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Article

Eviction in early childhood and neighborhood poverty, food security, and obesity in later childhood and adolescence: Evidence from a longitudinal birth cohort

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ABSTRACT

Eviction affects a substantial share of U.S. children, but its effects on child health are largely unknown. Our objectives were to examine how eviction relates to 1) children's health and sociodemographic characteristics at birth, 2) neighborhood poverty and food security at age 5, and 3) obesity in later childhood and adolescence. We analyzed data from the Fragile Families and Child Wellbeing Study, a longitudinal cohort of children born in 20 large U.S. cities. Children who lived in rental housing with known eviction histories and measured outcomes were included. We compared maternal and infant health and sociodemographic characteristics at the time of the child's birth. We then characterized the associations between eviction and neighborhood poverty and food security at age 5 and obesity at ages 5, 9, and 15 using log binomial regression with inverse probability of treatment and censoring weights. Of the 2556 children included in objective 1, 164 (6%) experienced eviction before age 5. Children who experienced eviction had lower household income and maternal education and were more likely to be born to mothers who were unmarried, smoked during pregnancy, and had mental health problems. Evicted and non-evicted children were equally likely to experience high neighborhood poverty at age 5 (prevalence ratio (PR) = 1.03, 95% CI 0.82, 1.29) but had an increased prevalence of low food security (PR = 2.16, 95% CI 1.46, 3.19). Obesity prevalence did not differ at age 5 (PR = 1.01; 95% CI 0.58, 1.75), 9 (PR = 1.08; 95% CI 0.715, 1.55); or 15 (PR = 1.05; 95% CI 0.51, 2.18). In conclusion, children who went on to experience eviction showed signs of poor health and socioeconomic disadvantage already at birth. Eviction in early childhood was not associated with children's likelihood of neighborhood poverty, suggesting that eviction may not qualitatively change children's neighborhood conditions in this disadvantaged sample. Though we saw evidence supporting an association with low child food security at age 5, we did not find eviction to be associated with obesity in later childhood and adolescence.

Introduction

The United States is in the midst of a housing affordability crisis, owing to rising housing costs and stagnant income growth (Desmond, 2015). At the same time, a growing share of families with children are living in rental housing (Joint Center for Housing Studies, 2017). Together, these trends suggest that the current generation of U.S. children will experience unprecedented rates of eviction. Eviction is defined

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as the "the dispossession of a tenant of leased property by force or especially by legal process." (Merriam-Webster, 2019) A recent study estimated that 15% of children born in large U.S. cities from 1998 to 2000 had experienced an eviction by age 15. (Lundberg & Donnelly, 2019) Without interventions to address housing affordability, eviction rates are likely to increase.

Recent sociological evidence suggests that eviction is not merely a symptom of adverse social conditions, but a cause of future adversity, both short and long-term (Desmond, 2012; Desmond, Gershenson, & Kiviat, 2015). In a study of low-income, urban families, past-year eviction was associated with increased material hardship, maternal depression, poor maternal health, and parenting stress, with the effects on material hardship and maternal depression persisting up to two years post-eviction (Desmond & Kimbro, 2015). Because evictions carry a lasting legal record, a single eviction can prevent a family from accessing quality, affordable housing in a desirable neighborhood years later (Desmond, 2016). This evidence suggests that a child who experiences an eviction early in life may be on a trajectory to experience a set of health-related exposures, leading to health disparities.

While eviction has been linked to adverse mental health, healthcare utilization, and infectious disease outcomes in adults (Collinson & Reed, 2018; Damon et al., 2019; Kennedy, Kerr, & McNeil, 2017; Kennedy, McNeil, et al., 2017b; Leifheit & Jennings, 2019; Niccolai, Blankenship, & Keene, 2018; Pilarinos et al., 2017; Rojas, 2017; Rojas & Stenberg, 2016; Vásquez-Vera et al., 2017), the relation between eviction and child health outcomes has been less studied. To our knowledge, only one study has evaluated the relation between eviction and child health in renter populations. The study found eviction in the past year to be associated with a 10% increased probability of poor parent-reported child health among five-year-old children (Desmond & Kimbro, 2015). It remains unknown, however, whether the health effects of an eviction in early childhood endure into later childhood and adolescence and whether eviction can be tied to specific childhood health outcomes. In particular, we focus on one outcome that is particularly sensitive to material hardship: childhood obesity.

We hypothesized that material hardship following an eviction might compromise a family's ability to provide nutritious food and exercise opportunities during early childhood, leading to obesity in later childhood and adolescence. Childhood obesity is a serious problem in the U.S. because it places children at risk for later poor health and mortality in adulthood (Hoffmans, Kromhout, & de Lezenne Coulander, 1989). In 2015–2016, the prevalence of obesity in children and adolescents aged 2–19 years was 18.5% and affected about 13.7 million children and adolescents (Hales, Carroll, Fryar, & Ogden, 2017, pp. 1–8). Childhood obesity follows a social gradient, with children in families with low income and educational attainment experiencing three to four times the odds of obesity of children with higher socioeconomic status (Singh, Siahpush, & Kogan, 2010).

