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Patient characteristics associated with SARS-CoV-2 infection in parturients admitted for labour and delivery in Massachusetts during the spring 2020 surge: A prospective cohort study

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A commentary related to this paper appears on pages 34-36

Abstract

Background: While studies from large cities affected by coronavirus disease 2019 (COVID-19) have reported on the prevalence of SARS-CoV-2 in the context of universal testing during admission for delivery, the patient demographic, social and clinical factors associated with SARS-CoV-2 infection in pregnant women are not fully understood.

Objective: To evaluate the epidemiological factors associated with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in women admitted for labour and delivery, in the context of universal screening at four Boston-area hospitals.

Methods: In this prospective cohort study, we reviewed the health records of all women admitted for labour and delivery at four hospitals from the largest health system in Massachusetts between 19 April 2020 and 27 June 2020. We calculated the risk of SARS-CoV-2 infection, including asymptomatic infection. We calculated associations between SARS-CoV-2 infection and demographic and clinical characteristics.

Results: A total of 93 patients (3.2%, 95% confidence interval 2.5, 3.8) tested positive for SARS-CoV-2 infection on admission for labour and delivery out of 2945 patients included in the analysis; 80 (86.0%) of the patients who tested positive were asymptomatic at the time of testing. Factors associated with SARS-CoV-2 infection included the following: younger age, obesity, African American or Hispanic race/ethnicity, residence in heavily affected communities (as measured in cases reported per capita), presence of a household member with known SARS-CoV-2 infection, non-health care essential worker occupation and MassHealth or Medicaid insurance compared to commercial insurance. 93.8% of patients testing positive for SARS-CoV-2 on admission had one or more identifiable factors associated with disease acquisition.

Conclusions: In this large sample of deliveries during the height of the surge in infections during the spring of 2020, SARS-CoV-2 infection was largely concentrated in patients with distinct demographic characteristics, those largely from disadvantaged communities. Racial disparities seen in pregnancy persist with respect to SARS-CoV-2 infection.

KEYWORDS

COVID-19, health disparities, pandemic, racial disparities, universal testing

1 | BACKGROUND

With over 1500 documented severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) cases per 100 000 residents at the end of June 2020,[1] the Commonwealth of Massachusetts had the third highest rate of infection per capita in the United States during the spring 2020 surge.[2] Mass General Brigham is the largest network of hospitals in Massachusetts. All birth hospitals within the network implemented universal SARS-CoV-2 testing of all women admitted for labour and delivery using polymerase chain reaction (PCR) testing for SARS-CoV-2 on 19 April 2020.

While studies from large cities affected by coronavirus disease 2019 (COVID-19), including this population, have reported on the prevalence of SARS-CoV-2 in the context of universal testing during admission for delivery, patient demographic, social and clinical factors associated with SARS-CoV-2 infection in pregnant women in the United States are not well characterised.[3-16] Now that the height of the spring COVID-19 surge is past, after action reports can help elucidate epidemiological factors associated with SARS-CoV-2 infection in pregnant women that may provide insight into patterns of infection which may be relevant for communities that subsequently experience a similar surge in infection. The aim of this study was therefore to determine the prevalence of, and factors associated with, SARS-CoV-2 infection in patients admitted for labour and delivery at four Boston-area hospitals. We hypothesised that, consistent with what had been observed in the general population, SARS-CoV-2 infection was concentrated in obstetrical patients with distinct demographic, occupational and socio-economic characteristics.

Synopsis

Study question

What are the factors associated with SARS-CoV-2 infection in women admitted for labour and delivery in Massachusetts during the height of the spring surge in 2020?

What is already known

Epidemiological factors associated with SARS-CoV-2 infection in pregnant women in the United States are not fully understood and may vary by patient demographics, occupation, comorbidities and socio-economic factors.

What this study adds

In the context of universal testing of patients admitted to labour and delivery in a large health care system in Massachusetts at the height of the initial surge, the risk of SARS-CoV-2 infection was concentrated in younger patients, patients of Hispanic ethnicity and African American race, obese patients, non-health care essential workers, Medicaid beneficiaries, women with household contacts with known infection and those residing in highly affected communities. Racial disparities seen in adverse pregnancy outcomes extended to SARS-CoV-2 infection during this period and mirror trends seen in the Massachusetts general population.

2 | METHODS

Universal testing of all patients admitted for labour and delivery at all Mass General Brigham hospitals began on 19 April 2020. Mass General Brigham includes four large hospitals: two academic medical centres and two community hospitals with a combined estimated annual delivery volume of approximately 15 000 deliveries per year.

2.1 | Cohort selection

All women who were admitted for labour and delivery at all Mass General Brigham hospitals between 19 April 2020 and 27 June 2020 and tested for SARS-CoV-2 up to 48 hours before admission or upon admission were included in this study.

