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Neighborhood conditions and birth outcomes

Understanding the role of perceived and extrinsic measures of neighborhood quality

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Background: Living in a disadvantaged neighborhood has been associated with adverse birth outcomes. Most prior studies have conceptualized neighborhoods using census boundaries and few have examined the role of neighborhood perceptions, which may better capture the neighborhood environment. In the present study, we examined associations between extrinsic and perceived neighborhood quality measures and adverse birth outcomes.

Methods: Participants resided in the San Francisco Bay Area of California and were enrolled in Chemicals in Our Bodies, a prospective birth cohort (N = 817). The Index of Concentration at the Extremes (ICE) for income, Area Deprivation Index (ADI), and the Urban Displacement Project's measure of gentrification were included as census block group-level extrinsic neighborhood quality measures. Poor perceived neighborhood quality was assessed using an interview questionnaire. Linear regression models were utilized to examine associations between extrinsic and perceived neighborhood quality measures, and gestational age and birthweight for gestational age z-scores. Covariates in adjusted models were chosen via a directed acyclic graph (DAG) and included maternal age, education, and marital status.

Results: In adjusted models, having poor perceived neighborhood quality was associated with higher birthweight z-scores, relative to those who did not perceive their neighborhood as poor quality (β = 0.21, 95% confidence intervals = 0.01, 0.42). Relative to the least disadvantaged tertile, the upper tertile of the ADI was associated with a modest reduction in gestational age (β = –0.35, 95% confidence intervals = –0.67, –0.02).

Conclusions: In the Chemicals in Our Bodies study population, extrinsic and perceived neighborhood quality measures were inconsistently associated with adverse birth outcomes.

Keywords: neighborhood; built environment; birth outcomes; pregnancy

Introduction

Preterm birth and low birthweight, two of the most common adverse birth outcomes, affect between 8% and 10% of all livebirths in the United States.[1] Over the lifespan, these infants suffer from chronic health conditions and neurodevelopmental delays at higher rates relative to those infants born at term, at a normal birthweight, and not growth restricted.[2–4] Furthermore, racial and ethnic disparities in adverse birth outcomes have been well-documented, with Blacks and Latinx consistently experiencing the highest rates of adverse birth outcomes.[1] Despite their high prevalence, the etiology of these adverse birth outcomes remains poorly understood. Known individual-level risk factors do not wholly explain racial/ethnic disparities in adverse birth outcomes,[5–7] leading to calls for more research on the role of neighborhood environments. It is becoming increasingly apparent that individual-level risk factors are not evenly distributed across geographic regions and social classes. Thus, there is a need to better understand the role that neighborhood social factors play in health outcomes.

Even after controlling for individual-level socioeconomic factors that influence which neighborhoods people live in, neighborhood inequalities may be driving disparities observed in adverse birth outcomes.[8] Living in a disadvantaged neighborhood can restrict access to healthy foods options[9] and educational opportunities,[10] increase exposure to community violence,[11] and may be associated

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What this study adds

Living in a disadvantaged neighborhood has been associated with adverse birth outcomes. However, most prior studies have conceptualized neighborhoods using census boundaries, which may not always correlate with how individuals classify their neighborhoods. We observed that those who lived in an extrinsically disadvantaged neighborhood and who had poor neighborhood perceptions had modestly higher birthweight z-scores. This is one of few studies examining neighborhood perceptions in conjunction with extrinsic measures of neighborhood quality, defined using census block group indicators. Our findings indicate that neighborhood factors are not consistently associated with adverse birth outcomes.

with reduced physical activity because of limited greenspace.[12] Neighborhood inequities are attributable to structural discrimination, such as racial residential segregation and housing discrimination, which ultimately influenced land use decisions, such as where to build highways (e.g., a source of emissions), and prevented communities from building wealth through homeownership.[13] Together with more overt forms of discrimination, these factors can limit economic mobility and produce health disparities. Extrinsic measures of neighborhood disadvantage capture distinct aspects of the physical environment within a well-defined physical area (i.e., census units) and are often defined using a variety of indicators comprised of poverty, deprivation, racial residential segregation or racial composition, police violence, and crime.[14] Studies have shown that neighborhood disadvantage, defined using extrinsic measures, may be particularly deleterious during pregnancy, as pregnant people who live in the most deprived neighborhoods are at the highest risk for preterm birth and low birthweight,[14] with the strongest association observed among Blacks and Latinx.[15] Further, our prior work has shown that perceived neighborhood quality, assessed via in-person interview questionnaires, is associated with experiences of stressful life events during pregnancy, and that experiencing stressful life events is associated with reduced fetal growth.[16,17]

