Strong Upward Neighborhood Mobility and Reduced Preterm Birth in California: a Sibling Design Approach

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ABSTRACT

Much cross-sectional work reports positive associations between neighborhood disadvantage and illness. Limitations of this work include that persons with pre-existing unmeasured morbidity may "select" into, or out of, certain neighborhoods. This selection issue remains a key rival explanation for most work concerned with place-based disparities in birth outcomes. We move beyond a cross-sectional approach and exploit a sibling-linked dataset in California to test whether mothers who move from a very high to a very low disadvantaged neighborhood exhibit a lower than expected risk of preterm birth (i.e., delivery <37 weeks). We retrieved data on 461,061 sibling pairs (i.e., 922,122 births total) to mothers who gave birth in California from 2005 to 2010. We linked mother's address at two times (i.e., two sibling birth dates) to a census-derived composite indicator of neighborhood disadvantage. Importantly, logistic regression methods controlled for mother's risk of preterm birth in the sibling delivered *before* the move when estimating the relation between strong upward mobility and preterm of the subsequent birth *after* the move. As hypothesized, strong upward mobility (relative to no mobility) varies inversely with the risk of PTB of the second sibling (odds ratio [OR] for PTB = 0.83, 95% confidence interval: 0.74, 0.93; $p < .001$). This finding indicates that mothers moving from very high to very low disadvantaged neighborhoods appear to show an upward perinatal health trajectory above and beyond what is expected prior to her move.

INTRODUCTION

Extensive literature reports positive associations between residence in a disadvantaged neighborhood and adverse health. The literature on birth outcomes, for instance, includes a meta-analysis of over 1,500 articles over a 20-year period on this topic (1). Preterm birth (PTB; delivery <37 weeks of gestation) represents one important birth outcome which occurs more frequently in neighborhoods characterized as disadvantaged. PTB in the US accounts for ~10% of births in the US but over 50% of infant deaths (2). In addition, preterm infants that survive beyond the first year show an increased risk of developmental disorders, reduced educational attainment, and reduced earnings in adulthood (2).

Given the life-course sequelae of PTB, and its association with neighborhood disadvantage, scholars from a diverse set of fields have proposed hypotheses by which neighborhood disadvantage may affect PTB. Although definitions of neighborhood disadvantage vary, most scholars operationalize this construct through aggregate-level indicators of concentrated poverty, disinvestment in public resources, and lack of economic opportunity in a defined geographic area (3). A few (but by no means exhaustive) proposed pathways by which neighborhood disadvantage may affect PTB and other birth outcomes include elevated stress during pregnancy, peer norms that increase alcohol, tobacco, and other drug consumption, low quality housing conditions, ambient air pollution, lack of access to healthy food, and reduced access to health care and other services (1).

Scholars, however, note that the cross-sectional nature of research in this area precludes establishment of a causal relation (4,5). Cross-sectional study designs cannot rule out the key plausible rival of “neighborhood selection” in which healthier women, over time, move to less disadvantaged neighborhoods. Similarly, women with relatively worse health may, for various reasons, move to more disadvantaged neighborhoods or remain in these areas despite wanting to move away from disadvantage (6). To the extent that these moves correlate with factors that affect maternal and perinatal health, the non-random selection of persons into neighborhoods may strongly bias the relation between neighborhood disadvantage and birth outcomes.

We contribute to the literature by moving beyond cross-sectional approaches to examine the relation between neighborhood disadvantage and PTB. We exploit a unique sibling-linked dataset of over 900,000 births in California which allows us to track a mother’s residence, and her birth outcomes, over two time points. These data permit a sibling design approach and identification of upwardly mobile mothers who move from high to low disadvantaged neighborhoods.

