American Journal of Epidemiology

Vol. 183, No. 2
DOI: 10.1093/aje/kwv189
Advance Access publication:
December 10, 2015

Original Contribution

Health Selection into Neighborhoods Among Families in the Moving to Opportunity Program

Mariana C. Arcaya*, Corina Graif, Mary C. Waters, and S. V. Subramanian

* Correspondence to Dr. Mariana C. Arcaya, Department of Urban Studies and Planning, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139 (e-mail: marcaya@mit.edu); or Dr. Corina Graif, Department of Sociology and Criminology, Pennsylvania State University, 603 Oswald Tower, University Park, PA 16802 (e-mail: corina.graif@psu.edu).

Initially submitted March 19, 2015; accepted for publication July 10, 2015.

Moving to Opportunity for Fair Housing was a randomized experiment that moved very low-income US families from high-poverty neighborhoods to low-poverty neighborhoods starting in the early 1990s. We modeled report of a child's baseline health problem as a predictor of neighborhood outcomes for households randomly assigned to move from high- to low-poverty neighborhoods. We explored associations between baseline health problems and odds of moving with the program upon randomization (1994–1997), neighborhood poverty rate at follow-up (2002), and total time spent in affluent neighborhoods and duration-weighted poverty. Among 1,550 households randomized to low-poverty neighborhoods, a smaller share of households reporting baseline child health problems ($P = 0.004$) took up the intervention (38%) than those not reporting a health problem (50%). In weighted and covariate-adjusted models, a child health problem predicted nearly 40% lower odds of complying with the experimental condition (odds ratio = 0.62, 95% confidence interval: 0.42, 0.91; $P = 0.015$). Among compliers, a baseline child health problem predicted 2.5 percentage points' higher neighborhood poverty at take-up (95% confidence interval: 0.90, 4.07; $P = 0.002$). We conclude that child health problems in a household prior to randomization predicted lower likelihood of using the program voucher to move to a low-poverty neighborhood within the experiment's low-poverty treatment arm and predicted selection into poorer neighborhoods among experimental compliers. Child morbidity may constrain families attempting to improve their life circumstances.

children; health; Moving to Opportunity; neighborhoods; poverty; residential mobility; selection

Abbreviations: LPV, low-poverty voucher; MTO, Moving to Opportunity for Fair Housing; OR, odds ratio.

Strong connections between population health and neighborhood disadvantage have been observed repeatedly across myriad population groups, geographic settings, and health outcomes (1–4). Possible explanations for this robust finding include the following: 1) associations are confounded, reflecting complex relationships among individual characteristics, neighborhood, and health; 2) neighborhood environments affect health; and 3) health status systematically sorts individuals into neighborhoods ("health selection"). Although all 3 explanations may operate simultaneously, academic literature on health and place is dominated by a unidirectional interest in neighborhood effects, while treating confounding and selection as nuisances (5).

Attention to neighborhood effects has been motivated by academic efforts to better understand the social determinants of health, and by practical interest in improving population health and reducing health disparities (6) through interventions on neighborhood factors. Methodologists have noted difficulties associated with estimating neighborhood effects on health from observational data, often conceptualizing health-related selection into neighborhoods as one of many potential sources of bias (7, 8) rather than as a substantively important process (5, 9). Broadly, efforts to understand neighborhood effects on other dimensions of well-being suffer similar challenges (10). To help clarify the causal role of neighborhoods in shaping individual outcomes, Congress funded an experimental housing mobility research demonstration, the Moving to Opportunity for Fair Housing (MTO) Demonstration Program, in the early 1990s. By randomizing poor families to receive either no rental assistance (Section 8)

housing vouchers, unrestricted housing vouchers, or vouchers to use in low-poverty neighborhoods, the program aimed to isolate causal neighborhood effects net of unmeasured background differences (11). Follow-up survey interviews were conducted in 2002 and 2008–2010. In the current study, we analyzed information on participants' residential history between baseline (1994/1996) and the 2002 wave. While most evidence regarding neighborhood effects on health is observational, the MTO study has provided valuable and rare experimental data implicating high-poverty neighborhoods in higher risks of diabetes and morbid obesity (12) and worse mental health among girls (13).

