Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Neighborhood deprivation and preterm delivery during the coronavirus 2019 pandemic

Stephanie A. Fisher, MD, MPH; Allie Sakowicz, MS; Cynthia Barnard, PhD, MBA; Seth Kidder, MPH; Emily S. Miller, MD, MPH

BACKGROUND: Prior studies have reported decreases in the preterm delivery incidence during the COVID-19 pandemic. However, the findings are inconsistent. Given the wide disparities in the pandemic's impact across communities, neighborhood deprivation may explain the observed variation in the relationship between the COVID-19 pandemic and preterm delivery.

OBJECTIVE: To characterize the changes in the incidence of preterm delivery during the COVID-19 pandemic with attention to the effect modification introduced by neighborhood hardship.

STUDY DESIGN: This retrospective cohort study included all the pregnant patients who delivered at an urban tertiary care hospital during the pandemic (April—November 2020) or before the pandemic (April—November 2019). We compared the incidence of preterm delivery, spontaneous preterm delivery, and medically indicated preterm delivery before 37 weeks' gestation across epochs. Planned analyses stratified the cohorts by neighborhood deprivation metrics defined by the residential zip code; the metrics included the median neighborhood household income and the hardship index (a composite index including dependency, educational attainment, unemployment, poverty, per capita income, and crowded housing). The Breslow-Day test for homogeneity assessed the association of the delivery epoch and neighborhood deprivation with the preterm delivery outcomes.

RESULTS: Of 16,544 eligible deliveries, 8.7% occurred preterm. The incidences of preterm delivery (8.4% vs 9.0%; *P*=.17), spontaneous preterm delivery (5.0 vs 5.4%; *P*=.27), and medically indicated preterm delivery (3.2% vs 3.5%; *P*=.47) were similar in the pandemic and prepandemic epochs. However, the preterm delivery (odds ratio, 0.78; 95% confidence interval, 0.64—0.96) and spontaneous preterm delivery (odds ratio, 0.76; 95% confidence interval, 0.59—0.99) decreased from the prepandemic to the pandemic epoch in those living in neighborhoods <50th percentile for median income (Breslow-Day *P* values.047 and.036, respectively). Similarly, the preterm delivery (odds ratio, 0.78; 95% confidence interval, 0.64—0.97) and spontaneous preterm delivery (odds ratio, 0.74; 95% confidence interval, 0.57—0.98) decreased for those inhabiting the neighborhoods in the highest-hardship quartile (Breslow-Day *P* values.045 and.029, respectively).

CONCLUSION: The populations residing in socioeconomically disadvantaged neighborhoods experienced reductions in preterm delivery during the COVID-19 pandemic. Neighborhood-level social determinants of health offer insight into the complex etiologies that contribute to preterm delivery and provide opportunities for public health and equity-focused prevention strategies.

Key words: COVID-19 pandemic, preterm delivery, social determinants of health

Introduction

The World Health Organization declared the novel COVID-19 a global pandemic on March 12, 2020.[1] As the United States entered lockdown, its impact was not distributed equally. Chicago, in particular, which is the third-most populous city in the United States composed of 77 distinct community areas with a wide breadth of social and economic diversity, has experienced significant differential neighborhood-level impact of the pandemic.[2–5]

The income levels of individuals strongly influence their ability to take protective measures against viral transmission, including staying at home.[6] Essential workers disproportionately reside in higher hardship communities and have had a lesser scope to work from home. However, service and low-income workers may also have been more likely to lose their employment, as many small businesses and restaurants closed or reduced staff, forcing them to stay home.[6–8] Just as shutdown measures seem to have averted the influenza season altogether, it is possible that the forced reductions in discretionary activity and an increased proportion of community members quarantining at home during the pandemic may have had protective effects on pregnant patients, who are normally exposed to a range of risks in normal occupational and social life.[6–8] Given the increased adverse obstetrical outcomes associated with SARS-CoV-2 infection in pregnancy, including increased preterm delivery (PTD) rates, pregnant workers may have preferred to limit exposures during the pandemic, accepting forced unemployment and lockdown at home.[9–11] One-third of pregnant patients stayed home from work owing to the fear of contracting the virus, and almost half of them altered their primary mode of transportation.[11] These and other pandemic-related maternal behavior changes may influence obstetrical outcomes.[12]

Several reports on the incidence of PTD during the pandemic have emerged from medical centers in Europe, Asia, and northeastern North America with mixed results. Although some studies found a decreased incidence of PTD,[1,13–17] others have not identified any significant change.[18–21] Additionally, the differences in the PTD rates according to race, ethnicity, or insurance payer type have not been identified.[19,21,22] However, these studies have not evaluated the extent to which

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AJOG MFM at a Glance

Why was this study conducted?