Early childhood may be a critical window during which social exposures like eviction have a high potential to impact later obesity (Wells, Evans, Beavis, & Ong, 2010; Slopen, Koenen, & Kubzansky, 2014; Tamayo, Christian, & Rathmann, 2010). A large body of literature suggests that children's BMI trajectories are established in the antenatal period and early in childhood (ages 0–5) (Dietz, 1994; Koletzko, Brands, Poston, Godfrey, & Demmelmair, 2012). Fig. 1 illustrates two potential mechanisms through which eviction in early childhood may lead to obesity later in childhood and adolescence. An eviction may cause a family to move to less expensive housing in a more impoverished neighborhood (Collyer & Bushman-Copp, 2019). Low-income neighborhoods tend to be highly obesigenic, with low access to healthy foods and safe play opportunities for children (Carroll-Scott, Gilstad-Hayden, & Rosenthal, 2013). Independently, material scarcity following an eviction may also lead to poor food security, defined as reduced quantity, quality, variety, and/or desirability of a child's diet (USDA Economic Research Service, 2019). Over time, these dietary changes may lead to elevated rates of obesity for a child in later childhood and adolescence.

Overall goal and objectives

In this paper, our overall goal was to contribute to a body of knowledge regarding the impact of the U.S. housing affordability crisis on child health. We sought to better understand the health consequences of eviction and gain insight into whether eviction may be contributing to a high prevalence of obesity among low-income, urban children. Using data from a longitudinal cohort of low-income children born in 20 large U.S. cities from 1998 to 2000, our objectives were to: 1) describe and compare the health at birth and sociodemographic characteristics of children and parents who experienced an eviction in early childhood (ages 0–5) versus those who did not; 2) determine the association between eviction in early childhood and shorter-term outcomes of a) high neighborhood poverty or b) low food security at age 5; and 3) determine the association between eviction in early childhood and the longer-term outcome of increased prevalence of obesity at ages 5, 9, and 15.

Materials and methods

Source Population and Study Design

Data for this study were collected as part of the Fragile Families and Child Wellbeing cohort study. The study is a birth cohort of nearly 5000 children born to "fragile families" (i.e. largely unmarried, low-income parents) in 20 large U.S. cities (with populations over 200,000) between 1998 and 2000 and followed for 15+ years (Reichman, Teitler, Garfinkel, & McLanahan, 2001). The study provides a unique opportunity to understand how policies and environmental conditions affect children born into fragile families and is one of few studies to have captured longitudinal data on family evictions along with objectively measured child health data. Most variables included in analyses are part of the public use Fragile Families dataset and are freely downloadable

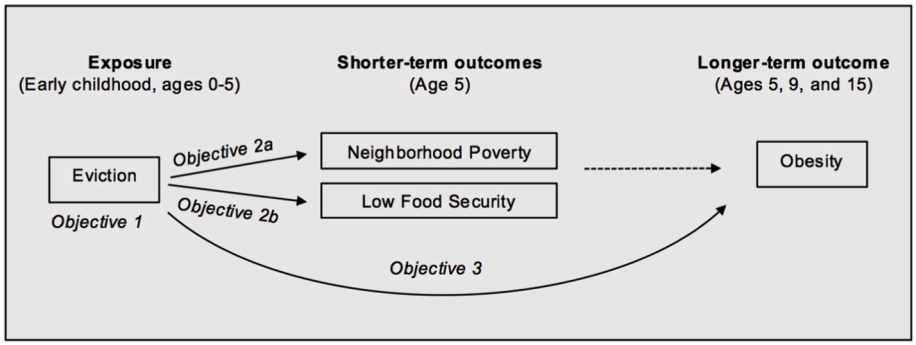

Fig. 1. Overview of study objectives evaluating two hypothesized mechanisms for the development of obesity following an eviction in early childhood.

via Princeton University's Office of Population Research data archive. However, variables derived from medical records and census-tract-level contextual information were part of the study's restricted use contract data and required an application for access.

The study methods have been previously described (Reichman et al., 2001). Briefly, study cities (n = 20) were selected randomly within strata of welfare generosity, the strengths of the child support system, and local labor market conditions. Within selected cities, live births were randomly sampled within strata of marital vs. non-marital births to participate following delivery. Children were excluded from the study if they were placed for adoption at birth, did not have two living parents, or had parents who were not proficient in English or Spanish. Enrolled biological parents were interviewed at birth to collect baseline data on parental demographic and socioeconomic information, as well as information on the pregnancy and maternal and infant health. Follow-up visits were conducted around the child's 1st, 3rd, 5th, 9th, and 15th birthdays, including interviews of both biologic parents and in-home assessments of the child. Certain survey items were only asked of primary caregivers, whom Fragile Families defines as the biologic parent or adult who lives with the index child at least half of the time, defaulting to the mother if the child lives with both biologic parents.

