


Living in a block group with a higher eviction rate is associated with increased odds of preterm delivery

Alexa A Freedman ,^{1,2} Britney P Smart,² Lauren S Keenan-Devlin,² Ann Borders,^{2,3,4} Linda M Ernst,⁵ Gregory E Miller^{1,6}

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¹Institute for Policy Research, Northwestern University, Evanston, Illinois, USA

²Department of Obstetrics and Gynecology, NorthShore University HealthSystem, Evanston, Illinois, USA

³Department of Obstetrics and Gynecology, Division of Maternal Fetal Medicine, Northwestern University Feinberg School of Medicine, Chicago, Illinois, USA

⁴Department of Medical Social Sciences, Northwestern University Feinberg School of Medicine, Chicago, Illinois, USA

⁵Department of Pathology, NorthShore University HealthSystem, Evanston, Illinois, USA

⁶Department of Psychology, Northwestern University, Evanston, Illinois, USA

Correspondence to

Dr Alexa A Freedman, Institute for Policy Research, Northwestern University, Evanston, IL 60201, USA; alexa.freedman@northwestern.edu

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ABSTRACT

Background Housing instability is associated with adverse pregnancy outcomes. Recent studies indicate that eviction, which may affect a larger segment of the population than other forms of housing instability, is also associated with adverse pregnancy outcomes. However, these studies evaluate eviction across large areas, such as counties, so it remains unclear whether these patterns extend to individual-level pregnancy outcomes.

Methods We used data on a cohort of all singleton live births at a single Chicago hospital between March 2008 and March 2018 to investigate the associations between block-group eviction rates and individual adverse pregnancy outcomes. Eviction data were obtained from the Eviction Lab at Princeton University. Generalised estimating equations were used to estimate associations and account for correlations among individuals living in the same block groups.

Results Individuals living in block groups in the highest quartile for eviction filing rate were 1.17 times as likely to deliver preterm (95% CI: 1.08 to 1.27) and 1.13 times as likely to deliver a small for gestational age infant (95% CI: 1.03 to 1.25) as compared with individuals living in block groups in the lowest quartile. Further, tests for linear trend indicated that for each quartile increase in eviction filing rate, there was a corresponding increase in odds of adverse outcomes ($p < 0.05$).

Results were strongest in magnitude for those with low neighbourhood and individual socioeconomic status, who are most likely to be renters and affected by local eviction policies.

Conclusion Our results suggest that individuals living in block groups with higher eviction rates are more likely to deliver preterm. Future research should explore associations of individual experience with eviction on adverse pregnancy outcomes and examine whether policies to improve tenant protections also impact pregnancy outcomes.

INTRODUCTION

Housing instability is associated with adverse pregnancy outcomes. Several studies have evaluated pregnancy outcomes among individuals experiencing homelessness and have reported slight reductions in birth weight.^{1–4} Similarly, one study found that neonates born to those experiencing homelessness are more likely to be preterm and low birth weight.⁵ Additionally, moving two or more times in a year (an indicator of housing instability) is associated with a reduction in birth weight.⁶

Two recent studies suggest that eviction may also be associated with adverse pregnancy outcomes.^{7,8}

Khadka *et al* evaluated county-level eviction filing data in 39 states and found that exposure to eviction is associated with increased risk of preterm birth and low birth weight.⁷ Similarly, Hazekamp *et al*⁸ examined eviction rates and pregnancy outcomes by census tract in Chicago and found that census tracts with higher eviction rates have higher rates of infant mortality and very low birth weight. These results warrant additional study. Khadka *et al* evaluated associations with county-level eviction data, which may not reflect individual exposure to eviction. Though Hazekamp *et al* evaluated a smaller geographical area (census tracts; which typically have 1200–8000 residents), they conducted an ecological study, and associations observed at the population level may not extend to the individual level. Further, potential mechanisms have not been examined. Eviction is a psychological stressor, with financial, social and emotional implications. Like other stressors, it could impact pregnancy by affecting function of the placenta, which facilitates oxygen, nutrient and waste exchange. Common placental lesions with implications for pregnancy outcomes include inflammation and vascular malperfusion.⁹ Additionally, some lesions, such as chronic inflammatory lesions, are associated with stress.¹⁰