Few studies have evaluated the differences in the preterm delivery rates by neighborhood deprivation indices in pregnant patients during the COVID-19 pandemic. This study was conducted to elucidate the healthcare disparities and socioeconomic factors associated with the differences in the preterm delivery incidence during the pandemic.

Key findings

Utilizing the metrics of neighborhood hardship, we identified a unique intersection between the neighborhood-level social determinants of health and the changes enacted as a part of the COVID-19 pandemic, which contributed to the decreased incidence of preterm delivery and can be attributed to spontaneous preterm delivery in socioeconomically disadvantaged neighborhoods.

What does this add to what is known?

These findings offer additional insight into the complex etiologies that contributed to decreased preterm delivery rates during the COVID-19 pandemic and reveal the opportunity for public health interventions to address the differential impact of the COVID-19 pandemic on adverse pregnancy outcomes.

other social determinants of health (SDOH) may have modified their findings. As SDOH may be imputed from neighborhood hardship and is associated with adverse perinatal outcomes including PTD,[23] understanding the interplay between the neighborhood environment and the observed changes in PTD may explain the observed variation. Thus, we aimed to characterize the changes in PTD incidence during the COVID-19 pandemic with particular attention to the effect modification introduced by neighborhood hardship. We hypothesized that the PTD incidence would be similar overall during the pandemic and during the time before the pandemic, but specifically in the areas of high neighborhood hardship, the incidence of PTD would be reduced during the pandemic.

Materials and Methods

This retrospective cohort study was conducted at the Northwestern Memorial Hospital's Prentice Women's Hospital, an urban academic tertiary care center in Chicago, IL. Pregnant patients who delivered from April 1, 2019 to November 30, 2019 represented the prepandemic epoch; those who delivered from April 1, 2020 to November 30, 2020 represented the pandemic epoch. Similar periods during the pandemic and prepandemic months were utilized to account for seasonal changes in the delivery volume at our center, which has a delivery volume of approximately 12,000 patients per year. Historically, at our institution, most of the deliveries of patients cared for in our system are inborn, and no secular changes were noted during the pandemic with respect to inborn deliveries.

We included pregnant patients aged 18 years or older and excluded the individuals who underwent pregnancy termination or delivered before 20 weeks' gestation. The eligible patients were identified via queries of the electronic health records. The sociodemographic characteristics including the maternal age, self-reported race and ethnicity, preferred language, and insurance status were abstracted. We also abstracted the obstetrical characteristics including parity, any prior history of PTD, and the presence of multiple gestations. We confirmed pregnancy dating and the gestational age at delivery by the last menstrual period and the earliest ultrasound performed.[24] We also identified patients with a SARS-CoV-2 diagnosis during the pregnancy who delivered during the pandemic, as all the patients underwent universal screening on admission for labor and delivery after April 2020.

The recorded zip code of the residence was used to delineate the levels of neighborhood deprivation. Specifically, we identified the median neighborhood annual household income and dichotomized each patient based on whether the zip code was at or above vs below the median annual household income for Chicago, which was $58,247 in 2019.[25] In addition, we assigned a combined hardship index score to each patient according to the residential zip code from the 2015−2019 American Community Survey 5-year estimates.[26,27] This index score averages 6 variables on a standardized scale: dependency (population <18 or >64 years of age), education (percent of residents >25 years of age without a high school diploma), unemployment (percent of residents >16 years of age and unemployed), poverty (percent of households below the federal poverty line), per capita income level, and crowded housing (percent of housing units with >1 person per room). Higher hardship index scores indicate a greater degree of socioeconomic disadvantages and social vulnerability. The calculated hardship index was divided into quartiles, and the highest-hardship quartile was compared with the lower 3 quartiles. A similar approach was used to evaluate the specific subcomponents of the hardship index.

The primary outcome was PTD, defined as any delivery before 37 weeks' gestation. It includes stillbirths, as these are not mutually exclusive events. The secondary outcomes included spontaneous and medically indicated PTD, which did not include stillbirths. To ascribe an etiology (spontaneous or medically indicated) to each PTD, the medical record of each PTD was abstracted by a maternal-fetal medicine clinician (S.A.F.), who was blinded to the epoch. Spontaneous PTDs included those that occurred in the setting of preterm labor, preterm premature rupture of membranes, or placental abruption. The medical indications for the indicated PTDs included preeclampsia or other hypertensive disorders of pregnancy, fetal indication, or abnormal placentation.