We hypothesize that women who show strong upward mobility, by moving from a very-high to a very-low disadvantage neighborhood, will show a lower than expected risk of delivering a preterm infant. These strong upwardly mobile mothers represent a unique group that, unlike most persons living in a disadvantaged context (6), do not experience persistence in their exposure to disadvantage. We exploit this unique opportunity to assess the salience of a potentially protective effect of very low-disadvantage neighborhoods and the risk of preterm birth. We test our hypothesis using mothers with at least two live births in California from 2005 to 2010. We also examine as a secondary outcome small-for-gestational age (SGA), which captures severe growth restriction independent of the gestational age at delivery (7). California accounts for over 15% of all births in the US and includes a high degree of diversity in terms of racial/ethnic and socioeconomic composition. Importantly, the California dataset includes information on the PTB (and SGA) status of the index sibling born ***before*** the move. This information permits baseline control for unmeasured health characteristics related to the mother's risk of delivering a preterm infant.

METHODS

Variables and Data

We retrieved birth data from the California Department of Public Health (CDPH) birth files for years 2005-2010 (8). This time span represents the longest series of data years, with the requisite variables to perform our tests, available to us at the time of the analysis. The birth file contains over 99.99% of all live births in California and includes health and demographic information collected from the certificate of birth (8). The quality and provenance of the data are described elsewhere (8). Importantly, the birth file contains mother's home address at the time of birth, which permits linkage of neighborhood disadvantage variables (described below). The State of California and the University of California, Irvine approved the study (IRB protocol approval # 13-06-1251 and 2013-9716, respectively).

We geocoded maternal residential address of mothers at first birth and second birth using ArcGIS software version 10.4 (Redlands, California). We located maternal addresses using a 2013 street directory and assigned a corresponding census tract (a proxy of neighborhood) based on 2010 US Census geography. We excluded birth records with maternal addresses that failed to reach a minimum location match score of 80 percent or with unknown, missing, or non-California census tracts.

We used neighborhood disadvantage, measured at the census tract level, as our key independent variable (3). The disadvantage factor consists of six variables taken from the 2010 U.S. Decennial Census: the proportion of households with income <$15,000, the proportion of households with income >=$50,000 (reverse coded), the proportion of families in poverty, the proportion of households receiving public assistance, the total unemployment rate, and the proportion of vacant housing units (Cronbach's alpha = .92). We standardized each variable and then performed exploratory factor analysis to arrive at a composite indicator of the neighborhood disadvantage factor. We refer the reader to previous work describing the measurement characteristics of the neighborhood disadvantage factor (3,9).

We used PTB as our key dependent variable, categorized as binary (yes/no). We, consistent with the literature, defined PTB as gestational age of less than 37 completed weeks at delivery (i.e., <259 days) (10). We excluded observations with missing gestational age or missing exposure (see below) information or census tract. Given that previous literature finds that intrauterine growth also varies with characteristics of the social environment (11), we also examined small-for-gestational-age (SGA) as a second dependent variable. SGA, defined categorically as birth weight below the 10^{th} percentile for the given gestational age and sex (yes/no), serves as a clinically meaningful designation for severely growth-restricted infants. Perinatal epidemiologists have argued distinct etiologies of PTB and SGA, which indicates that these measures may respond differently to the social environment (7).

Sibling Linkage Strategy

We used a probabilistic linkage strategy to identify consecutive singleton live births to the same mother from January 2005 through December 2010. We performed record linkages using Link Plus (version 2.0), an open-source probabilistic record linkage program developed at CDC's Division of Cancer Prevention. Link plus computes linkage scores based on a theoretical framework (12). The program first identifies potential matches by "blocking" pairs of records with exact values on a specified field. Comparison-pairs receive a match score based on similarity of specified "match" variables. Pairs with higher scores appear more likely to reflect "true" matches. The user sets an upper-bound score above which all pairs receive a "true" match designation.

We used Linkplus to "block" records based on maternal date of birth. Pairs then received a match score according to similarity of maternal first and last name, in addition to maternal date of birth. We set the upper-bound score at 15.0, at or above which comparison-pairs share a common maternal date of birth, last name and first name. We rejected pairs of women with different last names, corresponding to match scores below 12.0. We conducted a manual review of pairs with match scores between 12.0 and 14.9 and additionally compared infant date of birth (in record 1) with date of last delivery (in record 2). We coded records with comparable dates for last delivery (in record 2) and infant birth (in record 1) as matches. This process, as well as exclusion of women with non-singleton births and/or missing values of independent or dependent variables, left us with an analytic sample of 461,061 sibling pairs (i.e., 922,122 births total).