While studies have examined extrinsic measures of neighborhood disadvantage in relation to birth outcomes, we have a limited understanding of how perceived neighborhood quality may influence birth outcomes and if there is a joint effect of living in an objectively deprived neighborhood and perceiving it as such. This may be particularly important, as census tract boundaries, defined as statistical subdivisions of a county encompassing between 1,200 and 8,000 residents, do not always correlate with how individuals define their neighborhoods and spend their time,[18] suggesting that extrinsic measures of neighborhood disadvantage may be subject to exposure misclassification. Additionally, extrinsic measures do not fully capture collective efficacy or social cohesion, which reflect perceived willingness of residents to improve their neighborhoods and provide help to one another[19] and may buffer against harmful effects.[20] The health effects associated with neighborhood economic transitions (i.e., gentrification) are also under explored and studies indicate the effects of gentrification on the risk of preterm birth vary across racial and ethnic groups.[21]

In the present study, our study team leveraged an ongoing birth cohort in the San Francisco Bay Area of California with information on multiple extrinsic indicators of neighborhood disadvantage, as well as individual-level information about neighborhood perceptions, assessed via interview questionnaire. We examined extrinsic and perceived neighborhood quality measures in relation to gestational age and birthweight for gestational age z-scores, hypothesizing that worse extrinsic and perceived neighborhood quality would be associated with shorter gestational age and birthweight z-scores. Extrinsic measures were defined based on secondary data linked to geocoded residential addresses and perceived measures were assessed via an interview questionnaire at the second trimester.

Methods

Study population

Participants were enrolled in the Chemicals in Our Bodies (CIOB) study, an ongoing prospective birth cohort which has previously been described in detail elsewhere.[22] Participants included in the present analysis delivered between 2014 and 2020 and included all individuals with completed medical record abstraction at the time of our analysis (N = 817). CIOB was designed to examine the cumulative effects of chemical and nonchemical stressors on fetal growth and offspring neurodevelopment. Pregnant people were recruited during the second trimester of pregnancy from three hospitals affiliated with the University of California, San Francisco (UCSF). Those recruited from Moffitt Long and Mission Bay were economically and ethnically diverse and were primarily privately insured, whereas the Zuckerberg San Francisco General Hospital serves predominantly low-income people of color without private health insurance. Eligibility criteria for CIOB included >18 years of age, singleton pregnancy, and English or Spanish speakers. As part of the study, participants consented to study staff accessing their medical records. The Institutional Review Boards at the UCSF (10-00861) and the University of California, Berkeley (2010-05-04) approved the study and all participants provided written, informed consent.

Perceived neighborhood measures

Perceived neighborhood quality was assessed during the second trimester using a self-administered interview questionnaire. The validated questionnaire included 15 questions regarding four subscale measures: collective efficacy, neighborhood safety, neighborhood satisfaction, and neighborhood physical order (Table S1; http://links.lww.com/EE/A195).[23–25] Participants were classified as having experienced poor perceived neighborhood quality if they reported that their neighborhood lacked any of the four components.[26] For all questions, answer options ranged from strongly disagree (a score of one) to strongly agree (a score of five) and positively worded statements were reverse coded so that higher scores always corresponded to poorer perceived neighborhood quality.

To assess collective efficacy, participants were asked how strongly they agreed with the statements "people around here are willing to help their neighbors," "this is a close-knit neighborhood," "people in this neighborhood can be trusted," "people in this neighborhood generally don't get along with each other," "people in this neighborhood do not share the same values," "children were skipping school and hanging out on a street corner," "children were spray-painting graffiti on a local building," "children were showing disrespect to an adult," and "a fight broke out in front of their house." Participants experienced low collective efficacy if their average score was ≥4.

Participants who strongly disagreed or disagreed to the statement "I feel safe in this neighborhood" were considered to perceive their neighborhood as unsafe.

Participants were considered to experience neighborhood dissatisfaction if they strongly disagreed or disagreed with the statement "I think this neighborhood is a good place for me to live" or strongly agreed or agreed with the statement "I would move out of this neighborhood if I could."

Neighborhood physical order was assessed using three questions: "there is a lot of loud noise from cars, motorcycles, music, neighbors, or airplanes in my neighborhood," "my neighborhood has a lot of vacant lots or vacant houses," "there is heavy car or truck traffic in this neighborhood." Participants were classified as living in a disorderly neighborhood if their average score was ≥4.

Extrinsic neighborhood measures

Maternal addresses during pregnancy were linked to census block group measures of extrinsic neighborhood quality. Addresses were geocoded using the Decentralized Geomarker Assessment for Multi-Site Studies (DeGAUSS) geocoding package. For addresses that could not be successfully geocoded with DeGAUSS, we used Google API.

Index of concentration at the extremes—Income

The Index of Concentration at the Extremes (ICE) captures the extent to which the disadvantaged and privileged populations are concentrated within a specific geographic area.[27,28] We focused on ICE for income and defined advantaged individuals as those with an annual household income of >$200,000 and disadvantaged individuals as those with annual household income of <$40,000, representing the 20th versus 80th percentile of household income in the San Francisco Bay Area. We calculated ICE using 2014 to

2018 US American Community Survey (ACS) 5-year block group estimates.[29] ICE is a continuous variable with scores ranging from negative one to one. We created tertiles for ICE based on all block groups in the CIOB study population, where the lowest tertile was considered the most disadvantaged and the highest tertile was considered the least disadvantaged.