We compared the maternal baseline sociodemographic, obstetrical, and neighborhood deprivation characteristics

by epoch with the descriptive characteristics and frequencies reported, and bivariable analyses were performed. Independent sample *t* tests compared the normally distributed continuous variables. Chi-square tests compared the categorical variables. We performed generalized estimating equation log-binomial regression for binary outcomes for the primary and secondary outcomes to compare the odds ratios during the pandemic and prepandemic epochs, accounting for the clustering effect of multiple gestations. The odds ratios were adjusted for those baseline characteristics that were found to differ across the epochs ($P<.05$) in a bivariable analysis.

We performed generalized estimating equation log-binomial regression subgroup analysis for spontaneous and medically indicated PTD stratified by neighborhood deprivation metrics, including the median annual household income percentile by zip code (<50th percentile vs >50th percentile) and hardship index (highest-hardship quartile vs lower 3 quartiles) for both the combined hardship index and its subcomponents. We utilized the highest-hardship quartile in an attempt to differentiate those experiencing the highest degree of hardship, as we hypothesized that those with a more extreme exposure to the SDOH would exhibit the most significant changes in PTD incidence. Analyses using the Breslow-Day test of homogeneity were planned for the PTD categories that demonstrated significant differences in the bivariable subgroup analysis to determine whether effect modification was present across neighborhood deprivation metrics. A *P* value <.05 was considered statistically significant.

Statistical analyses were conducted using Stata version 16.1 (StataCorp, College Station, TX). The study was approved by the Northwestern University Institutional Review Board before its initiation with a waiver of informed consent.

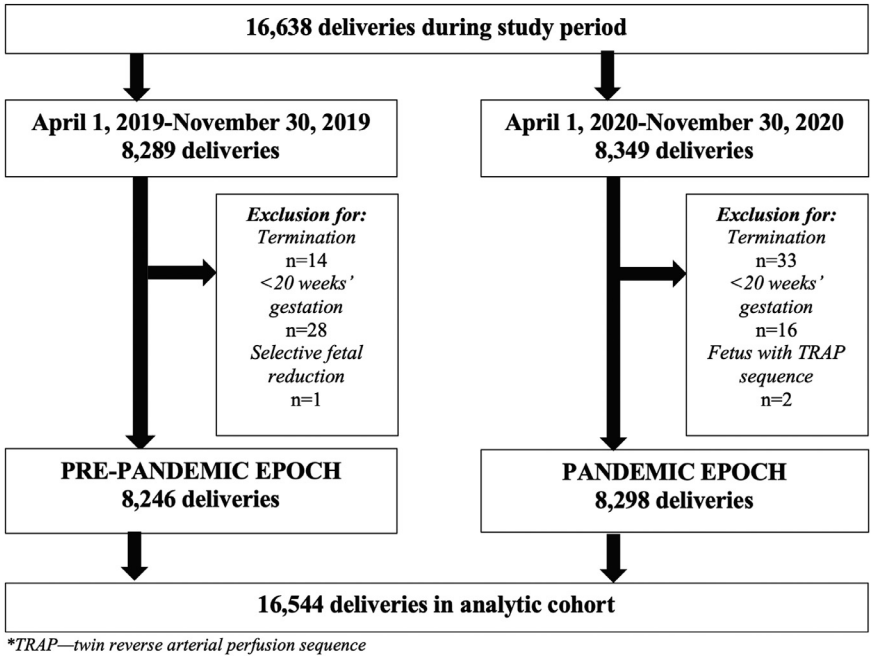
Results

During the study period, the analytical cohort encompassed 16,544 deliveries (Figure 1), with the baseline sociodemographic characteristics described in Table 1. Small but statistically significant differences were noted for the self-reported race and the prevalence of multiple gestations across epochs. Notably, no differences in the neighborhood deprivation were noted across epochs. During the pandemic epoch, 5.9% of the patients had SARS-CoV-2 infection during their pregnancy.

A total of 1435 deliveries (8.7%) occurred preterm, 694 (48.4%) of which occurred during the pandemic epoch. We did not detect a significant difference in the odds of PTD, spontaneous PTD, or medically indicated PTD across epochs in bivariable analyses or after adjusting for race and multiple gestations in multivariable analyses (Table 2). As the self-reported race and ethnicity represent social constructs without a biologic basis for association with PTD, additional sensitivity analysis excluding the race and ethnicity from multivariable analysis was performed without a change in these findings.