2.2 | Exposure

All SARS-CoV-2 testing was performed by nasopharyngeal reverse transcription-PCR (RT-PCR) using assays approved via United States Food and Drug Administration Emergency Use Authorisation. Testing of all women admitted for labour and delivery was routine and universal during this time period. For women undergoing planned induction of labour or caesarean delivery, testing may have been performed prior to admission (though within 48 hours of admission). In these instances, the chart was reviewed for tests performed elsewhere. For women presenting in labour or without prior SARS-CoV-2 testing, the testing was performed in-house with rapid (2- to 8-hour turnaround time) RT-PCR testing. Electronic health records were manually reviewed by four co-authors (SR, MLM, CK, SB) for all patients admitted to labour and delivery during the study period to abstract SARS-CoV-2 test results, demographic data and medical variables that may be associated with SARS-CoV-2 infection.

2.3 | Outcomes

We calculated the risk (and exact 95% confidence interval) of a positive SARS-CoV-2 test up to 48 hours before or on admission to labour and delivery among our study population over the entire study population and by study week. Patients not tested for SARS-CoV-2 were excluded from these analyses, as were patients who tested positive earlier in pregnancy but negative at the time of admission for labour and delivery, given the focus of the study was on the risk of SARS-CoV-2 infection at the time of delivery. We calculated the proportion of women testing positive for SARS-CoV-2 on admission who were asymptomatic, with symptoms defined as fever, chills, cough, dyspnoea, myalgia, headache, anosmia, ageusia, sore throat, rhinorrhea, nausea or vomiting, abdominal pain, or diarrhoea. Patient symptoms were recorded based on nursing intake questionnaires completed on all patients during the pandemic. The average daily positive tests per 100 admissions to labour and delivery were compared to statewide data from the Massachusetts Department of Public Health per 100 000 residents aged 20-39 by study week.

Demographic, socio-economic and clinical factors evaluated for their association with infection included maternal age, body mass index (BMI), race, comorbidities (gestational diabetes, pre-existing diabetes, asthma, smoking, opioid use disorder), zip code, known SARS-CoV-2 infection in a household member, parity (as a surrogate for number children in the household), occupation and insurance type (MassHealth or Medicaid vs commercial insurance). We identified the factors most strongly associated with SARS-CoV-2 infection and determined the risk of infection, stratified based on the number of factors associated with infection present.

The zip code of patient residence was mapped to the corresponding towns.[17] The COVID-19 rate, defined as the number of confirmed cases per capita provided from the Massachusetts Department of Public Health,[1] was recorded on 13 May 2020. Occupation for each patient was classified into categories based on the United States Bureau of Labor Statistics 2018 Standard Occupation Classification System.[18] Occupations were then classified as essential workers vs nonessential workers, with health care workers being a subset of essential workers. Occupations were determined to be essential based on the emergency order enacted by the governor of Massachusetts on 23 March 2020[19]; those included as essential were as follows: building and grounds cleaning and maintenance occupations, food preparation and serving related occupations, health care practitioners and technical occupations, health care support occupations, installation, maintenance, and repair occupations, military support occupations, protective service occupations, and transportation and material moving occupations. The medical records of all essential workers were manually searched for documentation of whether the patient was working from home or not working. If patients whose job fell into the essential workers category were specifically noted to be working from home or not working for over 2 weeks prior to delivery, they were not included in the essential worker category.

2.4 | Statistical analysis

The purpose of this study was to assess the association between patient factors (including maternal age category, delivery BMI category, race/ethnicity, gestational diabetes, pre-existing diabetes, asthma, smoking, opioid use disorder, COVID-19 rate percentile among Massachusetts town category, household member with known SARS-CoV-2 infection, number of children at home grouped as none or 1 or more, occupation category and insurance type) and SARS-CoV-2 infection. The prevalence of SARS-CoV-2 infection stratified by patient characteristics is presented as percentages with 95% bias-corrected and accelerated (BCa) bootstrap confidence intervals (CI), estimated with 3000 resamples. Exact CIs are presented for complete case analysis of factors with 0 prevalence among SARS-CoV-2-positive patients, where there was no variability in prevalence estimates across bootstrap resamples. The univariate association between each patient factor of interest and the odds of SARS-CoV-2 infection was assessed using simple logistic regression models.

Effect sizes are presented as crude odds ratios with 95% BCa bootstrap CI estimated with 3000 resamples.[20] Profile likelihood CIs are presented for factors with at least one category with very few (<4) SARS-CoV-2-positive patients.[21] In these categories, bootstrap samples often contained no SARS-CoV-2-positive patients, producing bootstrap confidence interval lower limits for odds ratios of 0. Due to the limited number of SARS-CoV-2 infections, estimating a full multivariable logistic regression model including all covariates of interest was not feasible.[22] Therefore, as an exploratory analysis, multivariable logistic regression with the least absolute shrinkage and selection operator (lasso)[23] was used to identify a subset of predictors of interest with the strongest association with SARS-CoV-2 infection. Lasso is a penalised regression method that constrains the sum of the magnitude of regression model coefficients such that covariates that do not improve prediction of the outcome are shrunk to zero, thus creating a more parsimonious model.[24] The degree of penalisation, lambda, was selected as the largest value that maintained tenfold cross-validated prediction error within 1 standard error of the minimum.[23] Predictors entered into the lasso model included all factors assessed for univariate association with SARS-CoV-2 infection.