Based on the sibling link and the geocoding of maternal addresses for each of the consecutive live births, we calculated a neighborhood mobility score. First, using mother's address at infant's live birth, we categorized the neighborhood disadvantage index into quartiles. Quartile 4 (Q4) represents the quartile with the highest disadvantage, and Q1 represents the quartile with the lowest disadvantage. Second, we categorized mothers by the level of neighborhood mobility away from, or into, disadvantage using the two time points of neighborhood information (i.e., index sibling and subsequent sibling, over 2005 to 2010). We created categorical variables for upward, downward, and no mobility. Strong upward mobility captures a move of 3 quartiles magnitude away from disadvantage (i.e., move from Q4 to Q1), while moderate upward mobility and low upward mobility capture a move of 2 quartiles, and 1 quartile, away from disadvantage, respectively. We coded downward mobility in a similar fashion to upward mobility but in the inverse (i.e., move from Q1 to Q4 is strong downward mobility). We coded mothers who show no upward or downward mobility as "no mobility." The "no mobility" category, however, does not imply that a mother reports identical residence for each birth. Mothers who move residence but do not change quartile of neighborhood disadvantage also qualify as "no mobility" given the presumed lateral nature of the move.

<u>Analysis</u>

Our test turns on whether the risk of PTB falls below expected values when mothers exhibit strong upward neighborhood mobility. Healthier mothers, however, with a lower risk of a PTB may show stronger upward mobility than would less-healthy mothers. This “neighborhood selection” problem, especially with cross-sectional data, makes it challenging for researchers to derive an expected value of preterm risk under the hypothetical (counterfactual case) of no neighborhood mobility. We addressed this issue by deriving the mother’s expected value of preterm from the birth outcome of her previous infant which occurred *before* mobility. This sibling control strategy rules out time-invariant confounding, such as mother’s overall health (or, for instance, race/ethnicity, education level), which affects the risk of preterm equally across consecutive births (13). Our strategy, also referred to as mother “fixed effects,” exploits within-mother variation in the risk of preterm.

The logic of the sibling control strategy led us to estimate the conditional logit (i.e., log-odds) of PTB (yes/no) of the second sibling as a function of the PTB status of the index sibling and of the mother’s neighborhood mobility score. We also inserted as control variables several time-varying characteristics of the mother as well as birth characteristics of the second sibling that reportedly affect the risk of PTB (14). These variables include maternal age at birth of second infant (categorized as <20, 20-24, 25-29, 30-34, 35-39, 40 years), expected payer for delivery (private insurance / Medicaid / other), parity, and infant sex. We then repeated the analysis but replaced PTB with SGA (yes/no) as the dependent variable. We conducted all analyses in SAS 9.4 (Cary, North Carolina).

RESULTS

Table 1 arrays 461,061 mothers by quartile of neighborhood disadvantage according the disadvantage scores of their residence at time 1 (i.e., index birth, horizontal axis) and time 2 (second sibling birth, vertical axis). The main diagonal indicates no mobility in that women's residence over the two recorded births remains within the same quartile of neighborhood disadvantage. Almost 29% of women, however, show mobility as indicated by off-diagonal cells. For instance, 3,812 women show strong upward mobility (upper right corner, from Q4 to Q1). Low and moderate mobility—both upward and downward—occur more frequently than does strong mobility.

We display the characteristics of the dependent variables, by level of mobility, in Table 2. Consistent with the fact that ~70% of mothers show no mobility, the majority of preterm cases appear in the no mobility category. The proportion of PTBs in any mobility category ranges from 8.47 to 10.95 per 100 births. The strong upward mobility category shows the lowest proportion of PTBs.