We then evaluated the odds of PTD, spontaneous PTD, and medically indicated PTD during the pandemic and prepandemic epochs according to the neighborhood deprivation metrics. Among the patients who resided in the zip codes with a median household income >50th percentile, the incidences of PTD overall, spontaneous PTD, and medically indicated PTD were similar in the pandemic and prepandemic epochs (Table 3). However, among the pregnant patients who resided in zip codes with median annual household income <50th percentile, the incidences of PTD overall (absolute risk reduction [ARR], −2.3%; *P*=.02) and spontaneous PTD (ARR, −1.6%; *P*=.03) were significantly decreased during the pandemic compared with the prepandemic epoch. The incidence of medically indicated PTD did not differ between epochs among pregnant patients who resided in lower-income areas.

FIGURE
Flow diagram



**TRAP—twin reverse arterial perfusion sequence*

Flow diagram of deliveries at our institution during the COVID-19 pandemic and the prepandemic epoch.

Fisher. Hardship and preterm delivery during COVID-19. Am J Obstet Gynecol MFM 2021.

TABLE 1
Baseline characteristics

Sociodemographic characteristics	Prepandemic epoch April–Nov. 2019 n=8246 (49.8) n (%)	Pandemic epoch April–Nov. 2020 n=8298 (50.2) n (%)	*P* value
Maternal age, y (mean, standard deviation)	32.6 (4.9)	32.6 (4.9)	.84
Race			.002
White	4943 (64.5)	4843 (62.2)	
Black	845 (11.0)	879 (11.3)	
Asian	697 (9.1)	693 (8.9)	
Other	1061 (15.4)	1300 (17.6)	
Ethnicity			.07
Non-Hispanic	6144 (81.0)	6164 (79.9)	
Hispanic	1437 (19.0)	1551 (20.1)	
Preferred language			.41
English	7820 (95.2)	7912 (95.5)	
Spanish	270 (3.3)	235 (2.8)	
Other European language	32 (0.4)	30 (0.4)	
Asian language	70 (0.8)	79 (0.9)	
Arabic or other Middle Eastern language	10 (0.1)	16 (0.2)	
Hindi	8 (0.1)	5 (0.1)	
African language	4 (0.1)	7 (0.1)	
Insurance			.75
Public	1542 (18.7)	1533 (18.5)	
Private	6688 (81.3)	6733 (81.5)	
Median annual household income percentile by zip code[a]			
>50th percentile (>$58,247/y)	6166 (75.2)	6209 (75.1)	.92
<50th percentile (<$58,247/y) Combined hardship index quartile	2038 (24.8)	2060 (24.9)	.29
First	4240 (52.6)	4247 (52.3)	
Second	1243 (15.4)	1252 (15.4)	
Third	851 (10.6)	819 (10.1)	
Fourth	1720 (21.4)	1804 (22.2)	
Obstetrical characteristics			
Nulliparity	3060 (37.2)	3188 (38.5)	.57
History of preterm delivery	402 (4.9)	432 (5.2)	.34
Multiple gestations	363 (4.4)	299 (3.6)	.008
COVID-19 test positive during pregnancy	—	493 (5.9)	—

[a] Median household income for Chicago, Illinois in 2019 was $58,247.[25]

Fisher. Hardship and preterm delivery during COVID-19. Am J Obstet Gynecol MFM 2021.

Among the pregnant patients in the highest-hardship quartile for hardship index, the incidences of PTD overall (ARR, −2.4%; *P*=.02) and spontaneous PTD (ARR, −1.8%; *P*=.03) were significantly lower during the pandemic than the prepandemic epoch. Within the individual hardship index subcomponents, the education and crowded housing indices contributed to significant reductions in the PTD overall and spontaneous PTD observed during the pandemic among the highest-hardship quartile (Table 4). Although we did not detect a statistical

