.3)	4 (3.8)	8 (7.1)	6 (4.9)	6 (5.3)	0.73
COVID-19 exposure risk factors						0.32
Recent travel	1 (0.2)	0 (0.0)	0 (0.0)	1 (0.8)	0 (0.0)	
COVID-19 exposure ≤14 days[a]	10 (2.2)	2 (1.9)	2 (1.8)	6 (4.9)	0 (0.0)	
Health care employee[b]	10 (5.8)	2 (9.5)	2 (5.3)	3 (3.6)	3 (10.7)	0.35

Abbreviations: COVID-19, novel coronavirus disease 2019; N/A, not applicable.
Note: Categorical variables presented as *n*, (%) unless otherwise specified.
[a]Presumed or confirmed COVID-19 infection. For gestational age, maternal age, and body mass index, the Chi-square test was used to compare categorical variables.
[b]Comparison based on patients with known health care employee status.

included in the analysis. The mean maternal age of the population was 30 years and the mean body mass index (BMI) was 30 kg/m^2. The population was 16% black and 55% Hispanic. The majority of patients (55%) had Medicaid insurance and were multiparous (56%). The most common medical condition was asthma (13%; ►**Table 1**). Evaluating these variables categorically by week of admission, only maternal age differed significantly and statistically, although the differences did not appear to be clinically significant. Overall, 79 of 454 women (17%) had COVID-19. The comparisons by week (15% in week 1, 18% in week 2, 23% in week 3, and 13% in week 4) were not statistically significant ($p = 0.24$). The proportion of patients with COVID-19 was relatively consistent over the study period with each quartile of patients with and without infection within 2 days of each other ($p = 0.65$; ►**Supplementary Table S1** [available in the online version]). When women with and without COVID-19 were compared, those with COVID-19 were significantly more likely to be less than 25 years of age (30 vs. 14%, $p < 0.01$) and less likely to be Hispanic (19 vs. 34%, $p < 0.03$). While patients with COVID-19 were more likely to live in the ZIP codes quartile with the most cases (47 vs. 41%) and less likely to live in the ZIP code quartile with the fewest cases (6 vs. 14%), these comparisons were not statistically significant ($p = 0.18$). Other comparisons by COVID-19 status were not statistically significant (►**Table 2**).

Evaluating symptomology on presentation, women with COVID-19 were significantly more likely to have fever, sore throat, cough, chest pain, dyspnea, myalgias, and malaise (►**Table 3**). Overall, 22 of 79 of women with COVID-19 (27.9%) had symptoms compared with 16 of 375 women without COVID-19 (4.3%). Women with COVID-19 were significantly more likely to have fever on presentation (3.8 vs. 0.0%, $p < 0.01$) but differences in pulse oximetry oxygen saturation ≤95% on presentation (0.0 vs. 1.4%, $p = 0.59$) and leukocyte count ≤6,000/uL (12.8 vs. 6.4%, $p = 0.06$) did not differ significantly. The likelihood of women with COVID-19 presenting with hypoxia ($p = 0.29$), leukocyte count ≤6,000/uL ($p = 0.50$), or symptoms such reported sore throat, cough, chest pain, dyspnea, ageusia or hypogeusia, chills, myalgia, rhinorrhea, nausea or vomiting, headache, abdominal pain, diarrhea, malaise, or rigor ($p = 0.31$) did not differ significantly by study week. In comparison, fever decreased significantly from 56.3% in the first week to 35.0% in the second week to 28.6% in the third week to 6.7% in the fourth week ($p = 0.03$; ►**Supplementary Table S2** [available in the online version]). Among those with COVID-19, 24 (30.4%) were asymptomatic, 49 (62.0%) had mild disease, 4 (5.1%) had severe disease, and 2 (2.5%) had critical disease based on criteria from the World Health Organization.