2.5 | Missing data

Missing data on maternal race (0.3%), occupation category (7.4%) and delivery BMI category (0.1%) were addressed using multiple imputation by fully conditional specification, assuming that data were missing at random given observed data.[25] BCa bootstrap CIs were calculated in the presence of multiply imputed data using a modified version of the "Boot MI" approach.[26] First, 3000 bootstrap resamples were drawn from the dataset with missing values. Second, in each bootstrap resample race and occupation category were imputed by the discriminant function method and delivery BMI category was imputed using logistic regression, producing 20 complete datasets per bootstrap resample. Imputation models included all predictors assessed for univariate association with SARS-CoV-2 infection, as well as delivery hospital and SARS-CoV-2 test result. Third, prevalence and odds ratio estimates were obtained from each of the 20 complete datasets and combined using Rubin's rules to produce one point estimate per bootstrap sample.[27] Fourth, these 3000 point estimates were used to calculate 95% BCa bootstrap CI for each prevalence and odds ratio estimate. For the lasso logistic regression model, pooled beta coefficients were obtained by averaging across imputations.

Statistical analyses were performed using SAS software version 9.4 (SAS Institute Inc, Cary, NC, USA) and R software version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria).

2.6 | Ethics approval

Mass General Brigham Institutional Review Board approval was obtained for this study, and the need for informed consent was waived.

3 | RESULTS

There were 2945 deliveries at Mass General Brigham hospitals during the study time period. Five patients who were not tested for SARS-CoV-2 and 18 who tested positive earlier in pregnancy but negative at the time of admission for labour and delivery were excluded from all analyses; 63 patients residing outside Massachusetts were excluded from any analysis assessing COVID-19 rate by zip code (Figure 1). Ninety-three out of 2945 women tested positive for SARS-CoV-2 on admission; the risk of SARS-CoV-2 infection of patients tested in our sample was 3.2% (95% CI 2.5, 3.8). In Figure 2, new positive tests per capita in our study are compared to age-specific statewide data from the Massachusetts Department of Public Health by study week.

Table 1 shows the prevalence of SARS-CoV-2 infection stratified by patient characteristics. Demographic and clinical factors strongly associated with SARS-CoV-2 infection include younger age, obesity, African American race and Hispanic ethnicity (Table 2). Geographic and occupational factors strongly associated with infection include an increased rate of documented SARS-CoV-2 infections per capita in the patient's town, a household member with known SARS-CoV-2 infection, essential worker occupation excluding health care workers and Medicaid insurance vs commercial (Table 3).

A vast majority (93.8%) of women who tested positive at the time of admission for labour and delivery had at least one of these factors strongly associated with SARS-CoV-2 infection; 43.2% had four or more identifiable factors (Figure 3). In contrast, only 6.8% of patients testing negative for SARS-CoV-2 had four or more factors associated with infection. While the number of outcome events precluded assessing the independent effect of each of these factors, the lasso regression identified COVID-19 rate in the 95-99th percentile, Hispanic ethnicity, household member with known SARS-CoV-2 infection, essential worker occupation (excluding health care worker) and MassHealth or Medicaid insurance as the strongest predictors (Table S1). Among women testing positive on admission for labour and delivery, 86.0% were asymptomatic (Table 4).