As hypothesized, strong upward mobility (relative to no mobility) varies inversely with the risk of PTB of the second sibling (odds ratio [OR] for PTB = 0.83, 95% confidence interval [CI]: 0.74, 0.93; $p < .001$, see Table 3). More modest mobility changes, as well as strong downward mobility, show no relation with PTB in that the 95% CIs contain the null value (i.e., 1.0). Other covariates yield coefficients that appear consistent with previous literature. Public health insurance (vs. private health insurance), for instance, varies positively with the risk of PTB, as does teenage pregnancy, preterm status of previous birth, and male infant sex.

Table 4 displays results predicting SGA of the second birth as a function of SGA of the index birth, neighborhood mobility, and covariates. We cannot reject the null for any level of upward mobility. By contrast, strong downward mobility varies with an increased risk of SGA, although the coefficient lies slightly outside conventional levels of statistical detection (odds ratio [OR] for SGA = 1.12, 95% CI: 1.00, 1.25; p=.06).

We assessed whether the mobility results appeared robust to alternative specifications. First, to ensure that a "positivity violation" did not distort results (15), we removed several maternal covariates that rise monotonically with progressing from the index birth to the subsequent birth (i.e., parity, maternal age). Second, for the strong upward mobility coefficient which rejected the null (Table 3; preterm test), we repeated the analysis using only the sample of mothers who initially resided in Q4 and therefore had the potential to exhibit strong upwardly mobile over time (i.e., move from Q4 to Q1 of neighborhood disadvantage). Inference from both sensitivity analyses remained essentially unchanged from the original tests (results available upon request).

DISCUSSION

Whereas much work reports cross-sectional associations between neighborhood conditions and perinatal health, non-random selection over time of individuals into place serves as a strong plausible threat to inferring any causal relation (1). We improve upon previous work by exploiting longitudinal information on maternal residence over two time points. We investigate the risk of PTB among California mothers who, from 2005 to 2010, moved from a neighborhood with high disadvantage to one with low disadvantage. We find that, controlling for mother's past risk of delivering preterm, the risk of preterm delivery falls below expected levels following a strong upward move to a very low-disadvantage neighborhood. This finding indicates that upwardly mobile mothers appear to show an upward perinatal health trajectory above and beyond what is expected prior to her move. Whereas we cannot interpret results as causal, this finding supports the plausibility of malleability of maternal and child health, even within a span of a few years, that corresponds with reduced neighborhood disadvantage.

Strengths of the analysis include the large sample size of over 900,000 births, drawn from the population base of a diverse set of mothers in California, over a six year period. This circumstance indicates external validity of results while ensuring adequate statistical power to examine the small subset of women (i.e., <1 percent of total) showing strong upward mobility. In addition, linkage of consecutive siblings by mother ID permits identification of neighborhood mobility over time while also controlling for mother's baseline risk of adverse birth outcomes before the move. This strategy, unlike earlier work (1), minimizes confounding due to selection of relatively healthier mothers into less disadvantaged neighborhoods.

Limitations include that results may not generalize to mothers with completed fertility of only one child, or to mothers with interbirth interval spacing that is longer than the six-year time span for which we had data. Mothers with at least two children over the study interval may show, on average, improved health and fecundity and therefore lower preterm and SGA risk. Whereas our sibling-comparison approach controls for these initial "endowments," we cannot know whether the mobility experiences of these mothers relate to the broader subset of women of childbearing age. We, moreover, do not have characteristics about the causes of change in residence, nor do we have detailed data on the socioeconomic circumstances of the family unit. For these reasons, we cannot identify potential mechanisms that may trigger mobility decisions and/or affect the health trajectory of mothers.

The sibling control strategy, while useful in minimizing unobserved confounding between mothers and time-invariant confounding within-mother, may introduce selection bias (15). In addition, all second births in this sibling pair occurred to an older mother of higher parity, both of which tend to affect risk of PTB and SGA. Although we include these covariates in the model to absorb between-mother differences, the fixed effects approach cannot fully adjust for contribution of these factors to PTB/SGA.