Many delivery outcomes were similar between women with and without COVID-19 infection. Indications for delivery did not differ significantly for women with and without COVID-19 with the exception that four women were delivered for COVID-19 symptoms (►**Table 4**). Women with COVID-19 were slightly less likely to undergo vaginal delivery (55.2 vs. 51.9%, $p = 0.04$). Women with COVID-19 were more likely to be diagnosed with chorioamnionitis ($p = 0.03$), pneumonia ($p < 0.01$), and fevers without a focal diagnosis ($p < 0.01$). Neonatal outcomes including Apgar's score ≤5 at 1

Table 2 Characteristics of patients with and without COVID-19 delivery hospitalization infection

COVID-19 status	Negative	Positive	*p*-Value
All patients	375 (82.6)	79 (17.4)	N/A
Gestational age at screening in weeks (median)	$39^{0/7}$	$38^{0/7}$	0.37
< 34	16 (4.3)	9 (11.4)	0.12
34–37	27 (7.2)	5 (6.3)	
37– < 39	118 (31.5)	24 (30.4)	
39– < 41	206 (54.9)	38 (48.1)	
41 or greater	8 (2.1)	3 (3.8)	
Maternal age in years (median)	30.7	29.2	0.06
< 25	51 (13.6)	24 (30.4)	<0.01
25–34	214 (57.1)	38 (48.1)	
35–39	74 (19.7)	13 (16.5)	
40 or older	36 (9.6)	4 (5.1)	
Race			0.33
Asian	24 (6.4)	2 (2.5)	
Native Hawaiian/Pacific Islander	2 (0.5)	1 (1.3)	
Black	61 (16.3)	12 (15.2)	
White	143 (38.1)	26 (32.9)	
Unknown	145 (38.7)	38 (48.1)	
Ethnicity			0.03
Hispanic	126 (33.6)	15 (19.0)	
Not Hispanic	196 (52.3)	53 (67.1)	
Unknown	53 (14.1)	11 (13.9)	
Insurance			0.11
Private	167 (44.5)	26 (32.9)	
Medicaid	199 (53.1)	52 (65.8)	
Missing	9 (2.4)	1 (1.3)	
Body mass index in kg/m^2 (median)	29.9	29.7	0.61
< 25	71 (18.9)	8 (10.1)	0.11
25– < 30	124 (33.1)	36 (45.6)	
30– < 35	117 (31.2)	22 (27.9)	
≥35	63 (16.8)	13 (16.5)	
Parity			0.45
0	165 (44.0)	37 (46.8)	
1	126 (33.6)	21 (26.6)	
≥2	84 (22.4)	21 (26.6)	
Medical condition			
≥1 comorbidity	142 (37.9)	27 (34.2)	0.57
Asthma	48 (12.8)	10 (12.7)	0.97
Chronic hypertension	29 (7.7)	5 (6.3)	0.97
Gestational diabetes	34 (8.8)	7 (8.9)	0.95
Pregestational diabetes	0 (0.0)	1 (1.3)	0.17
Anemia	47 (12.5)	11 (13.9)	0.74
Sickle cell	2 (0.5)	1 (1.3)	0.44
HIV	2 (0.5)	0 (0.0)	1.00
Hepatitis	1 (0.3)	0 (0.0)	1.00

Table 2 (*Continued*)

COVID-19 status	Negative	Positive	*p*-Value
Abnormal placentation	2 (0.5)	2 (2.5)	0.14
Previous cesarean	86 (22.9)	16 (20.3)	0.60
Multifetal gestation	9 (2.4)	1 (1.3)	0.53
Tobacco use	22 (5.9)	2 (2.5)	0.40
COVID exposure[b]			1.00
Recent travel	0 (0.0)	1 (1.3)	
COVID 19 exposure within 14 days[a]	0 (0.0)	10 (13.5)	
Health care employee[b]	5 (4.1)	5 (10.2)	0.15
COVID 19 cases per ZIP code[c]			0.18
1. (22–481 cases)	52 (13.9)	4 (5.1)	
2. (482–825 cases)	52 (13.9)	11 (13.9)	
3. (826–1,449 cases)	119 (31.7)	27 (34.2)	
4. (1,500–4,104 cases)	152 (40.5)	37 (46.8)	

Abbreviations: COVID-19, novel coronavirus disease 2019; N/A, not available.
[a]Presumed or confirmed COVID-19 infection.
[b]Excluded missing values.
[c]COVID-19 cases per ZIP code.