TABLE 2
Preterm delivery outcomes, overall cohort

PTD outcomes	Prepandemic epoch April–Nov. 2019 n=8246 (49.8)	Pandemicepoch April–Nov. 2020 n=8298 (50.2)	*P* value	OR (95% CI)	aOR[a] (95% CI)
PTDs, overall	741 (9.0)	694 (8.4)	.17	0.96 (0.86–1.08)	0.96 (0.86–1.09)
Spontaneous	444 (5.4)	415 (5.0)	.27	0.96 (0.83–1.10)	0.97 (0.84–1.12)
Medically indicated	286 (3.5)	262 (3.2)	.47	0.99 (0.83–1.19)	0.98 (0.82–1.18)
Medical indications for PTD:	n=270[b]	n=235[b]			
Preeclampsia or					
Hypertensive disorder of pregnancy	182 (67.4)	170 (72.3)	.97	1.00 (0.78–1.27)	0.99 (0.78–1.26)
Fetal indication	69 (25.6)	75 (29.2)	.35	1.21 (0.85–1.71)	1.21 (0.85–1.72)
Abnormal placentation	29 (10.7)	17 (7.2)	.12	0.61 (0.33–1.13)	0.61 (0.33–1.12)

Fetal indications: fetal anomaly, fetal growth restriction, nonreassuring fetal status, oligohydramnios.

Abnormal placentation: placenta previa, placenta accreta spectrum, vasa previa. Secondary outcomes spontaneous and medically indicated PTD do not include stillbirths. PTD includes any delivery at <37 weeks' gestation, which includes stillbirths as these are not mutually exclusive events.

aOR, adjusted odds ratio; *CI*, confidence interval; *PTD*, preterm delivery.

[a] Odds ratio adjusted for self-identified race and multiple gestations; [b] In 2019, there were 2 medically indicated PTDs without identifiable etiology; in 2020, 22 medically indicated PTDs without identifiable etiology.

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significance for dependency, education, poverty, and per capita income, the point estimates of PTD were all decreased in the areas of greater hardship during the pandemic epoch, irrespective of the metric used.

This pattern did not hold true for the patients in the lower 3 hardship quartiles, where the incidences of the PTD overall and spontaneous PTD were similar between the epochs (Table 3). The incidence of medically indicated PTD did not differ significantly among the pregnant patients according to the hardship index quartile, including the combined hardship index and its individual components.

We then performed the Breslow-Day test of homogeneity to compare the PTD overall and spontaneous PTD between the pandemic and prepandemic epochs according to the income percentile by zip code and hardship indices (Table 5). The observed differences in the odds of PTD and spontaneous PTD between epochs differed significantly for the income percentile by zip code and the combined, education, and crowded housing indices, further indicating a significant association between neighborhood hardship and changes in PTD incidence during the pandemic.

Discussion

Principal findings

This study of a large, diverse cohort found that the PTD incidence was similar during the COVID-19 pandemic compared with a similar prepandemic epoch. However, the pregnant patients residing in socioeconomically disadvantaged neighborhoods had lower rates of PTD and spontaneous PTD during the pandemic. In contrast to our findings, a large national registry in the Netherlands suggested that the reductions in PTD were confined to people living in high socioeconomic status neighborhoods.[15] Domestically, a study evaluating pregnant patients in Pennsylvania demonstrated that decreases in the spontaneous PTD rates were limited to women living in more advantaged neighborhoods determined by area deprivation indices.[28] To the best of our knowledge, this is the first study to specifically link increased neighborhood hardship with decreased PTD and spontaneous PTD rates during the pandemic.

Results

Our finding of lower rates of PTD overall and spontaneous PTD during the pandemic among the patients residing in lower-income areas with greater economic hardships may explain the conflicting reports published previously regarding the effect of the COVID-19 pandemic on the PTD rates. These prior evaluations did not account for neighborhood-level SDOH. By using the combined economic hardship index and other individual markers of economic hardship, we could identify the specific economic factors that may be associated with a lower rate of PTD owing to spontaneous PTD in socially vulnerable patients.

Clinical implications

The etiology of spontaneous PTD is likely multifactorial and largely unknown.[20] Race, ethnicity, and lower-income levels have been associated with increased PTD rates domestically and globally.[29–31] However, race and ethnicity have not been significantly associated with changes in PTD during the pandemic,[21,22] and our findings suggest that other SDOHs, particularly an individual's neighborhood environment,