Given the rarity of strong upward mobility in our sample, we recognize that the population-level influence, if any, of moving to lower neighborhood disadvantage on PTB remains modest. We, however, view our results as important because they indicate that perinatal health may improve, over a relatively short time frame, among mothers initially living in a highly disadvantaged neighborhood. This possibility runs counter to research on smaller intergenerational datasets which find no improvements in perinatal health among women born preterm or low weight into high-poverty areas (16,17). We encourage replication of our results as well as additional longitudinal research to identify which characteristics of the neighborhood, and/or characteristics of these upwardly mobile women, improve the health trajectory of her subsequent pregnancy.

REFERENCES

1. Metcalfe A, Lail P, Ghali WA, Sauve RS. The association between neighbourhoods and adverse birth outcomes: a systematic review and meta-analysis of multi-level studies. Paediatr Perinat Epidemiol 2011;25(3):236-45.
2. Goldenberg RL, Culhane JF, Iams JD, Romero R. Epidemiology and causes of preterm birth. Lancet 2008;371(9606):75-84.
3. King KE, Morenoff JD, House JS. Neighborhood context and social disparities in cumulative biological risk factors. Psychosom Med 2011;73(7):572-9.
4. Margerison-Zilko C, Cubbin C, Jun J, Marchi K, Fingar K, Braveman P. Beyond the cross-sectional: neighborhood poverty histories and preterm birth. Am J Public Health 2015;105(6):1174-80.
5. Kramer MR, Dunlop AL, Hogue CJ. Measuring women's cumulative neighborhood deprivation exposure using longitudinally linked vital records: a method for life course MCH research. Matern Child Health J 2014;18(2):478-87.
6. Glass TA, Bilal U. Are neighborhoods causal? Complications arising from the 'stickiness' of ZNA. Soc Sci Med 2016;166:244-253.
7. Oken E, Kleinman KP, Rich-Edwards J, Gillman MW. A nearly continuous measure of birth weight for gestational age using a United States national reference. BMC Pediatr 2003;3:6.
8. Birth Cohort Public Use File, 1999–2003 2015, https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm [accessed 10 November 2015].
9. Kane JB, Miles G, Yourkavitch J, King K. Neighborhood context and birth outcomes: Going beyond neighborhood disadvantage, incorporating affluence. SSM Popul Health 2017;3:699-712.
10. Collins JW, Rankin KM, David RJ. Downward economic mobility and preterm birth: an exploratory study of Chicago-born upper class White mothers. Matern Child Health J 2015;19(7):1601-7.
11. Collins JW, Jr., Mariani A, Rankin K. African-American women's Upward Economic Mobility and Small for Gestational Age Births: A Population-Based Study. Matern Child Health J 2011;22(8):1183-1189.
12. Fellegi IP, Sunter AB. A theory for record linkage. Journal of the American Statistical Association 1969;64:1183–1210.
13. Sjolander A, Zetterqvist J. Confounders, Mediators, or Colliders: What Types of Shared Covariates Does a Sibling Comparison Design Control For? Epidemiology 2017;28(4):540-547.
14. Bruckner TA, Mayo JA, Gould JB, Stevenson DK, Lewis DB, Shaw GM, Carmichael SL. Heightened risk of preterm birth and growth restriction after a first-born son. Ann Epidemiol 2015;25(10):743-7 e1.
15. Kaufman JS. Some models just can't be fixed. A commentary on Mortensen. Soc Sci Med 2013;76(1):8-11.
16. Collins JW, Rankin KM, David RJ. Low birth weight across generations: the effect of economic environment. Matern Child Health J 2003;15(4):438-45.
17. Collins JW, Jr., David RJ, Rankin KM, Desireddi JR. Transgenerational effect of neighborhood poverty on low birth weight among African Americans in Cook County, Illinois. Am J Epidemiol 2009;169(6):712-7.