Table 3 COVID-19-related findings and symptoms at time of hospital admission

COVID-19 status	COVID-19 negative		COVID-19 positive		
	Present *n* (%)	Absent *n* (%)	Present *n* (%)	Absent *n* (%)	*p*-Value
Symptoms on admission					
Any symptom	16 (4.3)	359 (95.7)	22 (27.9)	57 (72.2)	<0.01
Reported fever	1 (0.3)	374 (99.7)	8 (10.1)	71 (89.9)	<0.01
Sore throat	0 (0.0)	375 (100)	2 (2.5)	77 (97.5)	0.03
Cough	6 (1.6)	369 (98.4)	11 (13.9)	68 (86.1)	<0.01
Chest pain	0 (0.0)	375 (100)	4 (5.1)	75 (94.9)	<0.01
Dyspnea	0 (0.0)	375 (100)	3 (3.8)	76 (96.2)	<0.01
Ageusia or hypogeusia	0 (0.0)	375 (100)	1 (1.3)	78 (98.7)	0.17
Chills	0 (0.0)	375 (100)	3 (3.8)	76 (96.2)	<0.01
Myalgia	2 (0.5)	373 (99.5)	4 (5.1)	75 (94.9)	<0.01
Rhinorrhea	1 (0.3)	374 (99.7)	2 (2.5)	77 (97.5)	0.08
Nausea or vomiting	2 (0.5)	373 (99.5)	2 (2.5)	77 (97.5)	0.14
Headache	6 (1.6)	369 (98.4)	1 (1.3)	78 (98.7)	1.00
Abdominal pain	2 (0.5)	373 (99.5)	1 (1.3)	78 (98.7)	0.44
Diarrhea	0 (0.0)	375 (100)	1 (1.3)	78 (98.7)	0.17
Malaise	1 (0.3)	374 (99.7)	3 (3.8)	76 (96.2)	0.02
Rigor	0 (0.0)	375 (100)	0 (0.0)	79 (100)	n/a
Clinical and laboratory findings					
Fever (≥38.0 °C)	0 (0)	375 (100)	3 (3.8)	76 (96.2)	<0.01
Pulse oximetry oxygen saturation ≤95%	5 (1.4)	365 (98.7)	0 (0.0)	75 (100)	0.59
Leukocyte count ≤6,000/uL	24 (6.4)	350 (93.6)	10 (12.8)	68 (87.2)	0.06

Abbreviation: COVID-19, novel coronavirus disease 2019.
Note: Missing counts on pulse oximetry on admission ($n = 9$) and leukocyte count on admission ($n = 2$).

Table 4 Delivery characteristics

COVID-19 status	COVID-19 negative	COVID-19 positive	*p*-Value
Delivery indication			
Planned induction of labor	127 (33.9)	21 (26.6)	0.21
Planned cesarean section	61 (16.3)	10 (12.7)	0.42
Spontaneous labor	139 (37.1)	35 (44.3)	0.23
Preterm labor	3 (0.8)	0 (0.0)	1.00
Decreased fetal movement	10 (2.7)	4 (5.1)	0.28
Vaginal bleeding	8 (2.1)	3 (3.8)	0.41
Ruptured membranes	56 (14.9)	11 (13.9)	0.82
COVID-19 symptoms	0 (0.0)	4 (5.1)	<0.01
Mode of delivery			0.04
Vaginal delivery	207 (55.2)	41 (51.9)	
Cesarean	168 (44.8)	36 (45.6)	
Dilation and evacuation	0 (0.0)	2 (2.5)	
Postpartum length of stay (median)			
Vaginal delivery	1.52	1.78	0.07
Cesarean delivery	2.00	2.67	<0.01
Gestational age at delivery in weeks (median)	$39^{0/7}$	$39^{0/7}$	0.67
< 34	14 (3.7)	8 (10.1)	0.09
34–37	23 (6.1)	2 (2.5)	
37– < 39	111 (29.6)	23 (29.1)	
39– < 41	210 (56.0)	40 (50.6)	
41 or greater	17 (4.5)	6 (7.6)	
Antenatal steroid receipt with delivery	15 (4.0)	6 (7.6)	0.23
Hypertensive disorders of pregnancy	59 (15.7)	12 (15.2)	0.32
Lowest oxygen saturation (%)			0.19
95–100	304 (81.5)	60 (76.9)	
90–94	59 (15.8)	13 (16.7)	
80–89	8 (2.1)	3 (3.9)	
< 80	2 (0.5)	2 (2.6)	
Other infectious diagnoses			
Chorioamnionitis	9 (2.6)	6 (8.3)	0.03
Pneumonia	0 (0.0)	3 (3.8)	<0.01
Sepsis	0 (0.0)	0 (0.0)	N/A
Endometritis	6 (1.6)	2 (2.5)	0.63
Fevers without focal diagnosis	22 (5.9)	25 (31.7)	<0.01

Abbreviations: COVID-19, novel coronavirus disease 2019; N/A, not available.

and 5 minutes, cord pH of ≤7.10, birth weight <2,500 g, median birth weight, NICU admission and neonatal death did not differ significantly based on maternal COVID-19 status (►Table 5). Length of stay was significantly longer for neonates born to women with COVID-19 (1.66 vs. 1.38 days, $p < 0.01$).