4898 families were enrolled into the Fragile Families Study. We defined our source population as children in the study who met the following inclusion criteria during early childhood (ages 0–5): a minimum of one primary caregiver follow-up interview completed, residence with a parental primary caregiver for at least 1 study visit, and residence in a rental home for at least 1 study visit. We focused on renter populations in order to better inform policies related to eviction among renters. These exclusions resulted in a source population of 4238 children.

We then excluded children with missing exposure and outcome data. Children were excluded because their primary caregiver did not answer interview questions about past-year eviction (see "Measures" below) at the Year 1, 3, or 5 visit (n = 31). For Objectives 1 and 2, we excluded children with missing data on neighborhood poverty and food security at age 5, leaving a study population of 2556 children. Separately, for obesity analyses (Objective 3), we excluded children whose BMI was not objectively measured by study staff at ages 5, 9, and 15, leaving study populations of 1928, 2970, and 940 children at the respective ages. The study sample was particularly limited in year 15 because in-home assessments, including height and weight measurements were only conducted in a random subset of children due to budgetary constraints.

Measures

Eviction: We define the primary exposure as report of an eviction in the past year at the 1, 3, or 5-year visit by the child's primary caregiver. The exposure was derived from the question, "In the past 12 months, were you evicted from your home or apartment for not paying the rent or mortgage?"

Outcomes: The outcome of interest for Objective 2a was residence in a high poverty neighborhood at age 5. "High poverty" was defined per the U.S. Census definition of a poverty area, i.e. 20% or more of the census tract population with income below the federal poverty level (Bureau of the Census, 1995). For Objective 2 b, the outcome of low food security was defined based on primary caregiver responses to the U.S. Department of Agriculture Children's Food Security Scale at the Year 5 visit (USDA Economic Research Service, 2012). The scale is based on 8 questions designed to gauge difficulty encountered by parents in providing nutritionally adequate or foods for their children over the past 12 months. Responding affirmatively to two or more of the items indicates low children's food security. Obesity, the outcome for Objective 3, was calculated based on children's BMI at ages 5, 9, and 15. At each of these visits, trained research assistants measured height and weight using a stadiometer and scale. BMI was then calculated as kg/m^2 and converted to z-scores using CDC growth charts (Kuczmarski et al., 2000). We defined obesity as a z-score greater than or equal to 1.96 (i.e. the 95th percentile or greater). (CDC, 2017).

Baseline covariates: Baseline covariates, measured at birth, include measures of maternal demographic factors (age and race/ethnicity), socioeconomic status (maternal education, household income, neighborhood poverty level), parental relationship, maternal health (history of mental health problems, overweight/obese prior to pregnancy, smoking during pregnancy), child characteristics (sex at birth, ever breastfed, preterm birth, and low birth weight). Demographic and socioeconomic variables were drawn from parental surveys, whereas health and pregnancy-related variables were abstracted from mother and child medical records.

Statistical analysis

We began analyses by using multiple imputation by chained equations (Stuart, Azur, Frangakis, & Leaf, 2009) to impute missing data on baseline covariates in the source population. Baseline covariates were missing at rates of 0–38% in the source population (mean = 12%, median = 3%). The highest rates of missingness were in variables abstracted from medical records, in most cases because several hospitals barred researchers from accessing medical records, but occasionally because the mother did not consent to medical record review. We created 10 imputed datasets, using baseline covariates and the exposure (early childhood eviction) in the imputation model.

Then, as described above, in "*Source Population and Study Design*," we created 4 distinct datasets with complete exposure and outcome information: one for Objectives 1 and 2 and three for objective 3 (i.e. one for each age of obesity measurement). These study populations are delineated in a study flow diagram (Fig. 2). We conducted the weighting procedures described below on each study population independently.

In order to mitigate the effects of selection bias stemming from our exclusion of participants with incomplete data on exposures and outcomes, we used inverse probability of censoring weights (IPCW) (Cole & Hernán, 2008) to weight each study population to the full source population of Fragile Families who ever rented during early childhood. We constructed the model for censoring using backwards stepwise regression, identifying the set of baseline covariates and the exposure of interest (early childhood eviction) to model selection into each study population. Early childhood eviction was included in all selection models to mitigate the effects of study dropout driven by the exposure. Weights were stabilized using the marginal probability of selection (Cole & Hernán, 2008). We then checked the IPCW model by comparing the baseline characteristics of the full source population to those of the study population for each objective, before and after IPCW weighting.