Table 1. Number of women by quartile of neighborhood disadvantage at time 1 (before move) and quartile of neighborhood disadvantage at time 2 (after move), where Q1 = low neighborhood disadvantage; Q4 = high neighborhood disadvantage

		Time 1			
	Neighborhood disadvantage	Q1	Q2	Q3	Q4
Time 2	Q1 (very low)	89,379	13,907	8,225	3,812
	Q2 (low)	15,326	76,786	14,184	8,906
	Q3 (high)	7,109	15,935	75,828	16,473
	Q4 (very high)	3,460	8,657	16,986	86,058

Table 2. Percent of preterm birth (<37 weeks' gestation) and small-for-gestational age (birthweight-for-gestational age <10th percentile) at time 2 by maternal mobility

	Preterm birth		Small-for-gestational age	
Mobility	N	%	N	%
No change	32,721	9.97	26,335	8.03
Downward (inclusive)	7,044	10.44	5,942	8.81
Upward (inclusive)	6,537	9.98	5,531	8.44
Strong downward	357	10.32	337	9.74
Modest downward	1,726	10.95	1,418	8.99
Low downward	4,961	10.28	4,187	8.68
Low upward	4,476	10.04	3,824	8.58
Modest upward	1,738	10.15	1,404	8.20
Strong upward	323	8.47	303	7.95

Table 3. Odds ratios (OR) and 95% confidence intervals (CI) predicting the probability of preterm birth at time 2 as a function of preterm birth at time 1, maternal mobility levels (vs. no change), and covariates.

Parameter	OR	95% CI	P-value
Preterm birth (time 1)	2.98	(2.90, 3.05)	<.0001
Mobility			
Strong upward	0.83	(0.74, 0.93)	<0.001
Modest upward	1.02	(0.96, 1.07)	ns
Low upward	0.99	(0.95, 1.02)	ns
No change (ref)			
Low downward	0.99	(0.96, 1.03)	ns
Modest downward	1.04	(0.99, 1.09)	ns
Strong downward	0.96	(0.86, 1.07)	ns
Insurance			
Private (ref)			
Public	1.28	(1.25, 1.30)	<.0001
Other	1.26	(1.21, 1.32)	<.0001
Parity			
1 birth	0.88	(0.81, 0.95)	<.001
2 births	0.76	(0.75, 0.78)	<.0001
3 + births (ref)			
Infant male (time 1)	1.03	(1.01, 1.05)	<.001
Infant male (time 2)	1.16	(1.14, 1.18)	<.0001
Maternal age			
<20	1.29	(1.23, 1.35)	<.0001
20-24 (ref)			
25-29	0.90	(0.87, 0.92)	<.0001
30-34	0.86	(0.84, 0.89)	<.0001
35-39	0.94	(0.91, 0.97)	<.001
≥ 40	1.15	(1.09, 1.22)	<.0001

Table 4. Odds ratios (OR) and 95% confidence intervals (CI) predicting the probability of small-for-gestational age (SGA) at time 2 as a function of small-for-gestational age at time 1, maternal mobility levels (vs. no change), and covariates.

Parameter	OR	(95% CI)		p-value
SGA (time 1)	4.04	(3.94,	4.14)	<.0001
Mobility				
Strong upward	0.95	(0.84,	1.07)	ns
Modest upward	0.99	(0.93,	1.04)	ns
Low upward	1.03	(1.00,	1.07)	ns
No change (ref)				
Low downward	1.03	(1.00,	1.07)	.09
Modest downward	1.05	(0.99,	1.11)	ns
Strong downward	1.12	(1.00,	1.25)	.06
Insurance				
Private (ref)				
Public	1.22	(1.19,	1.25)	<.0001
Other	1.21	(1.16,	1.27)	<.0001
Parity				
1 birth	1.45	(1.34,	1.56)	<.0001
2 births	0.98	(0.96,	1.00)	0.10
3 + births (ref)				
Infant male (time 1)	1.03	(1.01,	1.05)	0.01
Infant male (time 2)	1.00	(0.98,	1.02)	ns
Maternal age				
<20	1.13	(1.07,	1.19)	<.0001
20-24 (ref)				
25-29	0.90	(0.87,	0.92)	<.0001
30-34	0.84	(0.82,	0.87)	<.0001
35-39	0.81	(0.78,	0.84)	<.0001
≥ 40	0.85	(0.79,	0.91)	<.0001