Understanding the association between eviction and pregnancy outcomes is important, as eviction potentially impacts a greater segment of the population than more severe forms of housing instability. Further, eviction is more common among demographic groups experiencing pregnancy, including female tenants and tenants with children.^{11–14} One study of low-income single mothers living in an urban Michigan county found that 20% reported being evicted at least once in a 6-year period.¹⁵ Another study estimated that one in seven children born in large US cities in 1998–2000, and one in four children living in deep poverty (income below 50% of poverty threshold), experienced eviction by age 15 years.¹⁶ Eviction can also trap individuals in poverty through increased risk of housing instability, homelessness, and job loss, and a reduction in earnings.¹⁷ Individuals who are evicted are also more likely to move to lower quality housing in neighbourhoods with higher rates of poverty and crime^{18,19} and low-income parents who are evicted experience more material hardship and worse mental health outcomes.²⁰

The purpose of our analysis was to build on the literature investigating housing instability and adverse pregnancy outcomes by investigating the

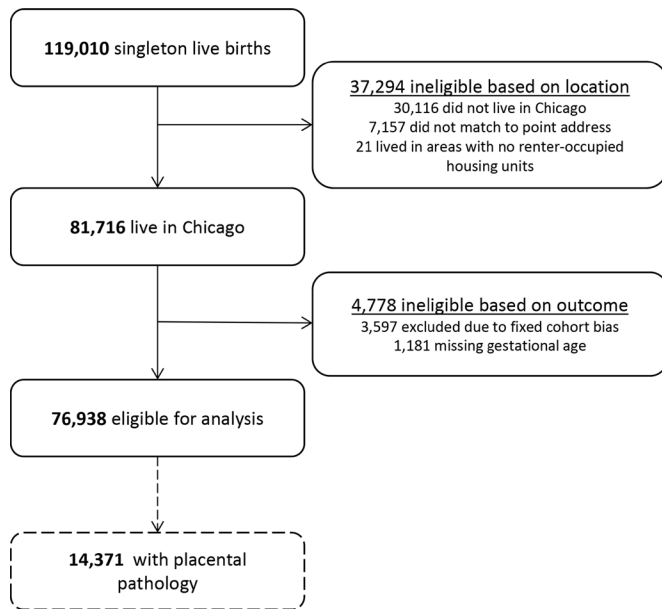


Figure 1 Study inclusion.

association between eviction rates and individual pregnancy outcomes in Chicago. In order to reduce spatial heterogeneity and better approximate an individual's exposure to eviction as compared with rates of counties or census tracts, we used data on eviction rates of block groups, which typically have 600–3000 residents. We investigated whether eviction is associated with adverse pregnancy outcomes including preterm birth (<37 weeks' gestation) and small for gestational age (SGA) infant (birth weight <10th percentile) and we explored adverse placental function related to eviction-associated stress as a potential mechanism. We hypothesised that individuals living in block groups with higher eviction rates would be more likely to experience adverse pregnancy outcomes.

METHODS

Study sample

Delivery records, including address at the time of delivery, were obtained for all singleton live births at a single Chicago hospital between March 2008 and March 2018 ($n=119\,010$). Study subjects living outside Chicago city limits, subjects with missing or incomplete address information and subjects living in areas with no renter-occupied housing units were excluded from the analysis (figure 1). Additionally, subjects with estimated dates of conception more than 20 weeks prior to the start of the study period or within 44 weeks of the end of the study period were excluded to account for fixed cohort bias.²¹