In order to describe and compare the baseline health and demographic characteristics of children and parents who went on to experience an eviction in early childhood (Objective 1), we present IPCW-weighted, imputed descriptive statistics, using chi-squared tests to compare distributions of categorical variables and t-tests to compare mean values between the two groups. For ease of discussion, these descriptive statistics are presented only for the IPCW-weighted Objective 2 study population (Table 1). Iteratively weighted baseline characteristics for each study populations in Objective 2 and Objective 3 can be found in Appendix 1.

To be able to compare outcomes between evicted and non-evicted children (Objectives 2 and 3), we then calculated inverse probability of treatment weights (IPTW) (Cole & Hernán, 2008) to account for systematic differences in the covariate values of children who experienced eviction in early childhood vs. those who did not. As with the IPCW models, we used backward model selection to identify a set of baseline covariates that was predictive of treatment (i.e. eviction in early childhood). We checked for non-positivity by plotting the distribution of propensity scores (i.e. predicted probability of treatment) among the treated and untreated groups, ensuring that there was sufficient overlap in the predicted probability of eviction between the

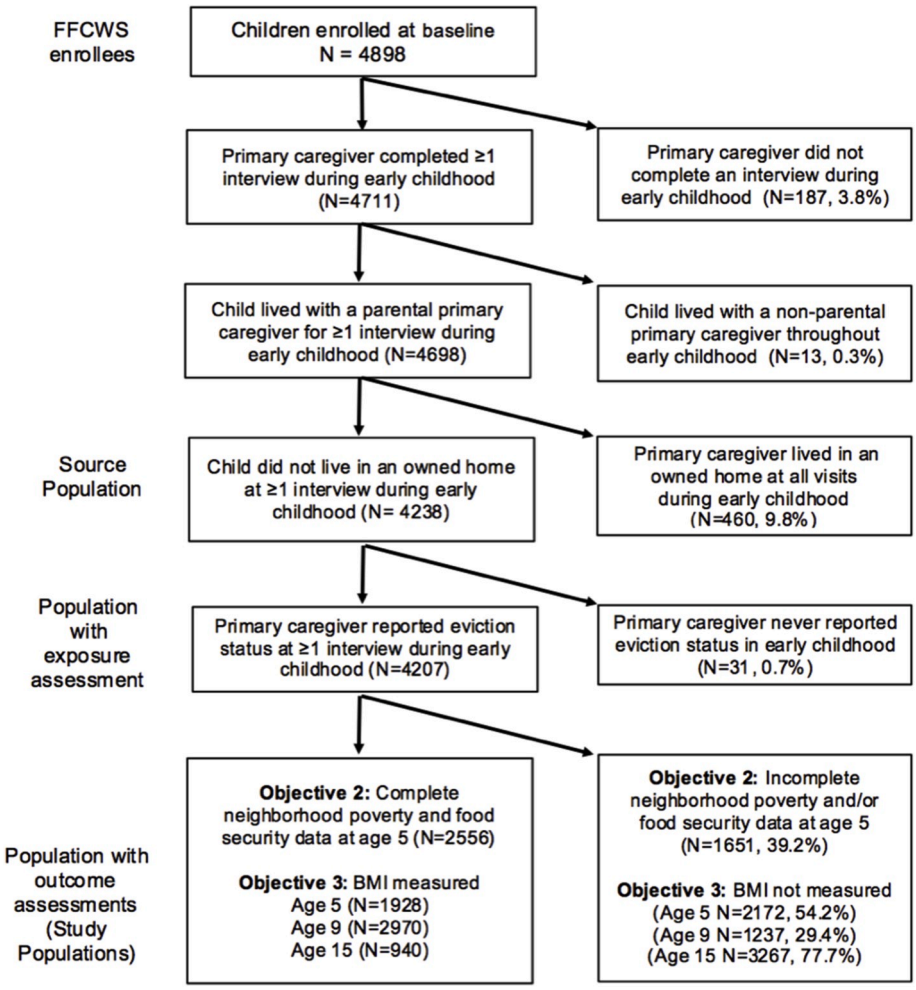

Fig. 2. Diagram showing selection of Fragile Families and Child Wellbeing Study (FFCWS) participants into the study population for Objectives 2 and 3. FFCWS is a birth cohort of children born in 20 large US cities between 1998 and 2000.

evicted and non-evicted children. We then stabilized the treatment weights using the marginal probability of treatment and created combined weights by multiplying censoring and treatment weights (Cole & Hernán, 2008). We checked the IPTW model by plotting the standardized differences between the treated and untreated groups before and after weighting (i.e., IPCW only versus combined weights). (Austin & Stuart, 2015).