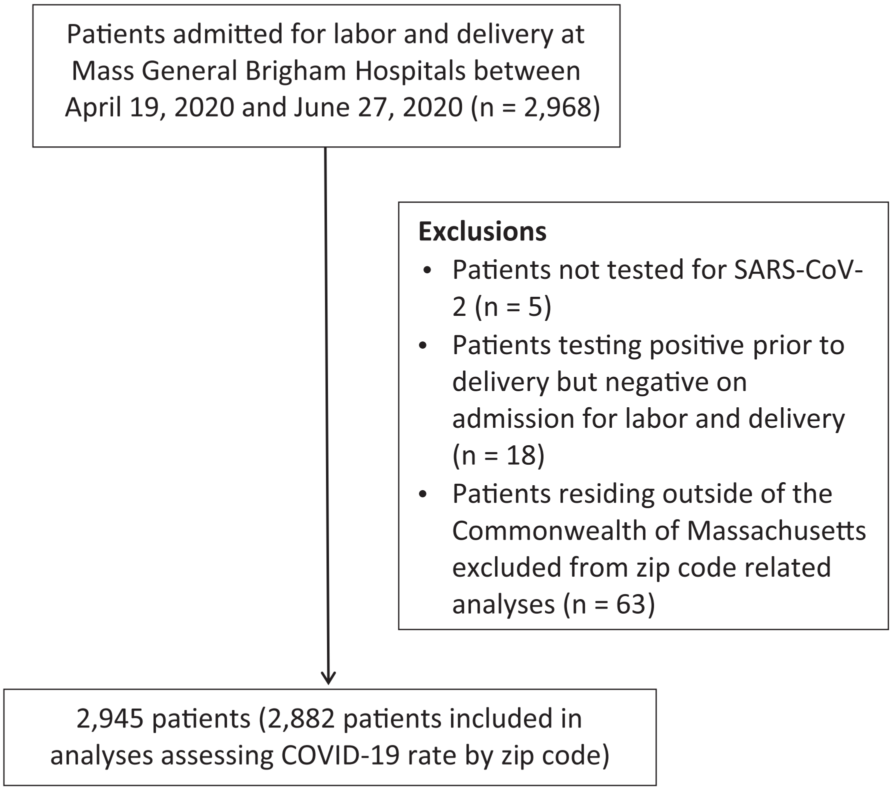

FIGURE 1 Cohort selection

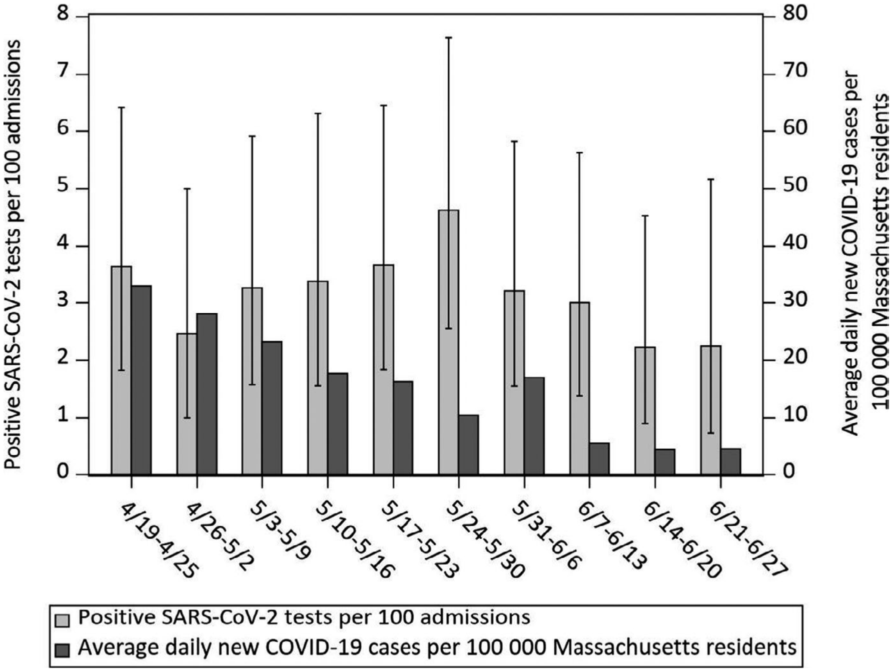

FIGURE 2 Age-specific disease burden over time

4 | COMMENT

4.1 | Principal findings

In this large sample of patients admitted for labour and delivery undergoing universal SARS-CoV-2 testing during the height of the initial surge of infections in Massachusetts, we observed an overall 3.2% risk of infection, with over three-quarters of infected patients being asymptomatic. The risk was largely clustered in patients with distinct demographic and occupational characteristics. The risk of infection was 10% for women living in the town's most heavily affected by COVID-19 based on publicly reported case rates in the general population, compared to 1% for those living in towns with the lowest infection rates. Approximately 12% of Hispanic women and 7% of African American women were infected, versus 1% of Caucasian and Asian women. The risk of infection in public insurance beneficiaries was nearly tenfold higher than in privately insured women, and essential workers outside of health care had a markedly high risk of infection, 14%. These results are consistent with findings in non-obstetric populations demonstrating increased vulnerability among African American and Hispanic populations, in addition to those of lower socio-economic status and those with essential worker occupations.[28-31]

4.2 | Strengths of the study

Strengths of our study include the high rate (>99%) rate of SARS-CoV-2 testing on admission, with a large study population of nearly 3000 patients included in a 10-week time period. Furthermore, manual chart review of all patients allowed for robust examination of detailed demographic and clinical data.

4.3 | Limitations of the data

With 93 cases of infection in our sample, it was not possible to perform extensive multivariable adjustments, particularly given that a number of factors associated with infection may be correlated, but an understanding of the factors associated with infection remains relevant to recognising which patients may be at risk for SARS-CoV-2 infection. Moreover, the linear relationship of risk of infection with each additional associated factor suggests that the factors are not all correlated and that there is additive risk with each added factor. In this study, we equate a negative test with the lack of infection, but while the sensitivity of the test is high, it may be imperfect. However, in the context of an overall low prevalence of infection, false negatives are unlikely to substantially bias the associations with risk factors reported. Finally, the frequencies of SARS-CoV-2 infection in pregnant patients and factors associated with infection may not be fully generalisable to the general population, given physiologic changes specific to pregnancy and potential variations in behaviour of pregnant women compared to the general population, particularly in the weeks leading up to delivery. Nonetheless, our findings remain important in understanding the epidemiology of the disease among pregnant women.