TABLE 3
Preterm delivery outcomes by metrics of neighborhood deprivation

Household income and hardship index	Prepandemic epoch 2019 n (%)	Pandemic epoch 2020 n (%)	*P* value	Household income and hardship index	Prepandemic epoch 2019 n (%)	Pandemic epoch 2020 n (%)	*P* value
Median annual household income <50th percentile by zip code[a]	n=2038	n=2060		Median annual household income >50th percentile by zip code	n=6166	n=6209	
PTD, overall	239 (11.7)	194 (9.4)	.02	PTD, overall	498 (8.1)	500 (8.1)	.94
Spontaneous PTD	149 (7.3)	117 (5.7)	.03	Spontaneous PTD	277 (4.5)	293 (4.7)	.55
Indicted PTD	81 (4.0)	71 (3.5)	.37	Indicated PTD	205 (3.3)	191 (3.1)	.43
Hardship index highest-hardship quartile	n=1720	n=1804		Hardship index lower 3 quartiles	n=6334	n=6318	
PTD, overall	221 (12.8)	188 (10.4)	.02	PTD, overall	483 (7.6)	486 (7.7)	.92
Spontaneous PTD	133 (7.7)	106 (5.9)	.03	Spontaneous PTD	272 (4.3)	286 (4.5)	.53
Indicated PTD	82 (4.8)	74 (4.1)	.34	Indicated PTD	192 (3.0)	186 (2.9)	.77

Secondary outcomes spontaneous and medically indicated PTD do not include stillbirths. PTD includes any delivery at <37 weeks' gestation, which includes stillbirths as these are not mutually exclusive events.

PTD, preterm delivery.

[a] Median annual household income for Chicago, Illinois in 2019 was $58,247[25].

Fisher. Hardship and preterm delivery during COVID-19. Am J Obstet Gynecol MFM 2021.

impact the PTD risk more significantly. Individual indices for education and crowded housing within the hardship index were key contributors to the reduction in the PTD overall and spontaneous PTD observed during the pandemic. Although not statistically significant, all the other indices of neighborhood hardship consistently exhibited lower point estimates for PTD and spontaneous PTD incidence during the pandemic.

Prior studies have associated a lower maternal educational attainment and housing instability with an increased incidence of PTD.[32–34] The seemingly contradictory reduction in PTD that we identified among this subgroup during the pandemic may relate to unique pandemic-driven changes that occurred in the economy and workforce. The pandemic disproportionately affected low-wage workers and individuals from lower-income backgrounds.[35] Between February 2020 and May 2020, the unemployment rate for workers with a high school diploma or less rose by >12% points, compared with 5.5% points for workers with a bachelor's degree or higher.[36] Maternal stress, shift work and other work-related stressors, and working ≥40 hours per week have specifically been associated with an increased PTD risk of >5-fold.[37,38] Data also demonstrate that individuals with less educational attainment are more likely to work in a job with medium or high contact, requiring greater public interaction than workers with a bachelor's degree or higher.[39] Taken together, these statistics support the theory that pregnant individuals with a lower educational attainment were more likely to become unemployed during the pandemic, resulting in decreased public interaction and work-related stress, and ultimately leading to a decreased incidence of PTD. These changes, in turn, may have modulated the immune system response that plays an active role in preterm labor initiation.[40–42]

With additional consideration to unemployment, the financial stress associated with the loss of income for those unemployed during the pandemic was partially offset by the unprecedented income support and eviction moratoria by the federal government as part of the pandemic response. Therefore, the pandemic-associated unemployment was, for some, a less financially stressful experience than unemployment might have been under standard circumstances. The pandemic may have further impacted the nature of social support available for pregnant people. Low or inconsistent social support has a negative impact on pregnancy-related outcomes.[43] In light of the stressful and uncertain pandemic circumstances, the increased time at home with partners and family members within a defined "quarantine bubble" may have offered opportunities for greater social support, further reduction in stress and resultant immunomodulation, and positive effects on overall well-being.[44] It is possible that these changes in maternal behavior and increased social and financial support for lower-income pregnant patients improved the obstetrical outcomes, including reducing the rates of spontaneous PTD.

Pregnant patients from lower-income areas may also face systems-level barriers to accessing prenatal care, such as transportation difficulties and an