We conducted log binomial regression for Objectives 2 and 3, using the imputed datasets and combined weights. Each of the five models regresses a dichotomous outcome on early childhood eviction. The exponentiated coefficients from the regression model can be interpreted as prevalence ratios, comparing the prevalence of each outcome between the evicted vs. non-evicted children.

Sensitivity analyses

Because other studies of childhood adversity and obesity have found divergent effects by child sex (Isohookana, Marttunen, Hakko, Riipinen, & Riala, 2016; Suglia, Duarte, Chambers, & Boynton-Jarrett, 2012, 2013), we ran stratified models for Objective 3, testing for associations separately in male and female children.

To control for differential distributions of covariates by outcome status, we conducted doubly robust regression, adding confounders as covariates to the combined weight outcome models for Objectives 2 and 3 (Funk et al., 2011). We examined whether this approach substantially changed prevalence ratios estimating the associations between early childhood eviction and the outcomes.

We also replicated analyses from Objectives 2 and 3 using continuous, rather than dichotomized outcomes. These analyses were motivated by the hypothesis that eviction might change mean levels of outcomes, such that children change within rather than between categories, for example, increasing BMI following an eviction without shifting qualitatively from non-obese to obese.

Finally, given our use of multiple imputation and weighting, we are not able to account for the hierarchical data structure induced by the Fragile Families sampling scheme (i.e. children nested within cities) using standard multilevel approaches. To get a sense of whether non-independence of children within cities might affect our results, we ran unweighted multilevel mixed effects models, adjusting for the confounders in the IPTW model, and compared the point estimates and standard errors derived from this model to those derived from a non-hierarchical model. Separately, we included city of birth as indicator variables in regression models to determine whether city fixed effects might influence our results.

Results

Objective 1

Among 2556 children, 164 (6%) primary caregivers reported an eviction in early childhood (Table 1). Among children ever-evicted, 81 (51%) children were evicted between birth and age 1, 54 (35%) were

Table 1
Objective 1: Baseline (i.e. at birth) characteristics of mothers and children evicted in early childhood (ages 0–5) vs. not evicted in early childhood. The study sample consists of renting households in the Fragile Families and Child Wellbeing Study, a birth cohort of children born in 20 large US cities between 1998 and 2000 (N = 2556, IPCW weighted).

	Not Evicted	Evicted	p-value
	N = 2392	N = 164	
Maternal & Pregnancy Characteristics			
Age			
<20	20%	22%	
20–34	72%	70%	
≥35	8%	7%	0.784
Race/ethnicity			
NH White	18%	21%	
NH Black	50%	48%	
Hispanic	28%	26%	
Other/missing	4%	6%	0.495
Education			
< High school	37%	49%	
High school or equivalent	32%	29%	
Some college or technical school	24%	21%	
College or Graduate	7%	1%	0.009
Smoked during pregnancy	22%	35%	<0.001
Mental health problems	13%	25%	<0.001
Overweight/obese pre-pregnancy	49%	51%	0.677
Household Characteristics			
Parental relationship			
Married	20%	8%	
Cohabiting	38%	50%	
Not married or cohabiting	42%	43%	0.001
Annual Income in $1000s – mean (SD)	28.2 (29.8)	23.2 (20.8)	0.004
High neighborhood poverty (%)	45%	46%	0.798
Child Characteristics			
Female	48%	47%	0.877
Ever breastfed	54%	55%	0.803
Born pre-term	11%	16%	0.071
Low birth weight	10%	14%	0.197

evicted between ages 2 and 3, and 59 (36%) were evicted between ages 4 and 5. Twenty-four (16%) of the evicted children experienced more than one eviction during early childhood.

After applying censoring weights, the baseline characteristics of the Objective 1-2 study population were similar to that of the full source population (See Appendix 2, comparing source population vs. IPCW-weighted study populations). Comparing the weighted populations of children who experienced an eviction to those who did not, we found that evicted children were more likely to be born to a mother with lower educational attainment (49% vs. 37% not completing high school, p = 0.007; Table 1). Children who were evicted (vs. those who were not) were also more likely to be born to mothers who reported ever smoking during pregnancy (35% vs. 22%, p < 0.001) and mothers who reported a history of mental health problems (25% vs. 13%, p < 0.001). Children who were evicted (vs. those were did not) were less likely to live with parents who were married at baseline (8% vs. 20%, p < 0.001) and lived in households with lower annual incomes, on average ($23,200 [SD 20,800] vs. $28,200 [SD 29,800], p = 0.004). Evicted children were slightly more likely to be born pre-term than children with no reported eviction (16% vs. 11%, p = 0.071).