Eviction exposure

To legally evict a tenant, the landlord must first provide the tenant with written notice of lease termination. Once the termination period has expired, the landlord can then file for eviction in court (eviction filing). If the judge rules in favour of the landlord, the judge can sign an Eviction Order (eviction). However, some evictions occur outside the formalised court process (such as when a landlord changes the locks), thus court-ordered evictions may underestimate the true burden of evictions and eviction filings may be a better proxy.^{20 22} In Chicago, roughly 60% of households live in rental units and are potentially at risk of eviction and in 2016, there were estimated to be 3.2 eviction

filings and 1.1 evictions per 100 renter-occupied housing units (online supplemental figure S1).²³

Addresses reported at the time of delivery were geocoded using ArcGIS Pro V.2.5 to identify the block group and link to area-based measures of eviction. Data on eviction filing rates and eviction rates for all block groups in Chicago were obtained from the Eviction Lab at Princeton University.²³ Briefly, the Eviction Lab collected, cleaned and aggregated data on 38 564 127 eviction cases in the USA between 2000 and 2016. Annual rates are reported as the number of eviction filings (eviction filing rate) or evictions (eviction rate) per 100 renter-occupied households. A detailed description of the methodology can be found in Desmond *et al.*²² As pregnancy can span 2 calendar years, subjects delivering between January and April were assigned eviction data from the year prior to delivery (when the majority of the pregnancy took place) and subjects delivering in May through December were assigned eviction data corresponding to the year of delivery. Eviction Lab data are only available through 2016, so deliveries occurring in 2017 and 2018 were assigned eviction data from 2016. In a second formulation of eviction exposure, for individuals with pregnancies spanning 2 calendar years, we instead calculated eviction variables as an average of the 2 years, weighted by the proportion of the pregnancy occurring in each calendar year.

Pregnancy outcomes

Pregnancy outcomes of interest were abstracted from delivery records. Outcomes included preterm birth (<37 weeks of gestation) and SGA infant (birth weight <10th percentile for gestational age and sex). Birth weight percentiles were determined based on Fenton growth charts.²⁴ In addition to analysing preterm births <37 weeks of gestation, we also conducted a sensitivity analysis using a conservative definition of preterm birth (<34 weeks) to account for potential inaccurate reporting of gestational age.

Placental pathology reports were abstracted from delivery records and diagnostic lines were searched for phrases indicative of lesions of interest using R V.3.6 (stringr package).²⁵ Placental lesion categories of interest include maternal acute inflammation, fetal acute inflammation, chronic inflammation, maternal vascular malperfusion and fetal vascular malperfusion, as defined by Amsterdam Criteria.⁹ Each lesion category was dichotomised based on presence of ≥ 1 lesion, except for maternal vascular malperfusion, where ≥ 2 lesions was used to determine presence due to subjectivity in identifying some lesions, such as increased syncytial knots. Stabilised inverse probability weights were calculated to account for selection bias due to indication for pathology.^{25 26}

Covariates

Individual-level demographic covariates, including age, race/ethnicity, parity and insurance status, were abstracted from delivery records. Individual covariate missingness ranged from 0.0% (age) to 6.5% (race/ethnicity) and was addressed using hot deck imputation.²⁷ We also considered several spatial covariates. The Eviction Lab database contains information on the per cent of housing units occupied by renters, obtained from 2010 Census and 2009–2015 5-year American Community Survey (ACS) data.²² For median household income of the block group, the midpoint of the 5-year ACS estimates was matched to the delivery year (eg, a subject with a delivery in 2013 was assigned estimates from the 2011–2015 ACS) and median household

income was obtained as 2018 inflation-adjusted dollars for all years.

Statistical analysis

Generalised estimating equations were used to estimate associations between eviction rates and pregnancy outcomes while accounting for non-nested clustering among subjects residing in the same block groups and subjects with multiple deliveries during the study period.²⁸ Generalised estimating equations were used to obtain population-averaged coefficients instead of mixed models because the research question does not require partitioning the variance explained at the block-group versus full-sample level.²⁹ Models were adjusted for age, race/ethnicity, parity and median household income of the block group (included as a proxy for individual socioeconomic status). We also included year of delivery and a quadratic term to account for temporal trends in eviction rates and adverse pregnancy outcomes. We conducted sensitivity analyses restricted to block groups with >30% renter-occupied housing units to estimate associations in areas where more households are at risk of eviction and we used the weighted average of eviction rates to account for pregnancies that spanned multiple calendar years. As a further sensitivity analysis, we used conditional logistic regression to estimate block-group fixed effects, which control for time-invariant block group characteristics. Finally, we considered the mechanistic role of placental lesions using weighted generalised estimating equations.