An ROC curve was calculated based on the adjusted model including maternal age, BMI, payer, race, health care worker's status, COVID-19 cases as per ZIP code, and diagnosis interval from March 1, 2020 (►Table 6). The AUC was found to be 0.71 (95% CI: 0.69, 0.80). The ability of differentiation was 42.6% (95% CI: 37.6, 59.4%). When the model was repeated with the 410 patients without symptoms and significant findings on presentation, the AUC (0.71, 95% CI: 0.68, 0.82) and ability of differentiation (42.2%, 95%CI: 35.6, 64.4%) were similar.

Discussion

This study found that a minority of patients who tested positive for COVID-19 by nasopharyngeal PCR swabs had symptoms on presentation necessitating a universal screening protocol. While major obstetrical and neonatal outcomes were

Table 5 Neonatal outcomes

Maternal COVID-19 status	COVID-19 negative	COVID-19 positive	*p*-Value
Apgar's score ≤5 *n* (%)[a]			
1 minute	24 (6.5)	4 (5.1)	0.80
5 minutes	8 (2.2)	1 (1.3)	1.00
Cord pH of ≤7.10 *n* (%)[a]			
Arterial	17 (6.6)	2 (3.5)	0.54
Venous	8 (2.5)	0 (0.0)	0.36
Birth weight <2,500 g *n* (%)	37 (9.9)	9 (11.7)	0.68
Birth weight in grams (median)	3,253	3,270	0.88
Disposition *n* (%)			0.20
Well baby nursery	319 (87.4)	62 (81.6)	
NICU	46 (12.6)	14 (18.4)	
Length of stay (median)	1.38	1.66	<0.01
Neonatal death	2 (0.5)	0 (0.0)	1.00

Abbreviations: COVID-19, novel coronavirus disease 2019; NICU, neonatal intensive care unit.

Table 6 Multivariable logistic regression model for COVID-19 infection

	Adjusted odds ratio	95% CI	*p*-Value
Maternal age (y)			
<25	Reference		
25–34	0.33	0.17, 0.64	<0.01
35–39	0.32	0.14, 0.75	<0.01
≥40	0.19	0.05, 0.66	<0.01
Body mass index (kg/m^2)			
<25	Reference		
25–29	5.22	1.70, 16.05	<0.01
≥30	3.41	1.12, 10.41	0.03
Payer			
Private	Reference		
Medicaid	1.25	0.68, 2.29	0.47
Maternal race			
Asian	Reference		
Other	1.93	0.39, 9.68	0.42
White	1.71	0.34, 8.58	0.52
Health care employee			
Yes	8.66	2.15, 34.90	<0.01
No	Reference		
COVID-19 cases per ZIP code			
Low	Reference		
High	1.96	0.65, 5.92	0.23
Diagnosis Interval from March 1, 2020	0.97	0.94, 1.00	0.06

Abbreviations: CI, confidence interval; COVID-19, novel coronavirus disease 2019.
Note: COVID 19 cases per ZIP code, the low category included the two quartiles of ZIP codes with the lowest COVID-19 case counts while the high category included the two quartiles of ZIP codes with the highest COVID-19 counts.

similar between the two cohorts, there were differences in mode of delivery, length of stay, and infectious diagnosis. Furthermore, the AUC of an ROC curve based on demographic factors did not differ in its ability to discriminate COVID-19 status when performed in symptomatic and asymptomatic patients. When patients with symptoms and significant findings on presentation were excluded performance was similar, indicating that screening based on symptomatology does not improve detection. Overall, the ability of the model to predict positive patients is not strong enough to replace universal screening on our inpatient units. The purpose of universal screening is to improve identification, minimize exposure, and prevent the spread of infection. Screening only those predicted by the model would miss a sizable portion of exposure and possible infection. Reports on overall epidemiology of COVID-19-associated risk and morbidity have demonstrated socioeconomic and racial disparities.[10–12] However, use of these parameters and other demographic factors was not able to differentiate COVID-19 status among all patients at these hospitals with excellent or outstanding discrimination. While the geographical factor of greater cases of COVID-19 per ZIP code was associated with higher likelihood of COVID-19 among delivery admissions, this differential was not statistically significant. Another important finding of our study was that patient symptomatology and clinical findings did not differ appreciably over the study period. We initially hypothesized that symptomatology on presentation would increase with increased spread of the virus in the New York City area. However, with our sample, we were not able to detect such an effect and throughout the study period, a minority of patients had symptoms or significant findings on presentation. The one significant trend that we detected over the study period was that likelihood of fever decreased from the beginning to the end of the study period.