TABLE 4
Preterm delivery outcomes by individual components of the hardship index

Hardship index individual components	Prepandemic epoch 2019 n (%)	Pandemic epoch 2020 n (%)	*P* value	Hardship index individual components	Prepandemic epoch 2019 n (%)	Pandemic epoch 2020 n (%)	*P* value
Dependency index highest-hardship quartile	n=1828	n=1850		Dependency index lower 3 quartiles	n=6009	n=6050	
PTD, overall	215 (11.8)	190 (10.3)	.14	PTD, overall	472 (7.9)	472 (7.8)	.88
Spontaneous PTD	113 (6.2)	113 (6.2)	.93	Spontaneous PTD	287 (4.8)	271 (4.5)	.44
Indicated PTD	95 (5.1)	70 (3.8)	.05	Indicated PTD	168 (2.8)	186 (3.1)	.37
Education index highest-hardship quartile	n=1950	n=1952		Education index lower 3 quartiles	n=5887	n=5948	
PTD, overall	243 (12.5)	182 (9.3)	.001	PTD, overall	444 (7.5)	480 (8.1)	.30
Spontaneous PTD	155 (7.9)	102 (5.2)	.001	Spontaneous PTD	245 (4.2)	282 (4.7)	.13
Indicated PTD	85 (4.4)	75 (3.8)	.42	Indicated PTD	177 (3.0)	181 (3.0)	.91
Unemployment index highest-hardship quartile	n=1865	n=1877		Unemployment index lower 3 quartiles	n=5972	n=6023	
PTD, overall	228 (12.2)	195 (10.4)	.07	PTD, overall	459 (7.7)	467 (7.8)	.92
Spontaneous PTD	132 (7.1)	115 (6.1)	.24	Spontaneous PTD	268 (4.5)	269 (4.5)	.96
Indicated PTD	89 (4.8)	73 (3.9)	.19	Indicated PTD	173 (2.9)	183 (3.0)	.65
Poverty index highest-hardship quartile	n=1935	n=1979		Poverty index lower 3 quartiles	n=5902	n=5921	
PTD, overall	179 (9.3)	176 (8.9)	.67	PTD, overall	508 (8.6)	486 (8.2)	.41
Spontaneous PTD	118 (6.1)	110 (5.6)	.47	Spontaneous PTD	282 (4.8)	274 (4.6)	.70
Indicated PTD	52 (2.7)	58 (2.9)	.65	Indicated PTD	210 (3.6)	198 (3.3)	.52
Per capita income highest-hardship quartile	n=1991	n=2008		Per capita income lower 3 quartiles	n=5845	n=5892	
PTD, overall	177 (8.9)	171 (8.5)	.67	PTD, overall	510 (8.7)	491 (8.3)	.41
Spontaneous PTD	100 (5.0)	110 (5.5)	.16	Spontaneous PTD	300 (5.1)	274 (4.7)	.23
Indicated PTD	72 (3.6)	57 (2.8)	.16	Indicated PTD	190 (3.3)	199 (3.4)	.70
Crowded housing index highest-hardship quartile	n=1908	n=1973		Crowded housing index lower 3 quartiles	n=5929	n=5927	
PTD, overall	217 (11.4)	179 (9.1)	.02	PTD, overall	470 (8.0)	483 (8.2)	.69
Spontaneous PTD	146 (7.7)	103 (5.2)	.002	Spontaneous PTD	254 (4.3)	281 (4.7)	.23
Indicated PTD	67 (3.5)	70 (3.6)	.95	Indicated PTD	195 (3.3)	186 (3.1)	.64

Secondary outcomes spontaneous and medically indicated PTD do not include stillbirths. PTD includes any delivery <37 weeks' gestation, which includes stillbirths as these are not mutually exclusive events.

PTD, preterm delivery.

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TABLE 5
Breslow-Day test of homogeneity of the odds ratios for reduction in preterm delivery during the pandemic compared with the prepandemic epoch

PTD outcome	Median household income percentile by zip code<50 percentileOR (95% CI)[a]	Median household income percentile by zip code>50% percentileOR (95% CI)	*P* value
PTD, overall	0.78 (0.64–0.96)	1.00 (0.87–1.14)	.047
Spontaneous PTD	0.76 (0.59–0.99)	1.05 (0.89–1.25)	.036
	Combined hardship index highest-hardship quartile OR (95% CI)	Combined hardship index lower 3 quartiles OR (95% CI)	*P* value
PTD, overall	0.78 (0.63–0.97)	1.01 (0.88–1.15)	.045
Spontaneous PTD	0.74 (0.57–0.98)	1.06 (0.89–1.26)	.029
	Education index highest-hardship quartile OR (95% CI)	Education index lower 3 quartiles OR (95% CI)	*P* value
PTD, overall	0.72 (0.58–0.88)	1.07 (0.94–1.23)	.001
Spontaneous PTD	0.64 (0.49–0.83)	1.15 (0.96–1.37)	<.001
	Crowded housing index highest-hardship quartile OR (95% CI)	Crowded housing index lower 3 quartiles OR (95% CI)	*P* value
PTD, overall	0.77 (0.62–0.96)	1.03 (0.90–1.18)	.02
Spontaneous PTD	0.66 (0.51–0.87)	1.11 (0.93–1.33)	<.001

Spontaneous PTD does not include stillbirths. PTD includes any delivery <37 weeks' gestation, which includes stillbirths as these are not mutually exclusive events.