We conducted several secondary stratified analyses to further investigate associations. First, we evaluated associations after stratifying block groups into those <25th and >75th percentile of median household income, reasoning that individuals living in the former areas were more likely to be renters versus owners, and as a consequence, more affected by local eviction trends. Based on similar reasoning, we also restricted analyses to subjects with public insurance, which is a rough proxy for low socioeconomic status and being a renter. Last, we also stratified analyses to determine if associations differed during the national housing crisis (2008–2012) and after the national housing crisis (2013–2018) and investigated models stratified by race/ethnicity. Analyses were performed using SAS V.9.4 (SAS Institute) and an alpha level of 0.05 was used to determine statistical significance.

RESULTS

Of the 119010 singleton live births during the study period, 76938 met eligibility criteria and were included in the analysis, representing 92.9% of block groups in Chicago (figure 1). The average age at delivery was 31.6 years (SD: 5.3; table 1). A majority of subjects were white (56.3%) and nulliparous (56.4%), 8.3% of deliveries were preterm and 8.0% of infants were SGA. The annualised mean eviction filing rate and annualised mean eviction rate were 3.4 (SD: 21.6) and 1.2 (SD: 8.5) per 100 renter-occupied housing units across the study period, respectively. On average, subjects lived in block groups where 54.1% of households were renting. Those living in block groups in the highest quartile of eviction filing rate were more likely to be black, have public insurance and to deliver preterm (online supplemental table S1).

In the full sample, subjects in the fourth quartile for eviction filing rate were more likely to deliver preterm as compared with subjects in the first quartile (OR: 1.17; 95% CI: 1.08 to 1.27; table 2). There was also a linear trend, indicating that for each quartile increase in eviction filing, there was a corresponding increase in preterm delivery ($p < 0.01$). Results were consistent

Table 1 Demographic, birth and block group characteristics for the full sample (n=76 938)

	Full sample n=76 938 n (%) or mean (SD)
Demographics	
Age, years	31.6 (5.3)
Race/ethnicity	
White	43 333 (56.3)
Black	8455 (11.0)
Hispanic	14 633 (19.0)
Asian	6228 (8.1)
Other	4287 (5.6)
Nulliparous	43 358 (56.4)
Insurance	
Private insurance	56 218 (73.1)
Public insurance	20 047 (26.1)
No insurance	672 (0.9)
Birth characteristics	
Preterm birth, <37 weeks	6350 (8.3)
Preterm birth, <34 weeks	2359 (3.1)
Small for gestational age	6119 (8.0)
Sex, male	39 380 (51.2)
Block group characteristics	
Eviction filing rate*	3.4 (21.6)
Eviction rate*	1.2 (8.5)
Per cent renter occupied	54.1 (19.3)
Median household income	81 324 (38 842)
Placenta characteristics n=14 371	
Maternal acute inflammation	7596 (52.9)
Fetal acute inflammation	7051 (49.1)
Chronic inflammation	5421 (37.7)
Maternal vascular malperfusion	5559 (38.7)
Fetal vascular malperfusion	4947 (34.4)

*Annual rates reported per 100 renter-occupied housing units.
SD, standard deviation.