There are several inferences from these findings that may have relevance for other hospitals in considering what type of COVID-19 screening program to implement for women admitted for delivery hospitalizations. First, it may be reasonable for clinicians and hospital leadership to presume that the majority of patients with COVID-19 will be asymptomatic on presentation and that those identified by screening for symptoms, fever, or other findings will represent a minority of cases. Second, because the proportion of COVID-19-positive patients with COVID-19 symptomatology did not change appreciably over the study period, continued universal

screening may be favored for high-prevalence populations on an ongoing basis rather than changing to targeted, risk-factor based approaches. Third, ZIP code case counts were not effective in discriminating between patients at high and low risk, demonstrating the potential limited utility of this type of geographic data. Fourth, even though the hospitals in this study have a sizable patient population and performed a large number of deliveries at the apex of the pandemic in New York City, precise estimates for risk factors were limited based on sample size. The limited ability to determine precise risk may similarly represent a challenge for other hospitals or hospital systems identifying patients for COVID-19 testing based on risk factors as opposed to universal screening.

Limitations

In considering the findings of this study, there are several important limitations to consider. First, in performing screening, we could not identify when infection occurred for women. It may be possible that patients screen positive for COVID-19 after active infection has passed and they no longer pose an infectious risk.[13] For this reason, positive tests ascertained from universal screening may overestimate the number of patients who present an active infection risk. Second, there is the possibility that false positives and false negatives could have contributed to the risk estimates present in the analysis. Data on the test characteristics of viral SARS-CoV-2 PCR of nasopharyngeal samples continue to evolve.[14] Third, the two hospitals in this study primarily serve patients from the South Bronx, Manhattan, and some neighborhoods in Brooklyn. Thus, it is not representative of the entire patient population of New York City, and other centers evaluating patient risk may create models based on risk factors with better or worse discrimination.[15] Fourth, our study cannot make estimates regarding at what population-level infection threshold of universal screening should be performed based on economic, operational, and other considerations. Given that New York City is beyond its apex of the COVID-19 infection, clinical management inferences from these 4 weeks may no longer be appropriate to New York City; with infection rates and population exposures fluid, there may not be static criteria on which to guide screening criteria. Fifth, this study did not analyze antenatal or postpartum admissions for symptomatic COVID-19 and thus does not fully account for the disease burden in the population including significant hypoxia. Sixth, this study used ZIP codes as a proxy for geographical risk which may be imprecise. Prior studies in this population have demonstrated that several characteristics in the built environment are associated with risk and more granular geographic mapping in subsequent analyses may account for more variance.[12] Seventh, many hospitals have already instituted universal screening.

Strengths

Strengths of the study include a relatively large number of deliveries occurring at the height of the COVID-19 pandemic in New York City that review was performed of clinical records, results were ascertained in the setting of a universal screening program, and results were collected from a relatively early time point in the citywide outbreak of COVID-19, past the peak of positive tests, hospitalizations, and deaths.[7]

Conclusion

In conclusion, this study found that COVID-19 symptoms were present in a minority of COVID-19-positive women admitted for delivery, and hospitalizations and symptomatology did not appear to differ before or after the apex of infection in New York City. While demographic risk factors demonstrated acceptable discrimination in modeling patient risk for screening positive, they are unlikely to capture a significant portion of patients positive for COVID-19.

Conflict of Interest

M.D. has had a leadership role in American College of Obstetrics and Gynecology (ACOG) II's Safe Motherhood Initiative which has received unrestricted funding from Merck for Mothers. C.G.-B. disclosed receiving money paid to her institution from Society for Maternal Fetal Medicine (SMFM)/AMAG Pharmaceuticals. She also received funding from Sera Prognostics and various funds for medicolegal work. She also disclosed receiving National Institute of Health (NIH) grants. R.M. disclosed receiving honorarium for writing a chapter on twin reversed arterial perfusion syndrome sequence for UpToDate. He received funds for medicolegal consulting (cases entirely unrelated to the topic of this study). The other authors did not report any potential conflicts of interest.

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