4.4 | Interpretation

The factors associated with SARS-CoV2 infection may vary between communities and are likely to evolve as the pandemic progresses in various settings. Based on Massachusetts data at the peak of the spring 2020 surge, the strong association of infection with particular demographic characteristics and neighbourhoods suggest the need for public health officials and clinicians to track and use this type of

TABLE 1 Prevalence of SARS-CoV-2 infection stratified by patient characteristics

	Total n = 2945	SARS-CoV-2 positive n = 93	Prevalence of SARS-CoV-2 infection (%, 95% CI)
Maternal age (y)			
<25	177	23	13.0 (8.6, 18.8)
25-35	1982	48	2.4 (1.8, 3.2)
≥36	786	22	2.8 (1.8, 4.2)
Missing	0	0	–
Body mass index (kg/m^2)			
Normal (≤24.9)	432	9	2.1 (0.9, 2.7)
Overweight (25.0-29.9)	1127	28	2.5 (1.7, 3.5)
Obese (≥30.0)	1382	56	4.0 (3.0, 5.2)
Missing	4	0	–
Race/ethnicity			
Caucasian	1902	23	1.2 (0.8, 1.8)
African American	257	18	6.9 (4.2, 10.4)
Hispanic	413	49	11.8 (8.8, 14.9)
Asian	346	3	0.9 (0.0, 2.1)
Other	8	0	0 (N/A)[a]
Missing	19	0	–
Comorbidities			
Gestational diabetes	286	9	3.1 (1.5, 5.7)
Pre-existing diabetes	25	1	4.0 (0.0, 15.0)
Asthma	366	11	3.0 (1.6, 5.1)
Tobacco exposure	25	2	8.0 (0.0, 22.6)
Opioid use disorder	22	0	0.0 (0.0, 15.4)[b]
Missing	0	0	–
COVID-19 rate category among Massachusetts towns (based on cases/100 000 residents)			
≤90th	1533	15	1.0 (0.6, 1.6)
90-94th	894	29	3.2 (2.2, 4.5)
≥95th	455	47	10.3 (7.8, 13.4)
Missing	63	2	–
Household member with known SARS-CoV-2 infection			
Yes	49	21	42.9 (28.0, 55.6)
No	2896	72	2.5 (2.0, 3.1)
Missing	0	0	–
Number of children at home			
≥1	953	37	3.9 (2.8, 5.3)
0	1992	56	2.8 (2.2, 3.6)
Missing	0	0	–
Occupation			
Nonessential workers	2273	58	2.7 (2.1, 3.4)
Health care workers	332	7	2.2 (0.8, 4.0)
Essential workers excluding health care workers	121	17	14.6 (8.7, 21.4)

(Continues)

TABLE 1 (Continued)

	Total n = 2945	SARS-CoV-2 positive n = 93	Prevalence of SARS-CoV-2 infection (%, 95% CI)
Missing	219	11	–
Insurance type			
MassHealth or Medicaid	486	58	11.9 (9.2, 15.0)
Commercial or out-of-pocket	2459	35	1.4 (1.0, 1.9)
Missing	0	0	–

Abbreviations: CI, Confidence interval; COVID-19, Coronavirus disease 2019; SARS-CoV-2, Severe acute respiratory syndrome coronavirus 2.
[a]Confidence interval not estimable for multiply imputed data due to zero prevalence of the factor in SARS-CoV-2-positive patients.
[b]95% confidence interval estimated using the exact method due to lack of variability in bootstrap samples given zero prevalence of the factor in SARS-CoV-2-positive patients.

data as outbreaks occur in order to implement interventions aimed at decreasing infection rates in particular communities.[32] The high risk of infection in non-health care essential workers suggests that directive work-related precautions should be offered to women who work in non-health care related high risk settings, if at all possible. As having a household member with known SARS-CoV-2 infection was also strongly associated with infection at the time of admission for labour and delivery, all household members should be counselled to take precautions to avoid infection, which may prevent transmission of the virus to the parturient.

TABLE 2 Demographics and clinical factors associated with SARS-CoV-2 infection

	SARS-CoV-2 testing		
	Positive (n = 93)	Negative (n = 2852)	Unadjusted odds ratio, 95% confidence interval
Maternal age (y) mean ± SD	29.6 ± 6.5	32.7 ± 4.8	
<25, n (%)	23 (24.7)	154 (5.4)	6.02 (3.48, 10.13)
25-35, n (%)	48 (51.6)	1934 (67.8)	1.00 (Reference)
≥36, n (%)	22 (23.7)	764 (26.8)	1.16 (0.67, 1.93)
Body mass index (kg/m^2)	31.6 ± 5.8	30.5 ± 5.9	
Normal (≤24.9), n (%)	9 (9.7)	423 (14.9)	1.00 (Reference)
Overweight (25.0-29.9), n (%)	28 (30.1)	1099 (38.6)	1.20 (0.59, 3.29)
Obese (≥30.0), n (%)	56 (60.2)	1326 (46.6)	1.99 (1.04, 5.41)
Race/ethnicity, n (%)			
Caucasian	23 (24.7)	1879 (66.3)	1.00 (Reference)
African American	18 (19.4)	239 (8.4)	6.14 (3.00, 11.86)
Hispanic	49 (52.7)	364 (12.8)	10.97 (6.71, 18.65)
Asian	3 (3.2)	343 (12.1)	0.72 (0.21, 2.39)[a]
Other	0 (0.0)	8 (0.3)	N/A[b]
Comorbidities, n (%)			
Gestational diabetes	9 (9.7)	277 (9.7)	1.00 (0.41, 1.81)
Pre-existing diabetes	1 (1.1)	24 (0.8)	1.28 (0.07, 6.16)[a]
Asthma	11 (11.8)	355 (12.4)	0.94 (0.42, 1.71)
Tobacco exposure	2 (2.2)	23 (0.8)	2.70 (0.43, 9.33)[a]
Opioid use disorder	0 (0.0)	22 (0.8)	N/A[b]