Area Deprivation Index

We included the Area Deprivation Index (ADI) as an extrinsic measure of neighborhood disadvantage. The ADI is publicly available through the Neighborhood Atlas and is derived from 2014 to 2018 US ACS data.[30] The 2018 ADI is a composite ranked index of 17 census block group factors encompassing a variety of social determinants of health, such as housing, income, employment, transportation, and education. State level ADI decile rankings range from 1 to 10, where one signifies the lowest level of neighborhood deprivation and a score of 10 signifies the highest level of deprivation. Tertiles of the ADI were created based on the distribution in the CIOB study population.

Gentrification

Information on displacement and gentrification typologies was obtained from the Urban Displacement Project,[31] which provides a nuanced view of the stages of gentrification for a given metropolitan region. The typology classifies a metropolitan area's census block groups into eight distinct categories using housing and demographic data obtained from the 1990, 2000, and 2010 US Decennial Census, 2013–2018 US ACS, and real estate market data from Zillow. Due to the small sample size across some categories, we collapsed the eight categories into three groups. Ongoing gentrification included those block groups classified as "low-income/susceptible to displacement," "ongoing displacement of low-income households," "at risk of gentrification," and "early/ongoing gentrification." "Advanced gentrification" and "stable moderate/mixed income" were considered to be stable. Finally, we considered block groups to be exclusive if they were classified as "at risk of being exclusive," "becoming exclusive," or "stable/advanced exclusive."

Demographic characteristics and birth outcomes

Maternal age, maternal education, marital status, current smoking status, maternal race/ethnicity, and maternal nativity were self-reported on an interview questionnaire administered during the second trimester. Participants were classified as experiencing financial strain if their annual household income was below the 2017 San Francisco county poverty line or reported finding it difficult to pay for food, housing, medical care, utilities, or other basic necessities.[32] Information regarding parity and prepregnancy body mass index (BMI; kg/m^2) was abstracted from the participant's medical record. Covariates were defined based on their presentation in Table 1.

Gestational age and infant birthweight were similarly abstracted from the medical record. Gestational age was estimated using the clinician's best estimation of chronological gestational age based on last menstrual period, early ultrasound, or in vitro fertilization date. To disentangle the effects of gestational age on fetal growth, we calculated birthweight for gestational age z-scores. Birthweight z-scores were sex specific and calculated using a US population based reference.[33]

Statistical analysis

We examined the distribution of extrinsic neighborhood measures across perceived measures of neighborhood, as well as the distribution of extrinsic and perceived neighborhood quality measures across racial and ethnic groups (white versus person of color [POC]) and nativity status (foreign versus US born). Unadjusted and adjusted linear regression models were used to examine associations between objective and perceived neighborhood quality measures, and birth outcomes (e.g., gestational age and birthweight z-scores). Extrinsic and perceived neighborhood quality measures were treated as individual exposures in separate models. In models which included extrinsic neighborhood quality measures as the exposure of interest, data were organized in a hierarchical fashion with individual participants (level-1 units) nested within block groups (level-2 units). Due to limitations associated with multilevel modeling in this setting

Table 1.

Demographics characteristics in the chemicals in our bodies study population (N = 817).

	N (%)
Maternal age, years	
18–24	81 (10%)
25–29	108 (13%)
30–34	297 (36%)
>35	317 (39%)
Missing	14 (1.7%)
Maternal education	
<High school	84 (10%)
High school degree or some college	204 (25%)
College degree	195 (24%)
Graduate degree	294 (36%)
Missing	40 (4.9%)
Maternal race/ethnicity	
White	309 (38%)
Black	49 (6%)
Asian/Pacific Islander	141 (17%)
Latina	279 (34%)
Other/multiracial	26 (3%)
Missing	13 (1.6%)
Prepregnancy body mass index	
Underweight (<18.5 kg/m^2)	23 (3%)
Normal (18.5–24.9 kg/m^2)	376 (46%)
Overweight (25–29.9 kg/m^2)	179 (22%)
Obese (>30 kg/m^2)	119 (15%)
Missing	120 (14.7%)
Parity	
No prior births	385 (47%)
One or more prior births	385 (47%)
Missing	47 (5.8)
Financial strain	
Yes	224 (27%)
No	374 (46%)
Missing	219 (26.8%)
Marital status	
Married	507 (67%)
Living together	145 (18%)
Single	78 (10%)
Missing	87 (10.6%)
Infant sex	
Male	391 (48%)
Female	399 (49%)
Missing	27 (3.3%)
Nativity	
Foreign born	313 (38%)
US born	401 (49%)
Missing	103 (12.6%)
Gestational age (weeks)	
Mean (SD)	39 (2.0)
Missing	55 (6.7%)
Birthweight (g)	
Mean (SD)	3345 (578.7)
Missing	34 (4.2%)
Birthweight z-score	
Mean (SD)	0.10 (0.99)
Missing	62 (7.6%)

SD, standard deviation.