CI, confidence interval; *OR*, odds ratio; *PTD*, preterm delivery.

[a] Median annual household income for Chicago, Illinois in 2019 was $58,247.[25]

Fisher. Hardship and preterm delivery during COVID-19. Am J Obstet Gynecol MFM 2021.

inability to take time off work.[45,46] Additional barriers may have presented themselves during the pandemic, including the fear of viral transmission related to seeking medical care and additional childcare responsibilities as a result of school and daycare closures. Increased telemedicine utilization during the pandemic, including at our institution, has led to a broader accessibility to high-quality prenatal care for many pregnant patients, albeit with remote care. Consistent prenatal care is associated with a decreased incidence of PTD.[47] Although the implementation and uptake of telehealth during the pandemic has likely been variable among different socioeconomic groups in various regions of the country, the potential for improved access to care for lower-income pregnant patients, who may have faced increased barriers to care before the widespread adoption of telemedicine during the pandemic, could have contributed to decreased spontaneous PTD rates in lower-income patients. To attribute a net protective effect, it would be hypothesized that these potential benefits of pandemic-driven home and occupational changes outweighed the known higher risks of PTD related to income and other SDOH.

Research implications

Future research to provide more specific insight into the changes in prenatal care delivery via telemedicine and alterations in workforce, employment, and work-from-home policies in the highest-hardship neighborhoods during the COVID-19 pandemic is indicated to better understand their association with decreased PTD rates. An evaluation of how government policies regarding employment, wage, and housing assistance and access to transportation and technology as part of the pandemic response have impacted pregnancy outcomes has the potential to drive future public policy. Following recovery from the pandemic, the further evaluation of public health interventions to address the socioeconomic disparities and the resultant impact on PTD in disadvantaged communities is warranted. Finally, future studies should similarly explore the association of socioeconomic status on differential rates of other obstetrical adverse pregnancy outcomes beyond PTD during the pandemic and prepandemic epochs, such as the incidence of hypertensive disorders of pregnancy and perinatal mood disorders that may be associated with increased stress and hardship during the COVID-19 pandemic.

Strengths and limitations

A major strength of this study is the large, diverse sample size encompassing epochs before and during the pandemic. This data stemmed from a comprehensive clinical data set of pregnant people who delivered during specified time

epochs, limiting the potential for selection bias. This study is also strengthened by our use of consistent pregnancy dating methods and manual chart review to systematically assess the PTD indications (spontaneous vs iatrogenic), which may not be feasible in the database or national registry studies examining the rates of PTD during the pandemic. Finally, the use of the American Community Survey's multiyear estimates facilitated the increased statistical reliability of economic hardship data, especially for less populated areas and small population subgroups.

This study is also subject to limitations. These data are limited to a single tertiary care institution, and our results may not be generalizable to other centers. The hardship index's unemployment subcomponent was derived before the pandemic and may not fully reflect the changes in employment status and hardships that occurred during the pandemic. We also recognize that we imputed the hardships based on the zip code, and this is only one marker of hardship, which may not represent the socioeconomic characteristics of individual persons within the community. Area level analysis by zip codes is further limited by their large, variable sizes and the heterogeneity of SDOH across these areas. However, the zip code has been shown to be an important marker to understand the overall needs of a population, and our use of data from the American Community Survey allowed us to incorporate several measures of economic hardship. Finally, our study is limited by the inability to adjust for unmeasured confounders and patient-level factors as a result of our observational and retrospective study design, which may influence the observed findings. Although many interesting hypotheses may be generated from the results of our study, our conclusions regarding the observed associations must remain tempered and cannot suggest causation.

Conclusion

SDOH are established contributors to health outcomes, and PTD is no exception. The unique intersectionality between neighborhood-level social determinants and changes resulting from the COVID-19 pandemic may have an impact on adverse pregnancy outcomes such as PTD. These findings may offer a greater insight into the complex etiologies that contribute to PTD and public health and equity-focused strategies for prevention. ■

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Author and article information

From the Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Northwestern University Feinberg School of Medicine, Chicago, IL (Drs Fisher and Miller); Northwestern University Feinberg School of Medicine, Chicago, IL (Ms Sakowicz); Department of Quality Strategies, Northwestern Memorial Hospital, Chicago, IL (Dr Barnard); Northwestern Medicine Lake Forest Hospital, Lake Forest, IL (Mr Kidder).

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Corresponding author: Stephanie A. Fisher, MD, MPH. stephanie.fisher@northwestern.edu