Abbreviations: N/A, Not applicable; SARS-CoV-2, Severe acute respiratory syndrome coronavirus 2; SD, Standard deviation.
[a]95% confidence interval estimated using the profile likelihood method because bootstrap samples often contained no SARS-CoV-2-positive patients within the category, producing a bootstrap confidence interval lower limit for the odds ratio of 0
[b]Odds ratio not estimable due to zero prevalence of factor in SARS-CoV-2-positive patients.

TABLE 3 Geographic and occupational factors associated with SARS-CoV-2 infection

	SARS-CoV-2 testing		Unadjusted odds ratio, 95% confidence interval
	Positive (n = 93)	Negative (n = 2852)	
Percentile, COVID-19 rate among Massachusetts towns (based on cases/100 000 residents)[a], n (%)			
<90th	15 (16.5)	1518 (54.4)	1.00 (Reference)
90-94th	29 (31.9)	865 (31.0)	3.39 (1.83, 6.98)
≥95th	47 (51.6)	408 (14.6)	11.66 (6.42, 22.25)
Household member with known SARS-CoV-2 infection, n (%)	21 (22.6)	28 (1.0)	29.42 (15.41, 55.20)
Number of children at home, median (Q1, Q3)	0 (0, 1)	0 (0, 1)	
None, n (%)	56 (60.2)	1936 (67.9)	1.00 (Reference)
≥1, n (%)	37 (39.8)	916 (32.1)	1.40 (0.89, 2.09)
Occupation, n (%)			
Nonessential workers	58 (70.7)	2215 (83.8)	1.00 (Reference)
Health care workers	7 (8.5)	325 (12.3)	0.81 (0.27, 1.68)
Essential workers excluding health care workers	17 (20.7)	104 (3.9)	6.24 (3.34, 11.15)
Insurance type, n (%)			
MassHealth or Medicaid	58 (62.4)	428 (15.0)	9.39 (6.19, 14.63)
Commercial or out-of-pocket	35 (37.6)	2424 (85.0)	1.00 (Reference)

Abbreviations: COVID-19, Coronavirus disease 2019; Q1, First quartile; Q3, Third quartile; SARS-CoV-2, Severe acute respiratory syndrome coronavirus 2.

[a]Number of cases per 100 000 residents are 0-1436, 1437-1791 and 1792-6404 corresponding to <90th, 90-94th and ≥95th percentiles, respectively.

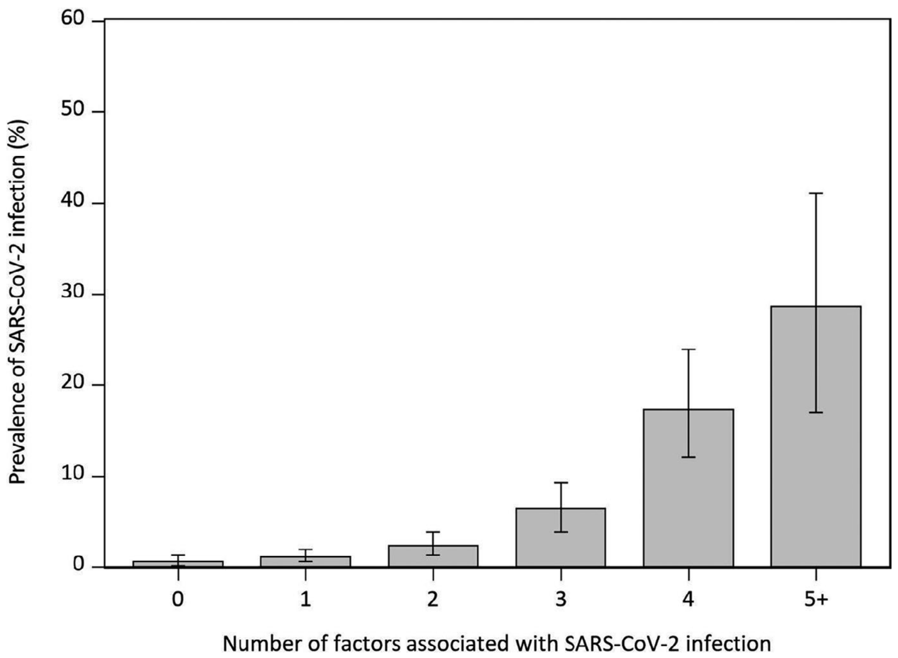

FIGURE 3 Patient risk of SARS-CoV-2 infection stratified by number of factors associated with infection present. *Legend*: Number of factors associated with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. Factors included in analyses: age < 25, body mass index (BMI) ≥30 kg/m^2, African American or Hispanic race/ethnicity, coronavirus disease 2019 (COVID-19) rate in the patient's town 95-99th percentile, household member with known SARS-CoV-2 infection, essential worker occupation (excluding health care worker), and MassHealth or Medicaid insurance. Number of infected patients in each category: 0 factors associated with infection, 5 patients; 1 factor, 10 patients; 2 factors, 13 patients; 3 factors, 18 patients; 4 factors, 22 patients; 5 + factors, 13 patients