(ie, unbalanced data with many small clusters), we accounted for the nonindependence and clustering of individuals within block groups using the Huber-White cluster sandwich estimator of variance.[34] We observed no evidence of nonlinearity was using loess curves (data not shown).

Maternal age, education, and marital status were retained as covariates in adjusted models. These covariates were chosen via a Directed Acyclic Graph (DAG; Figure S1; http://links.lww.com/EE/A195) that was informed via a literature review and associations between exposures and outcomes in our study population.[35] We did not adjust for smoking status due to the small number of participants in our study population who reported being a current smoker (<2%), and because we thought it was likely to be a mediator rather than a confounder. We conceptualized race/ethnicity and nativity as social factors that may be proxies for experiences of racism and other forms of discrimination. We did not adjust for race/ethnicity and nativity in our primary models as we hypothesized that they would modify the neighborhood quality and birth outcomes associations.[14,36] We hypothesized that financial strain may be acting as both a confounder and effect modifier, thus we conducted sensitivity analyses where we additionally adjusted for financial strain, as well as stratified by financial strain. To further examine effect modification, we examined the relationships between extrinsic and perceived neighborhood quality measures and birth outcomes using linear regression models stratified by race/ethnicity and nativity status. Additionally, we estimated the joint effects of poor perceived neighborhood quality and extrinsic neighborhood quality. In these analyses, we examined the association between extrinsic neighborhood quality indicators and birth outcomes stratified by overall poor perceived neighborhood quality (yes versus no).

We did not examine preterm birth (N = 63; 8.3%), low birthweight (N = 46; 5.9%), and small for gestational age (N = 70; 7.3%) due to the small number of participants who experienced these outcomes. Further, we did not adjust for multiple comparisons, as it is not always necessary in observational epidemiologic studies and may increase the probability of type II error due to low statistical power.[37] A complete case analysis was used for all models and all analyses were conducted in R Version 4.0.1.

Results

At the time of our analysis, there were 817 birth parent-child pairs enrolled in CIOB. Of this group, roughly 75% were at least 30 years of age (N = 614) and over 50% had a college or graduate degree (N = 489). Approximately 38% of participants self-identified as White (N = 309), 34% as Latina (N = 279), and 38% of participants were born outside of the United States (N = 313) (Table 1). The mean gestational age at delivery was 39 weeks and the mean birthweight was 3,345 g.

Approximately half of participants lived in a neighborhood classified as “stable,” as defined by the measure of gentrification (N = 375; 46%) (Table S2; http://links.lww.com/EE/A195). US born and white participants were more likely to live in the least disadvantaged neighborhoods according to ICE income and the ADI, while over 50% of participants who were people of color (N = 384) or foreign-born (N = 242) lived in areas that were stable or experiencing ongoing gentrification (Table S2; http://links.lww.com/EE/A195). In the overall study population, 17% (N = 141) reported poor perceived neighborhood quality and these individuals were also more likely to live in the most disadvantaged areas according to all extrinsic measures (Table 2). Few participants experienced poor collective efficacy (2%); therefore, we did not include it as an exposure in subsequent analyses. Block groups with at least 40% of participants reporting poor perceived neighborhood quality were clustered around the Bayview District and just north of the Mission District (Figure 1). Block groups classified as experiencing early or ongoing gentrification and were the most disadvantaged according to ICE income and were also clustered around these areas (Figure 1).

In unadjusted models, compared to the least disadvantaged tertile, living in a neighborhood in the most disadvantaged tertiles of ICE income was associated with shorter gestational age in weeks (Table 3) (β = –0.49, 95% confidence interval [CI] = –0.84, –0.15). The association with ICE was attenuated after adjustment for maternal age, education, and marital status, with maternal age being the strongest driver. In adjusted models and relative to the least disadvantaged tertile, living in the most disadvantaged tertile of the ADI was similarly associated with a reduction in gestational age (β = –0.35, 95% CI = –0.67, –0.02). Gentrification and perceived indicators of neighborhood quality were not strongly associated with gestational age in unadjusted or adjusted models (Table 3).

After adjustment for maternal age, education, and marital status, having poor perceived neighborhood quality, being dissatisfied with one’s neighborhood and living in a neighborhood experiencing ongoing gentrification were associated with higher birthweight z-scores (Table 3) (β = 0.21, 95% CI = 0.01, 0.42; β = 0.22, 95% CI = –0.02, 0.45; β = 0.22, 95% CI = –0.01, 0.44, respectively). This corresponds to an increase of 91 g and 95 g for poor perceived neighborhood quality and neighborhood dissatisfaction, respectively, for a 40-week gestation birth.