At birth, evicted and non-evicted children were equally likely to live in high poverty neighborhoods (46% vs. 45%, p = 0.789) and were born to similarly aged mothers (22% vs. 20% below 20, 70% vs. 72% 20–34, and 7% vs. 8% ≥ 35; p = 0.784) with similar age and racial and ethnic backgrounds (21% vs. 18% non-Hispanic white, 48% vs. 50% non-Hispanic Black, 26% vs. 28% Hispanic, and 6% vs. 4% other; p = 0.495). There were no apparent differences in rates of maternal pre-pregnancy overweight/obese status (51% vs. 49%, p = 0.677) or breastfeeding between groups (55% vs. 54%, p = 0.803).

Objective 2

After applying treatment weights, we found that 39.8% of children evicted in early childhood lived in high poverty neighborhoods at age 5, compared to 38.7% of children with no reported evictions (Objective 2a, Table 2). The prevalence ratio comparing the two groups was 1.03 (95% CI 0.82, 1.29), indicating no statistically significant difference in the prevalence of high neighborhood poverty between the two groups. We found that 16.8% of evicted children had low food security at age 5, compared to 7.8% of non-evicted children (Objective 2 b). The prevalence ratio for this comparison was 2.16 (95% CI 1.46, 3.19), indicating a statistically significant increase in the prevalence of low food security among the evicted children.

Objective 3

We assessed the association between early childhood eviction and obesity at age 5 in a sample of 1928 children, 125 (6.5%) of whom had experienced eviction. While the prevalence of obesity was slightly higher (i.e. not statistically significant) in children who had experienced eviction in models with censoring weights only (12.1% vs. 10.9%, prevalence ratio (PR) 1.11; 95% CI 0.67, 1.82; Table 3), the ratio was attenuated once treatment weights were applied (1.01; 95% CI 0.58, 1.75). We saw a similar pattern at ages 9 and 15. At age 9 in a sample of 2970 children, 189 (6.4%) of whom experienced an eviction in early childhood, evicted children had a slightly higher prevalence of obesity in censoring weight models (17.7% vs. 15.4%, PR 1.15; 95% CI 0.83, 1.58), but, again, the ratio was attenuated once treatment weights were applied (1.08; 95% CI 0.72, 1.55). At age 15, the sample was comprised of 940 children, 55 of whom (5.9%) had experienced early childhood eviction. Once again, the prevalence of obesity was slightly higher among evicted children in the censoring weight model (18.8% vs. 16.8%, PR 1.12; 95% CI 0.64, 1.96), but the ratio was attenuated in the model with combined weights (1.05; 95% CI 0.51, 2.18).

Sensitivity analyses

Analyzing data in strata of child sex, we did not see any statistically significant associations between early childhood eviction and obesity at 5, 9, or 15 for male or female children. For female children at ages 9 and 15, this increase was nonetheless meaningfully large, displaying a slight indication that obesity might be elevated among females who

Table 2
Objective 2: Proportion of children a) living in a high poverty neighborhood and b) with low food security at age 5, comparing children evicted in early childhood (ages 0–5) to children who were not evicted in early childhood (N = 2556).

	Censoring weights only		Combined weights[c]	
	Prevalence	95% CI	Prevalence	95% CI
2a High poverty neighborhood[a]				
Not evicted (N = 2392)	38.2%	36.2, 40.1	38.7%	36.7, 40.7
Evicted (N = 164)	39.6%	32.1, 47.1	39.8%	31.0, 48.5
Ratio	1.04	0.87, 1.28	1.03	0.82, 1.29
2b Low food security[b]				
Not evicted (N = 2392)	7.7%	6.6, 8.8	7.8%	6.7, 8.9
Evicted (N = 164)	18.0%	12.11, 23.8	16.8%	10.7, 22.8
Ratio	2.33	1.63, 3.33	2.16	1.46, 3.19

[a] 20% or more of the census tract population with income below the federal poverty level.
[b] Based on parental responses to the USDA U.S. Children's Food Security Scale.
[c] Model contains combined inverse probability weights for censoring and treatment. Treatment weights include the following baseline covariates, measured at birth: Maternal age category, maternal education, smoking during pregnancy, maternal mental health problems, parental relationship, household income, neighborhood poverty, and preterm birth.

Table 3
Objective 3: Prevalence of obesity and mean BMI at ages 5, 9, and 15, comparing children evicted in early childhood (ages 0–5) to children who were not evicted in early childhood.