TABLE 4 Characteristics of SARS-CoV-2-Positive Patients

	n = 93
Asymptomatic on admission, n (%)	80 (86.0)
Symptoms, n (%)	
Fever	6 (6.5)
Chills	1 (1.1)
Cough	5 (5.4)
Dyspnoea	4 (4.3)
Myalgia	3 (3.2)
Headache	3 (3.2)
Anosmia	6 (6.5)
Ageusia	2 (2.2)
Sore throat	2 (2.2)
Rhinorrhea	2 (2.2)
Nausea or vomiting	2 (2.2)
Abdominal pain	1 (1.1)
Diarrhoea	1 (1.1)
Caesarean delivery, n (%)	32 (34.4)
Gestational age at delivery, weeks, mean ± SD	38.8 ± 2.0

Abbreviations: SARS-CoV-2, Severe acute respiratory syndrome coronavirus 2; SD, Standard deviation.

Our data demonstrate that pregnant women from vulnerable populations were disproportionately affected by SARS-CoV2 infection during the first wave of infection in Massachusetts. These trends are in line with the widespread racial and socio-economic disparities in COVID-19 seen in the general population in Massachusetts[33] and in other large urban cities,[16] and though explanations for these disparities are multi-fold, it is likely that residence in crowded urban settings, poverty and employment in essential occupations, and decreased access to care play a role.[34,35] Thus, there are profound racial and economic disparities in COVID-19 in pregnant women in Massachusetts that track racial and economic disparities in maternal health and obstetrical outcomes observed more generally.[36]

Compared to data from our study, the documented rates of new SARS-CoV-2 infection per capita in the state of Massachusetts for the people aged 20-39 were multi-fold lower,[1] likely due to a substantial undercounting of disease burden given widespread asymptomatic disease among routinely tested labour and delivery patients, in contrast to the limited testing available for the general population. Most SARS-CoV-2 testing is performed due to patient symptoms; there are few settings where ongoing universal screening of otherwise healthy patients is conducted. Thus, such universal testing can provide valuable insight into the disease dynamics in the community and can be used to monitor the burden of disease.[3-6]

5 | CONCLUSIONS

In this large cohort of women admitted for labour and delivery in Massachusetts undergoing universal SARS-CoV-2 infection screening, there were multiple identifiable factors associated with infection. Almost all patients who tested positive for infection had one or more identifiable factors associated with disease. SARS-CoV-2 infection most heavily affected pregnant women who were younger, African American or Hispanic, non-health care essential workers, publicly insured or from heavily affected areas, underscoring another source of disparity in obstetrics.

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CONFLICT OF INTEREST

The authors report no conflicts of interest.

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REFERENCES

1. Archive of COVID-19 cases in Massachusetts. Massachusetts Department of Public Health. The Commonwealth of Massachusetts, 2020. (Accessed May 18, 2020, 2020, at https://www.mass.gov/info-details/archive-of-covid-19-cases-in-massachusetts#march-2020-).
2. Coronavirus Locations: COVID-19 Map by County and State. USAFacts, 2020. (Accessed May 18, 2020, 2020, at https://usafacts.org/visualizations/coronavirus-covid-19-spread-map/).
3. Sutton D, Fuchs K, D'Alton M, Goffman D. Universal screening for SARS-CoV-2 in women admitted for delivery. *N Engl J Med*. 2020;382(22):2163-2164.
4. Kissler S, Kishore N, Prabhu M, et al. Reductions in commuting mobility predict geographic differences in SARS-CoV-2 prevalence in New York City. 2020.
5. Gagliardi L, Danieli R, Suriano G, et al. Universal SARS-CoV-2 testing of pregnant women admitted for delivery in two Italian regions. *Am J Obstet Gynecol*. 2020;223(2):291-292.
6. Bianco A, Buckley AB, Overbey J, et al. Testing of patients and support persons for coronavirus disease 2019 (COVID-19) infection before scheduled deliveries. *Obstet Gynecol*. 2020;136(2):283-287.
7. Goldfarb IT, Diouf K, Barth WH, et al. Universal SARS-CoV-2 testing on admission to the labor and delivery unit: low prevalence among asymptomatic obstetric patients. *Infect Control Hosp Epidemiol*. 2020;41(9):1095-1096.
8. Emeruwa UN, Ona S, Shaman JL, et al. Associations between built environment, neighborhood socioeconomic status, and SARS-CoV-2 infection among pregnant women in New York City. *JAMA*. 2020;324(4):390-392.
9. Goldfarb IT, Clapp MA, Soffer MD, et al. Prevalence and severity of coronavirus disease 2019 (COVID-19) illness in symptomatic pregnant and postpartum women stratified by hispanic ethnicity. *Obstet Gynecol*. 2020;136(2):300-302.
10. Takemoto M, Menezes MO, Andreucci CB, et al. Clinical characteristics and risk factors for mortality in obstetric patients with severe COVID-19 in Brazil: a surveillance database analysis. *BJOG*. 2020;127(13):1618-1626.
11. Brandt JS, Hill J, Reddy A, et al. Epidemiology of COVID-19 in pregnancy: risk factors and associations with adverse maternal and neonatal outcomes. *Am J Obstet Gynecol*. 2020;S0002-9378(20):31134-0.