Table 2.

Distribution of perceived neighborhood measures across extrinsic neighborhood measures.

	Poor neighborhood quality		Dissatisfied with neighborhood		Disorderly neighborhood		Unsafe neighborhood	
	No	Yes	No	Yes	No	Yes	No	Yes
	(N = 531)	(N = 141)	(N = 668)	(N = 98)	(N = 718)	(N = 48)	(N = 656)	(N = 110)
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
ICE income								
Low (most disadvantaged)	143 (27%)	75 (53%)	185 (28%)	65 (66%)	224 (31%)	25 (52%)	58 (53%)	191 (29%)
Medium	189 (36%)	32 (23%)	233 (35%)	20 (20%)	242 (34%)	12 (25%)	21 (19%)	233 (36%)
High (least disadvantaged)	199 (37%)	34 (24%)	250 (37%)	13 (13%)	252 (35%)	11 (23%)	31 (28%)	232 (35%)
Area Deprivation Index								
Low (least disadvantaged)	252 (47%)	50 (35%)	308 (46%)	31 (32%)	326 (45%)	14 (29%)	302 (46%)	38 (35%)
Medium	122 (23%)	29 (21%)	153 (23%)	18 (18%)	159 (22%)	12 (25%)	149 (23%)	22 (20%)
High (most disadvantaged)	153 (29%)	62 (44%)	202 (30%)	49 (50%)	228 (32%)	22 (46%)	200 (30%)	50 (45%)
Urban displacement								
Exclusive	175 (86.6%)	27 (13.4%)	211 (94.2%)	13 (5.8%)	218 (97.3%)	6 (2.7%)	201 (89.7%)	23 (10.3%)
Stable	250 (82.2%)	54 (17.8%)	320 (91.4%)	30 (8.6%)	332 (94.6%)	19 (5.4%)	309 (88.0%)	42 (12.0%)
Ongoing gentrification	94 (6.2%)	58 (32.8%)	124 (70.1%)	53 (29.9%)	155 (88.1%)	21 (11.9%)	131 (74.4%)	45 (25.6%)

Percentages may not sum to 100 due to rounding. Perceived neighborhood quality is a composite measure of neighborhood dissatisfaction, disorderly neighborhood, unsafe neighborhood, and collective efficacy.