when a conservative definition of preterm birth (<34 weeks) was applied; when exposure was eviction rate, rather than filing rate (table 2); and when a weighted average of eviction rates was used (online supplemental table S2). In the fixed effects analysis, which controls for all time-invariant characteristics of the block group, the association between exposure to the highest quartile of eviction filing rate and preterm birth was slightly attenuated (OR: 1.12; 95% CI: 0.98 to 1.28; online supplemental table S3). However, approximately 40% of block groups, the unit of analysis on which the CIs are based, did not contribute to this analysis due to lack of variation in exposure and/or outcome. The highest quartile for eviction filing rate was also associated with increased odds of SGA infant (test for linear trend: $p = 0.04$; table 2). In a sensitivity analysis restricted to those living in block groups with >30% of households occupied by renters, associations were similar for preterm birth defined as <37 weeks (OR: 1.21; 95% CI: 1.10 to 1.33) and <34 weeks (OR: 1.25; 95% CI: 1.09 to 1.44), and for SGA infant (OR: 1.16; 95% CI: 1.05 to 1.28; online supplemental table S4).

Secondary analyses considered the possibility of differential associations for individuals most likely to be low in socioeconomic status, and therefore renters. Associations for preterm birth persisted for those in block groups <25th percentile for median household income, but not for those in block groups

Table 2 Associations between eviction rates of the block group and pregnancy outcomes for the full sample, n=76 938 (generalised estimating equations)

	Preterm birth, <37 weeks				Preterm birth, <34 weeks				Small for gestational age			
	Unadjusted		Adjusted*		Unadjusted		Adjusted*		Unadjusted		Adjusted*	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Eviction filing rate												
Quartile 1	Reference				Reference				Reference			
Quartile 2	1.10	1.01 to 1.19	1.04	0.96 to 1.13	1.05	0.91 to 1.20	0.98	0.85 to 1.12	1.11	1.02 to 1.20	1.07	0.99 to 1.15
Quartile 3	1.26	1.16 to 1.36	1.09	1.01 to 1.18	1.26	1.11 to 1.43	1.04	0.91 to 1.18	1.21	1.11 to 1.31	1.10	1.01 to 1.20
Quartile 4	1.64	1.52 to 1.78	1.17	1.08 to 1.27	2.02	1.78 to 2.28	1.22	1.07 to 1.38	1.43	1.31 to 1.55	1.13	1.03 to 1.25
Eviction rate												
Quartile 1	Reference				Reference				Reference			
Quartile 2	1.03	0.95 to 1.11	0.99	0.92 to 1.07	1.06	0.93 to 1.21	1.01	0.89 to 1.16	1.09	1.01 to 1.18	1.04	0.96 to 1.12
Quartile 3	1.15	1.06 to 1.24	1.04	0.96 to 1.12	1.19	1.04 to 1.36	1.04	0.92 to 1.19	1.18	1.09 to 1.28	1.08	1.00 to 1.17
Quartile 4	1.49	1.38 to 1.61	1.10	1.01 to 1.19	1.90	1.68 to 2.15	1.23	1.09 to 1.40	1.40	1.29 to 1.52	1.14	1.04 to 1.24

*Models adjusted for parental age, race/ethnicity, parity, median household income of the block group and year of delivery (includes a quadratic term). CI, confidence interval; OR, odds ratio.

>75th percentile (table 3). Patterns for those with public insurance were similar to those <25th percentile for median household income. In an analysis stratified by timing of the national housing crisis, living in a block group in the highest quartile of eviction filing rate was associated with increased odds of preterm delivery (both <37 weeks and <34 weeks) during the housing crisis (2008–2012) but associations were attenuated after (2013–2018; online supplemental table S5). In a secondary analysis stratified by race/ethnicity, the magnitude of the associations was strongest among black individuals, with those in the top quartile of eviction filing rate 1.92 times as likely to deliver preterm as compared with those in the first quartile (95% CI: 1.26 to 2.93; online supplemental table S6). In analyses of placental lesions, higher eviction filing rates were not associated with the

prevalence of any of the four placental lesion categories (online supplemental table S7).