12. Knight M, Bunch K, Vousden N, et al. Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: national population based cohort study. *BMJ*. 2020;369:m2107.
13. Andrikopoulou M, Madden N, Wen T, et al. Symptoms and critical illness among obstetric patients with coronavirus disease 2019 (COVID-19) infection. *Obstet Gynecol*. 2020;136:291-299.
14. Sakowicz A, Ayala AE, Ukeje CC, Witting CS, Grobman WA, Miller ES. Risk factors for SARS-CoV2 infection in pregnant women. *Am J Obstet Gynecol MFM*. 2020;2(4):100198.
15. Allotey J, Stallings E, Bonet M, et al. Clinical manifestations, risk factors, and maternal and perinatal outcomes of coronavirus disease 2019 in pregnancy: living systematic review and meta-analysis. *BMJ*. 2020;370:m3320.
16. Emeruwa UN, Spiegelman J, Ona S, et al. Influence of race and ethnicity on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection rates and clinical outcomes in pregnancy. *Obstet Gynecol*. 2020;136(5):1040-1043.
17. MassGIS Data: Zip Codes (5-digit) from HERE (Navteq). The Commonwealth of Massachusetts. (Accessed May 18, 2020, 2020, at https://docs.digital.mass.gov/dataset/massgis-data-zip-codes-5-digit-here-navteq-0).
18. Standard Occupational Classification System. United States Bureau of Labor Statistics. United States government, 2018. (Accessed May 18, 2020, 2020, at https://www.bls.gov/soc/2018/major_groups.htm).
19. COVID-19 Essential Services FAQs. Commonwealth of Massachusetts, 2020. (Accessed May 18, 2020, 2020, at https://www.mass.gov/info-details/covid-19-essential-services-faqs).
20. Davison AC, Hinkley DV. *Bootstrap Methods and Their Application*. Cambridge; New York, NY: Cambridge University Press; 1997.
21. Greenland S, Mansournia MA, Altman DG. Sparse data bias: a problem hiding in plain sight. *BMJ*. 2016;352:i1981.
22. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. *J Clin Epidemiol*. 1996;49:1373-1379.
23. Tibshirani R. Regression Shrinkage and Selection via the Lasso. *J Roy Stat Soc: Ser B (Methodol)*. 1996;58:267-288.
24. Pavlou M, Ambler G, Seaman SR, et al. How to develop a more accurate risk prediction model when there are few events. *BMJ*. 2015;351:h3868.
25. van Buuren S. Multiple imputation of discrete and continuous data by fully conditional specification. *Stat Methods Med Res*. 2007;16:219-242.
26. Schomaker M, Heumann C. Bootstrap inference when using multiple imputation. *Stat Med*. 2018;37:2252-2266.
27. Rubin DB. *Multiple Imputation for Nonresponse in Surveys*. New York: Wiley; 1987.
28. Vahidy FS, Nicolas JC, Meeks JR, et al. Racial and ethnic disparities in SARS-CoV-2 pandemic: analysis of a COVID-19 observational registry for a diverse US metropolitan population. *BMJ Open*. 2020;10:e039849.
29. Price-Haywood EG, Burton J, Fort D, Seoane L. Hospitalization and mortality among black patients and white patients with Covid-19. *N Engl J Med*. 2020;382:2534-2543.
30. Ioannou GN, Locke E, Green P, et al. Risk factors for hospitalization, mechanical ventilation, or death among 10131 US veterans with SARS-CoV-2 infection. *JAMA Netw Open*. 2020;3:e2022310.
31. Tenforde MW, Billig Rose E, Lindsell CJ, et al. Characteristics of adult outpatients and inpatients with COVID-19 - 11 academic medical centers, United States, March-May 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69:841-846.
32. Team CC-R. Geographic differences in COVID-19 cases, deaths, and incidence - United States, February 12-April 7, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(15):465-471.
33. New data on state's coronavirus cases, deaths show stark racial divide. 2020. (Accessed August 20, 2020, 2020, at https://www.bostonglobe.com/2020/06/19/nation/new-data-states-coronavirus-cases-deaths-show-stark-racial-divide/).
34. Webb Hooper M, Napoles AM, Perez-Stable EJ. COVID-19 and racial/ethnic disparities. *JAMA*. 2020;323(24):2466.
35. Yancy CW. COVID-19 and African Americans. *JAMA*. 2020;323(19):1891.
36. Bryant AS, Worjoloh A, Caughey AB, Washington AE. Racial/ethnic disparities in obstetric outcomes and care: prevalence and determinants. *Am J Obstet Gynecol*. 2010;202:335-343.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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