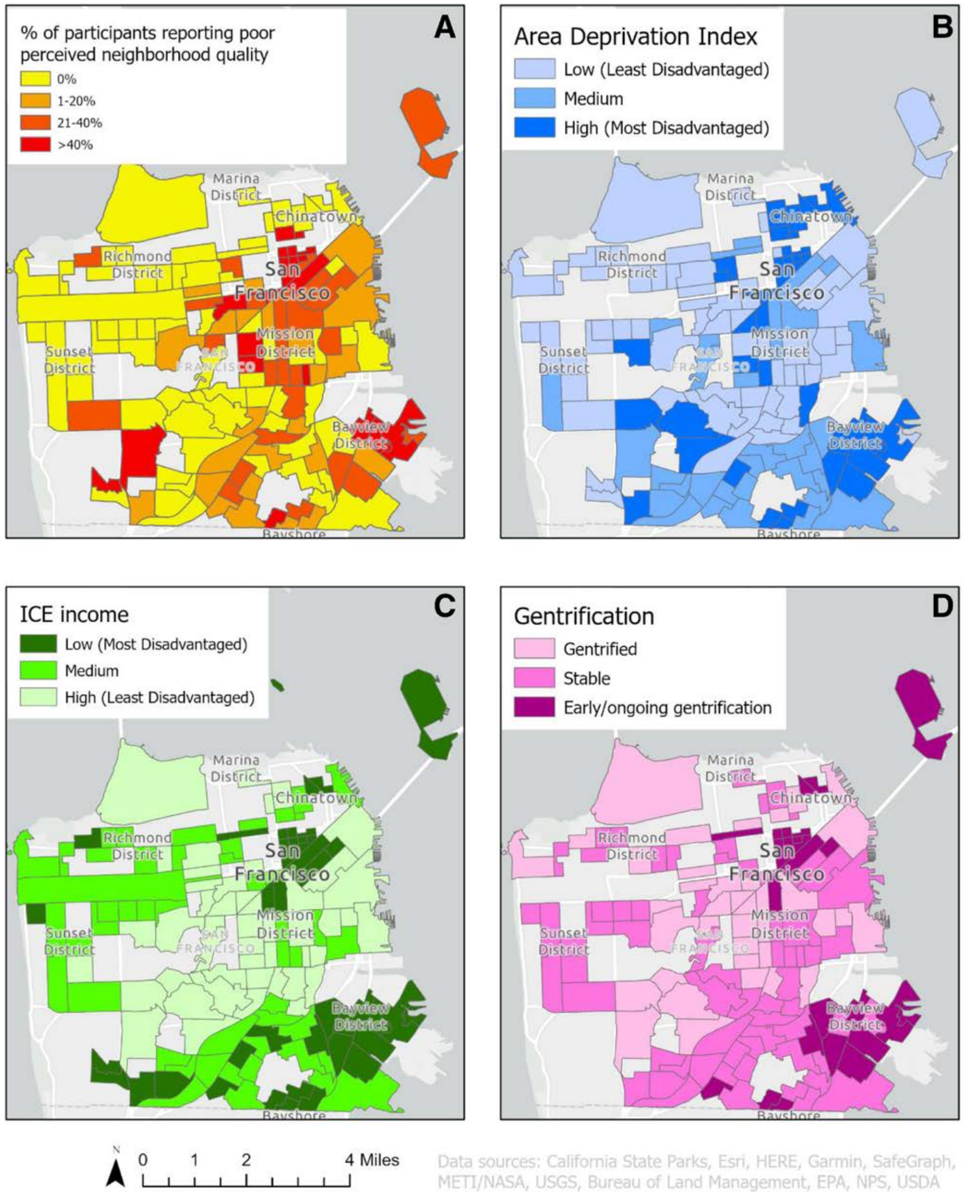

Figure 1. Distributions of poor perceived neighborhood quality, and tertiles of the ADI, ICE income, and gentrification across San Francisco, CA block groups. To protect confidentiality and avoid displaying unstable estimates, maps were restricted block groups in San Francisco with >2 participants (N = 683).

Associations between extrinsic and perceived neighborhood quality measures and adverse birth outcomes were similar when financial strain was added as a covariate in adjusted models, and CIs overlapped with our primary results (Table S3; http://links.lww.com/EE/A195). When stratifying by race/ethnicity, nativity, and financial strain, these unintuitive associations between neighborhood perceptions and birthweight z-scores generally persisted among US born, white participants, and those who did not experience financial strain only (Tables S4-S6; http://links.lww.com/EE/A195).

In models examining the joint effect of living in an extrinsic disadvantaged neighborhood and perceiving it as such, we observed that those who reported poor perceived neighborhood quality and lived in two most disadvantaged tertiles of the ADI compared to the most advantaged had lower birthweight z-scores (Table 4).

Discussion

Among a diverse cohort of pregnant people in the San Francisco Bay Area, we observed that those who perceived their neighborhood as poor quality were also more likely to live in extrinsically disadvantaged neighborhoods and reside in areas experiencing ongoing gentrification. Living in an extrinsically disadvantaged neighborhood, according to the ADI and ICE for income, and reporting poor neighborhood quality or feeling unsafe in one's neighborhood were also associated with shorter gestational age, although associations were not statistically significant. In contrast, we observed that living in a disadvantaged neighborhood, according to both extrinsic and perceived factors, was associated with higher birthweight for gestational age z-scores, an indicator of fetal growth. Our findings provide important information on the role of neighborhood perceptions, which contributes to the growing body of literature highlighting neighborhood social factors as contributors to birth outcomes.

Our finding that living in the most deprived tertiles of ICE for income was modestly associated with shorter gestational age at birth is consistent with past research examining ICE in relation to adverse maternal and child health outcomes, such as infant mortality, which occurs more frequently among those born preterm.[8,38–42] For example, a study using intergenerationally linked California birth records found that living

Table 3.

Linear regression estimates and 95% confidence intervals for the relationship between perceived and extrinsic neighborhood measures and birth outcomes.