DISCUSSION

Our results suggest that those living in areas with higher eviction rates are more likely to deliver preterm and to deliver an SGA infant than those living in areas with lower eviction rates. The observed associations were independent of covariates at both the individual and neighbourhood level and were similar in magnitude to studies evaluating eviction, as well as other neighbourhood characteristics, including deprivation.^{7 30} In the primary analysis, we analysed both eviction filing rate and eviction rate, as they may represent different metrics, with eviction filing rate

Table 3 Associations between eviction filing rate of the block group and preterm birth for those <25th and >75th percentile for median household income of the block group and restricted to those with public insurance

	Preterm birth, <37 weeks				Preterm birth, <34 weeks			
	Unadjusted		Adjusted*		Unadjusted		Adjusted*	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Median household income of block group <25th percentile (<\$49 372; n=19234)								
Quartile 1	Reference				Reference			
Quartile 2	1.40	1.10 to 1.78	1.30	1.03 to 1.66	1.40	0.98 to 2.01	1.30	0.90 to 1.87
Quartile 3	1.45	1.16 to 1.82	1.21	0.97 to 1.52	1.66	1.18 to 2.34	1.34	0.95 to 1.90
Quartile 4	2.01	1.63 to 2.49	1.31	1.05 to 1.63	2.70	1.95 to 3.75	1.55	1.10 to 2.18
Median household income of block group >75th percentile (>\$109 753; n=19232)								
Quartile 1	Reference				Reference			
Quartile 2	1.12	0.97 to 1.30	1.09	0.94 to 1.27	1.12	0.88 to 1.42	1.10	0.86 to 1.39
Quartile 3	1.06	0.91 to 1.25	1.03	0.89 to 1.20	0.79	0.60 to 1.04	0.78	0.59 to 1.02
Quartile 4	1.22	1.03 to 1.45	1.13	0.95 to 1.34	0.98	0.75 to 1.29	0.91	0.69 to 1.20
Restricted to those with public insurance† (n=20 047)								
Quartile 1	Reference				Reference			
Quartile 2	1.23	1.01 to 1.50	1.17	0.96 to 1.42	1.19	0.85 to 1.67	1.10	0.79 to 1.55
Quartile 3	1.38	1.16 to 1.65	1.21	1.01 to 1.45	1.63	1.21 to 2.18	1.34	0.99 to 1.81
Quartile 4	1.75	1.47 to 2.08	1.22	1.02 to 1.46	2.30	1.73 to 3.07	1.39	1.03 to 1.88

*Models adjusted for parental age, race/ethnicity, parity, median household income of the block group and year of delivery (includes a quadratic term).

†Median household income of block group for those with public insurance: \$56 611 (SD: 30 975); median household income of block group for those with private insurance: \$90 313 (SD: 37 505; p<0.01).

CI, confidence interval; OR, odds ratio.

being a better proxy for informal evictions. However, results were generally consistent across both measures.

In a secondary analysis, associations with preterm birth persisted among almost all quartiles of eviction filing rate for those living in block groups with a median household income <25th percentile and for those with public insurance. However, among those in block groups >75th percentile, eviction filing rate was not associated with preterm birth. This suggests that access to resources may modify the association between eviction rates and pregnancy outcomes. We also observed slightly stronger associations among those who delivered during the years of the national housing crisis as compared with those delivering in the years following the national housing crisis, particularly for those in the highest quartile of eviction filing rate. This is a particularly timely finding as the COVID-19 pandemic has resulted in many cities and states suspending eviction proceedings while not suspending rent payments. In many cases, landlords can still file evictions and there may be a spike in evictions once protections are lifted and court proceedings resume. A better understanding of how eviction impacts perinatal health is necessary as the country emerges from the COVID-19 pandemic, as the combination of increased evictions and high unemployment may lead to another housing crisis.