	Censoring weights only		Combined weights[b]	
	Prevalence	95% CI	Prevalence	95% CI
Obesity[a] at 5 (N=1928)				
Not evicted (N = 1803)	10.9%	9.4, 12.4	10.8%	9.3, 12.3
Evicted (N = 125)	12.1%	6.3,17.8	10.8%	5.1, 16.6
Ratio	1.11	0.67, 1.82	1.01	0.58, 1.75
Obesity at 9 (N=2970)				
Not evicted (N = 2781)	15.4%	14.1, 16.8	15.2%	13.9, 16.6
Evicted (N = 189)	17.7%	12.3, 23.1	16.4%	10.6, 22.2
Ratio	1.15	0.83, 1.58	1.08	0.72 1.55
Obesity at 15 (N=940)				
Not evicted (N = 885)	16.8%	14.3, 19.3	16.6%	14.2, 19.1
Evicted (n = 55)	18.8%	8.6, 29.0	17.4%	5.0, 29.9
Ratio	1.12	0.64, 1.96	1.05	0.51, 2.18

[a] Obesity is defined as a BMI z-score in the 95th percentile or above.
[b] Model contains combined inverse probability weights for censoring and treatment. Treatment weights include the following baseline covariates, measured at birth: Maternal age category, maternal education, smoking during pregnancy, maternal mental health problems, parental relationship, household income, neighborhood poverty, and preterm birth.

experienced eviction in early childhood (age 9 PR 1.18; 95% CI 0.76, 1.85; age 15 PR 1.24; 95% CI 0.55, 2.81), though the confidence interval included zero.

We found that effect estimates and confidence intervals derived from doubly robust regressions did not differ substantially from the results in the combined weights models. Likewise, analyses treating outcomes as continuous rather than dichotomous yielded null results in keeping with those reported in the main analysis.

In multilevel mixed effects models, intraclass correlation coefficients suggested low-to-moderate clustering by city, with 0–13% of total residual variance attributable to city random effects. Nonetheless, effect estimates and confidence intervals from the multilevel models did not differ substantially from those derived from non-hierarchical models. Likewise, adding city of birth as an indicator variable to regressions did not appear to impact our results (data not shown).

Conclusions

Using data from the Fragile Families and Child Wellbeing Study, we investigated the effects of eviction in early childhood on the obesity status of children later in childhood and adolescence—including two potential mechanisms, neighborhoods and food security—in a study population of low-income, urban children.

Our results highlight the vulnerability of children who experience eviction compared to non-evicted children (Objective 1). Children who experienced eviction in early childhood had a number of risk factors for poor health already at birth, including low socioeconomic status, maternal smoking and mental health problems, and preterm birth. Dissimilar to previous studies demonstrating that eviction is patterned by residential segregation and housing discrimination, disproportionately affecting people of color living in high poverty neighborhoods (Desmond, 2012; Desmond, An, Winkler, & Ferriss, 2013; Desmond & Shollenberger, 2015; Leifheit, Pollack, Black, & Jennings, 2018), we found no differences by race or neighborhood poverty in exposure to eviction. These findings likely stemmed from the fact that a large proportion of Fragile Families participants are people of color in low-income families. This relatively homogenous sample allowed us to test the effects of eviction among those families most likely to experience the exposure.

We observed that eviction in early childhood did not appear to be associated with a child's likelihood of living in a high poverty neighborhood at age 5 (Objective 2a). Given that 45% of the sample lived in a high poverty neighborhood at birth, we hypothesize that evictions resulted in lateral moves within high poverty neighborhoods, rather than displacement from a low poverty neighborhood to a high poverty neighborhood. This type of "residential churn" is common among low-income, urban families in the U.S. (DeLuca, Wood, & Rosenblatt, 2019; Desmond et al., 2015; Dragan, Ellen, & Glied, 2019) It may be that eviction would be associated with displacement in populations with higher socioeconomic status at baseline and/or in settings that are rapidly gentrifying. Indeed, studies conducted in San Francisco, New York City, and Milwaukee have found forced moves and evictions to be associated with living in a more impoverished neighborhood (Collyer & Bushman-Copp, 2019; Cushing, Kersten, & Yen, 2019; Desmond & Shollenberger, 2015). However, longitudinal data from Fragile Families afforded us unique insight into within-group experiences of neighborhood mobility following eviction. Future studies of eviction and health might consider incorporating longitudinal address information in order to better understand patterns of mobility following an eviction.

Consistent with Desmond and Kimbro's finding of increased material hardship following evictions (Desmond & Kimbro, 2015), we found that five-year-old children evicted in early childhood had over twice the prevalence of low food security compared to children with no evictions (Objective 2 b, 16.8% vs. 7.8%). This finding supports our hypothesis that children's access to adequate and nutritious food suffers following an eviction, likely due to material hardship rather than a neighborhood effect.