	Gestational age (weeks)						Birthweight z-scores					
	Unadjusted			Adjusted[1]			Unadjusted			Adjusted[1]		
	N	Beta	95% CI	N	Beta	95% CI	N	Beta	95% CI	N	Beta	95% CI
Extrinsic												
ICE Income												
Low (Most Disadvantaged)	241	–0.49	(–0.84, –0.15)	221	–0.14	(–0.53, 0.25)	239	0.11	(–0.07, 0.29)	219	0.19	(–0.01, 0.38)
Medium	255	–0.21	(–0.57, 0.14)	232	0.02	(–0.32, 0.35)	253	0.02	(–0.15, 0.19)	230	0.06	(–0.11, 0.23)
High (Least Disadvantaged)	266	Ref	Ref	245	Ref	Ref	263	Ref	Ref	242	Ref	Ref
Area Deprivation Index												
Low (Least Disadvantaged)	338	Ref	Ref	310	Ref	Ref	332	Ref	Ref	304	Ref	Ref
Medium	176	–0.46	(–0.85, –0.07)	154	–0.32	(–0.67, 0.03)	176	–0.02	(–0.19, 0.15)	154	0.01	(–0.17, 0.18)
High (Most Disadvantaged)	243	–0.38	(–0.71, –0.06)	231	–0.35	(–0.67, –0.02)	242	–0.04	(–0.21, 0.13)	230	–0.05	(–0.23, 0.14)
Urban displacement												
Exclusive	228	Ref	Ref	211	Ref	Ref	225	Ref	Ref	208	Ref	Ref
Stable	350	0.25	(–0.11, 0.61)	318	0.32	(–0.02, 0.65)	348	0.02	(–0.14, 0.18)	316	0.07	(–0.09, 0.24)
Ongoing Gentrification	168	–0.2	(–0.63, 0.24)	156	0.19	(–0.26, 0.64)	166	0.1	(–0.1, 0.3)	154	0.22	(–0.01, 0.44)
Perceived												
Poor neighborhood quality												
No	511	Ref	Ref	486	Ref	Ref	509	Ref	Ref	484	Ref	Ref
Yes	130	–0.25	(–0.61, 0.1)	123	–0.1	(–0.46, 0.27)	128	0.14	(–0.06, 0.33)	121	0.21	(0.01, 0.42)
Dissatisfied with neighborhood												
No	640	Ref	Ref	605	Ref	Ref	635	Ref	Ref	600	Ref	Ref
Yes	89	–0.33	(–0.75, 0.09)	87	0.05	(–0.39, 0.5)	87	0.16	(–0.06, 0.38)	85	0.22	(–0.02, 0.45)
Disorderly neighborhood												
No	685	Ref	Ref	649	Ref	Ref	678	Ref	Ref	642	Ref	Ref
Yes	45	0.2	(–0.37, 0.78)	43	0.43	(–0.16, 1.01)	45	0.11	(–0.19, 0.41)	43	0.18	(–0.13, 0.49)
Unsafe neighborhood												
No	628	Ref	Ref	594	Ref	Ref	622	Ref	Ref	588	Ref	Ref
Yes	102	–0.27	(–0.67, 0.12)	98	–0.14	(–0.55, 0.26)	101	0.05	(–0.15, 0.26)	97	0.12	(–0.1, 0.33)

[1]Models adjusted for age, education, and marital status.

Perceived neighborhood quality is a composite measure of neighborhood dissatisfaction, disorderly neighborhood, unsafe neighborhood, and collective efficacy.

Table 4.

Adjusted linear regression estimates and 95% confidence intervals for the relationship between extrinsic neighborhood measures and birth outcomes stratified by perceived poor neighborhood quality.

	Gestational age (weeks)						Birthweight z-scores					
	Poor neighborhood quality—Yes			Poor neighborhood quality—No			Poor neighborhood quality—Yes			Poor neighborhood quality—No		
	N	Beta	95% CI	N	Beta	95% CI	N	Beta	95% CI	N	Beta	95% CI
Extrinsic												
ICE income												
Low (most disadvantaged)	66	–0.13	(–0.94, 0.69)	130	–0.38	(–0.83, 0.08)	65	0.17	(–0.31, 0.64)	129	0.18	(–0.05, 0.42)
Medium	27	–0.34	(–1.2, 0.52)	172	–0.03	(–0.38, 0.33)	26	0.19	(–0.29, 0.67)	172	0.06	(–0.14, 0.26)
High (least disadvantaged)	30	Ref	Ref	184	Ref	Ref	30	Ref	Ref	183	Ref	Ref
Area Deprivation Index												
Low (least disadvantaged)	44	Ref	Ref	231	Ref	Ref	42	Ref	Ref	230	Ref	Ref
Medium	25	–0.02	(–0.78, 0.74)	111	–0.3	(–0.67, 0.07)	25	–0.31	(–0.86, 0.25)	111	0.04	(–0.16, 0.23)
High (most disadvantaged)	54	–0.07	(–0.91, 0.77)	142	–0.34	(–0.71, 0.02)	54	–0.67	(–1.2, –0.13)	141	0.04	(–0.17, 0.26)
Urban displacement												
Exclusive	25	Ref	Ref	161	Ref	Ref	25	Ref	Ref	160	Ref	Ref
Stable	45	–0.56	(–1.31, 0.19)	229	0.33	(–0.02, 0.69)	44	0.15	(–0.3, 0.59)	229	0.05	(–0.15, 0.24)
Ongoing gentrification	51	0.1	(–0.8, 1.01)	86	–0.09	(–0.63, 0.45)	50	0.35	(–0.17, 0.87)	85	0.17	(–0.12, 0.45)

Models adjusted for age, education, and marital status.