In a secondary analysis stratified by race/ethnicity, we observed the strongest associations among black individuals. There is significant racial disparity in adverse birth outcomes, which is not explained by traditional individual risk factors.³¹ Studies have examined psychosocial stress as a contributor to disparities, including neighbourhood-level stressors, and threat of eviction may be another contributor to psychosocial stress that is disproportionately experienced by black individuals.^{14 32}

Recent studies have reported that county-level eviction filings are associated with preterm birth and low birth weight in the USA⁷ and that higher eviction rates in census tracts are associated with increased rates of infant mortality and very low birth weight in Chicago.⁸ Our results build on these findings by evaluating a smaller spatial measure of eviction (block group) and by using data on individual pregnancy outcomes. We similarly observed increased odds of preterm birth and SGA infant with higher eviction rates. Further, both infant mortality and very low birth weight are consequences of preterm birth.^{33 34}

Associations between housing instability and pregnancy outcomes may be mediated by changes in mental health and health behaviours. Housing instability is associated with increased anxiety and depression,³⁵ which are associated with adverse pregnancy outcomes.³⁶ Additionally, mothers reporting housing instability are more likely to screen positive for generalised anxiety and depression, independent of other stressors, such as intimate partner violence.³⁷ Housing instability is also associated with unsafe sexual practices and increased risk of sexually transmitted infections,^{38 39} which may increase the risk of adverse pregnancy outcomes.⁴⁰ While we did not have the necessary data to evaluate potential mediation by these factors, we did investigate the role of placental inflammation and vascular malperfusion, which are associated with biomarkers of stress and demographic profiles.¹⁰ However, our results indicate that eviction filing rate is not associated with placental pathology.

There are several limitations of our study. By using medical records, we did not have data on individual experience with eviction or individual measures of socioeconomic status. Our findings are based on eviction rates of an area, which may not capture individual experience with housing instability. Further, some subjects in our dataset likely own their own homes and are not at risk of eviction. To account for this, we conducted

a sensitivity analysis restricted to those living in block groups where >30% of households are occupied by renters. Similarly, models were adjusted for median household income of the block group because we did not have data on individual measures of socioeconomic status beyond insurance type. Adjustment for median household income of the block group should also help reduce confounding due to other neighbourhood characteristics, such as violence. Eviction estimates from the Eviction Lab also likely underestimate the true eviction rate of a block group. Estimates are based on court proceedings, which do not capture informal evictions (may account for nearly half of all forced moves¹⁸), or evictions where tenants move out during the termination period, which occurs prior to filing in court.^{20 22} Our analysis of placental data is also based on the subset of placentas that are submitted to pathology for evaluation, which are not reflective of all deliveries. Finally, our results may not be generalisable, as our sample was restricted to a single metropolitan area and eviction policies and tenant protections vary.

The strength of our analysis includes the use of a large dataset from a single hospital. We also restricted the sample to those living in the city of Chicago to ensure consistent eviction policies. Our findings were consistent across several sensitivity analyses. Additionally, we used data on placental pathology reports to investigate potential biological mechanisms.

Associations between the eviction rate of the block group and individual odds of preterm birth suggest that eviction may have health implications for pregnancy. These findings should be replicated and future research should determine whether individual experience with eviction is associated with adverse pregnancy outcomes. Future research should also investigate potential mechanisms, including changes in mental health and health behaviours. Additionally, several cities and states have implemented policies to protect tenants in the eviction process. Studies should investigate whether policies that improve housing stability are associated with improved health outcomes, especially for pregnant individuals.

What is already known on this subject

- ▶ Several studies have reported associations of forms of housing instability, such as homelessness, with adverse pregnancy outcomes. However, eviction is less studied and may impact a greater segment of the population than more severe forms of housing instability.

What this study adds

- ▶ Our results indicate that individuals living in block groups with higher eviction rates were more likely to deliver preterm, independent of demographic characteristics and block-group socioeconomic status. Associations were stronger in magnitude for individuals in block groups with lower median household incomes as compared with those in block groups with higher median household incomes, suggesting that access to resources may modify the association between eviction and pregnancy outcomes.

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Contributors AAF acquired and analysed the data with feedback from BPS, LSK-D, AB, LME and GEM. All authors assisted with interpretation of the results. AAF and BPS drafted the manuscript and LSK-D, AB, LME and GEM critically reviewed and provided feedback on multiple versions of the manuscript. All authors approved the final manuscript.

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ORCID iD

Alexa A Freedman <http://orcid.org/0000-0001-9745-7768>

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