In Objective 3, we found that small (not statistically significant) increases in prevalence of obesity at ages 5, 9, and 15 among evicted children were eliminated when we applied treatment weights, suggesting that baseline differences between evicted and non-evicted children may be responsible for any observed differences in obesity. This null association may be attributable to a number of factors. First, it is possible that we were underpowered to detect effects in potentially important subgroups such as female adolescents. Consistent with studies reporting more pronounced effects of social stressors on obesity among females (Isohookana et al., 2016; Suglia et al., 2012, 2013), our sensitivity analysis suggested a slight positive association between eviction and obesity in older female children, but these results did not reach statistical significance. Second, neighborhood poverty or disadvantage is an important determinant of childhood obesity (Carter & Dubois, 2010; Greves Grow et al., 2010; Rossen, 2014). Eviction doesn't appear to push children into high poverty neighborhoods and, by extension, obesogenic food environments in this sample. Rather, a large proportion of children were already living in obesogenic environments, regardless of their exposure to eviction. Although eviction was associated with low food security, we don't know how long this low food security persists or how it alters children's diets. Moreover, the relationship between low food security and obesity is complex and research findings have been mixed (Casey, Simpson, & Gossett, 2006; Franklin et al., 2012; Gundersen, Garasky, & Lohman, 2009). Finally, eviction affected some of the most vulnerable families in the Fragile Families Study (Objective 1). It is possible, given the force of poverty and disadvantage already evident when these children were born, that eviction may not independently change the health trajectories of children in this group, particularly with respect to outcomes like obesity that develop via complex mechanisms closely linked to family and neighborhood resources.

Our study has a number of limitations. First, we measure the exposure of eviction during early childhood via parental report at three study visits. This likely results in misclassification of the exposure and specifically, under-reporting of eviction. Parents may not report an eviction either due to the stigma and legal implications attached to the experience. Moreover, evidence suggests that individuals may not be aware that they have been evicted or may view the eviction as a decision to move (Desmond, 2016). Additionally, our study design allows for report of eviction from birth to age 1, from age 2 to age 3, and from age 4 to age 5. This leaves two one-year periods in early childhood during which eviction is not measured. If we assume that parental underreporting is

non-differential by outcome status (e.g. obese or not), this misclassification would bias our results toward the null. Future research could avoid misclassification by linking health data to eviction court records. Second, though we used censoring weights to limit the effects of emigrative selection bias on our results, censoring was extensive in our study and it is unlikely that we were able to completely model the censoring mechanism(s) with available variables. Thus, our results may not fully reflect the associations we would have observed in the source population.

Following children longitudinally, we found that eviction in early childhood did not increase the prevalence of obesity in a sample of low-income, urban children. We attribute this finding largely to the extreme health and socioeconomic disadvantage of children who went on to experience eviction, apparent already at birth, and the fact that eviction did not appear to radically change children's neighborhood context. This is not to say that eviction is not an important determinant of child health. Indeed, we found evidence of a strong association between early childhood eviction and low food security at age 5. Given the importance of adequate nutrition for child health and development, this finding has far-reaching implications for the health of low-income children in the United States. Finally, this work explored one disease pathway anchored on material scarcity and neighborhood resources. While our obesity results were null, we expect that eviction might affect child health even among the most disadvantaged children through a different, as yet unexplored pathway: psychosocial stress. In future work with the Fragile Families dataset, we aim to explore whether eviction might have profound effects on child health outcomes that are more sensitive to stress, such as preterm birth, child development, and behavioral, emotional, and mental health. Given the potential that eviction might push families into unhealthy housing, future research might also focus on incidence of asthma and lead poisoning associated with eviction, information also captured in Fragile Families.

Taken together, our findings suggest two main takeaways for policymakers. First, the relationship we identified between eviction and child food security suggests that, on the population level, interventions to reduce urban eviction (e.g. renter protections, affordable housing interventions) could improve children's access to food. A more downstream intervention might involve tailoring nutrition programs for families experiencing eviction. Second, children who experience eviction in early childhood, at least in this sample, already show signs of poor health and social vulnerability at birth. Programs to prevent eviction and expand housing affordability would be an important step in protecting these children from further adversity.

Declaration of competing interest

Dr. Pollack owns stock in Gilead Pharmaceuticals. The work detailed here does not evaluate any specific drugs or interventions produced by Gilead. Dr. Pollack is an unpaid member of Enterprise Community Partners' Health Advisory Council and was a paid consultant to the Open Communities Alliance. In September 2019 Johns Hopkins University entered into a contract with the Department of Housing and Urban Development (HUD) for Pollack to work part time on a temporary assignment, assisting the department on housing and health issues. The findings and conclusions in this article are those of the authors and do not necessarily represent those of HUD or other government agencies.

CRediT authorship contribution statement

Kathryn M. Leifheit: Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Funding acquisition. **Gabriel L. Schwartz:** Methodology, Validation, Writing - review & editing. **Craig E. Pollack:** Writing - review & editing, Conceptualization. **Maureen M. Black:** Writing - review & editing, Conceptualization. **Kathryn J. Edin:** Writing - review & editing, Investigation. **Keri N. Althoff:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Jacky M. Jennings:** Conceptualization, Methodology, Writing - review & editing, Supervision.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2020.100575.

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