Perceived neighborhood quality is a composite measure of neighborhood dissatisfaction, disorderly neighborhood, unsafe neighborhood, and collective efficacy.

in neighborhoods with the greatest concentration of poverty according to ICE for income both in early childhood and adulthood was associated with an increased risk of preterm birth.[8] Among a study of very preterm infants (<32 weeks gestation) in New York City, living in the lowest quintile (greatest concentration of poverty) relative to the highest was associated with a 40% increased risk of neonatal death.[40] Similar associations were also observed in Chicago and California, where communities in the lower quintiles had higher infant mortality rates relative to the those in the most advantaged quintile of ICE for income.[38,39]

Using the ADI, we also observed that neighborhood deprivation was associated with a slight reduction in gestational age. Prior studies assessing neighborhood deprivation and gestational age have observed similar relationships,[14] although to our knowledge none have used the ADI. For example, a study of eight metropolitan cities in the United States found that those in the most deprived quintile relative to the least deprived had increased odds of delivering preterm.[43] Living in a disadvantaged neighborhood (operationalized by the ADI), was also associated with worse outcomes in terms of desired postpartum sterilization.[44] Other factors that may contribute to neighborhood disadvantage, including fatal police violence, have also been linked to adverse birth outcomes.[45]

A unique aspect of our study was that we also had detailed information on neighborhood perceptions, which provides information about how individuals feel about their neighborhoods, as opposed to solely focusing on extrinsic measures, which may not reflect where individuals spend their time. We found that those who reported living in a poor quality or unsafe neighborhood had moderately shorter gestational age relative to those with better neighborhood perceptions. These unadjusted findings support what was observed with the Los Angeles Mommy and Baby surveys, which showed that worsening economic hardship and poor perceived neighborhood quality were associated with increased odds of preterm birth.[46] However, associations between neighborhood perceptions and gestational age were further attenuated after adjusting for covariates in our study population. One explanation for these findings could be that neighborhood perceptions differ across racial and ethnic groups, which could be due to experiences of discrimination. Prior research using the California Behavioral Risk Factor Surveillance System (BRFSS) indicates that Latinos and Blacks report worse perceived neighborhood disorder relative to whites.[47] In stratified analyses, we observed that poor perceived neighborhood quality was associated with a reduction in gestational age among POC only, although CIs were wide. While our fully adjusted models did not include race/ethnicity, we did include education, and marital status as indicators of socioeconomic status. In our study, non-White participants tended to be younger, unmarried and have lower education attainment, which is likely reflective of structural barriers and discrimination that disproportionally influence POC.

Contrary to our hypothesis, we observed that those who lived in an area experiencing ongoing gentrification and who reported poor perceived neighborhood quality and neighborhood dissatisfaction had higher birthweight z-scores. These inverse associations may be reflective of the uniqueness of our cohort. For example, participants living in San Francisco may be more likely to report their neighborhood as poor quality, even if they have a relatively high income, as San Francisco experienced an affordable housing shortage during the timeframe of our study. It is possible that neighborhood perceptions may change over time, and could vary based on how long an individual has lived in their neighborhood. Prior evidence also suggests that the neighborhood environment does not strongly influence birthweight among immigrants, of which we have many in our study.[48] When stratifying by race/ethnicity and nativity status, the positive associations between neighborhood perceptions and higher birthweight z-scores persisted primarily among white and US born participants. However, the sample size for these analyses was small and this imprecision is reflected in our wide CIs. While a small percentage of white participants perceived their neighborhood as being of poor quality (<10%), the majority of white, US born participants in our study lived in exclusive and advantaged neighborhoods according to our extrinsic measures. Neighborhood affluence has been shown to be protective against adverse birth outcomes,[49] which may suggest that other socioeconomic factors are more strongly tied to birthweight relative to neighborhood perceptions.

Our study has many strengths. We had detailed information on both perceived neighborhood quality and extrinsic indicators of neighborhood disadvantage, representing an advancement over prior studies as extrinsic neighborhood measures may not be truly reflective of where individuals interact and spend their time. We also included a measure of gentrification, that has not been as extensively studied in relation to birth outcomes and may be an important contributor to health disparities. We also acknowledge our limitations. First, we were not able to assess how social support modifies the relationship between objective and perceived neighborhood quality. Prior work suggests that social relationships and personal contacts buffer the negative effects of neighborhood deprivation on health outcomes.[50] Second, we were unable to further stratify our results beyond white versus POC due to the sample size restrictions. It is highly likely that the relationship between perceived neighborhood quality and birth outcomes would vary across individual non-White racial and ethnic groups, as this has been observed previously.[47] Third, we did not have information on paternal characteristics, which may have an impact on the birth outcomes examined here. We additionally did not have information on maternal exposure to smoking prior to pregnancy. Finally, our results may not be generalizable beyond the San Francisco Bay Area and larger studies are needed to confirm these findings.

Conclusions

In our study population, we observed that living in the most extrinsically disadvantaged neighborhoods and having poor neighborhood perceptions were both associated with a modest increase in birthweight z-scores, while associations with gestational age were less consistent. Our findings indicate that the neighborhood environment is inconsistently associated with adverse birth outcomes, which contributes to a growing body of literature exploring the role of neighborhood inequalities on health outcomes. Future studies are needed to further disentangle the effects of objective and perceived neighborhood quality on additional maternal and child health outcomes, such as offspring neurodevelopment.

Conflict of interest statement

The authors declare that they have no financial conflict of interest with regard to the content of this report.

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