Although it was designed to explore the causal effects of places on people, MTO also presented a unique opportunity to explore health-related selection into neighborhoods through differential take-up of treatment conditions, variation in within-treatment-group neighborhood poverty rates, and differential persistence in low-poverty neighborhoods by baseline health status. Previous research has mainly focused on clarifying neighborhood-effects estimates, treating remaining selection as a nuisance to adjust for (12, 14, 15). We are not aware of any existing MTO studies that substantively explored health as a neighborhood selection factor. Given the important role health selection may play in reinforcing health disparities and other social disparities, understanding these processes is crucial to achieving public policy goals. In this paper, we focus on health as a selection factor that may sort households differentially into neighborhoods. In doing so, we conceptualize morbidity as a potential barrier to families' improving their life circumstances.

Within the MTO data set, we analyzed differences in households' neighborhood environments over time as a function of baseline health status, focusing on variations within households randomized to receive housing assistance in low-poverty neighborhoods. Understanding how mobility outcomes differ for households with and without baseline health challenges allows us to determine whether, to what extent, and how health selection may have occurred among MTO families.

We focused our analysis on child health problems because they have been shown to impose significant economic, psychological, and health burdens on caregivers (16–19) that could affect mobility and neighborhood outcomes. For example, children's activity limitations or other health problems have been associated with parental interruptions in employment and with financial problems (20). The importance of child health for residential mobility has also been highlighted by recent observational evidence showing associations between child health problems and neighborhood poverty over time (9). While our focus here was on children, parental health problems may also influence neighborhood environments over time—for example, through the loss of federal financial assistance (17). Thus, we also report associations between a global measure of household health and neighborhood outcomes.

METHODS

Study design

MTO was a federally funded housing mobility experiment launched in 1994. The program enrolled low-income families with at least 1 child under age 18 years who were living in public housing in high-poverty (over 40% poverty) census tracts. By December 1997, MTO families were randomly assigned to either 1) a control group; 2) a traditional voucher group that received geographically unrestricted housing vouchers to subsidize private market rent; or 3) a low-poverty voucher (LPV) group that received housing counseling and vouchers that could only be used in neighborhoods with poverty rates below 10% (21). Information was collected about family and individual characteristics, health problems, prior mobility, victimization experience, neighborhood ties, reasons for intended mobility, and participants' perceptions of their baseline neighborhoods.

In 2002, follow-up data collection was initiated with 4,248 of these families. Data on 1 adult and up to 2 randomly sampled children (ages 5–19 years in 2001) were collected in each family (21, 22). Administrative and location data were identified for all households, and the second-wave adult, child, and youth surveys yielded effective response rates over 87% for all groups.

This analysis focused on the relationship between baseline child health and neighborhood outcomes among the 1,729 households randomly assigned to the LPV group before 1998. They were distributed as follows: 252 in Baltimore, Maryland; 366 in Boston, Massachusetts; 460 in Chicago, Illinois; 250 in Los Angeles, California; and 401 in New York, New York. Of the 806 LPV households that moved with the program, 747 had valid data on child health. Every family moved at its own pace. While at baseline the LPV households were distributed across 116 neighborhoods, they were spread across 751 neighborhoods by 2002. Clustering within sites was addressed by using fixed-effects dummy variables for study sites and robust standard errors. Additional adjustments for clustering within baseline tracts yielded similar results.

Measures

Our main predictor was a single-item baseline child health measure based on an adult respondent's answer to the following question about children in the home: "Does this child have any physical, emotional, or mental problems that 1) make it hard to get to school or 2) make it hard to play active games or sports?" Single-item questions on children's limitations at play or in school are standard in health surveys because they capture the core functional domains of children (23). While such measures offer only crude estimates of overall health, they are useful for capturing a wide range of health impairments and their treatments (24, 25).

Our child health measure exhibited good criterion validity through strong associations with overall household health problems, reports of a child requiring special medicine or equipment, and, more modestly, reports of a child receiving help in school for behavioral, emotional, or learning problems. A child health problem in the household was also associated with known dimensions of population health disparities, including membership in a racial/ethnic minority group and residence in an unsafe neighborhood at baseline.

We coded any household in which the adult respondent answered affirmatively for either sampled child as reporting a baseline child health problem. Those who answered "no" were coded as not reporting a baseline child health problem.

Table 1. Baseline Characteristics (Proportions) of Households and Adult Respondents in the Moving to Opportunity for Fair Housing Demonstration Program, 1994/1997–2002[a]

Characteristic	All Households ($n = 4,219$)	LPV Group Households ($n = 1,716$)
Baseline Health Status		
Health problem in the household	0.16	0.16
Child health problem	0.09	0.1
Assignment to Study Arm		
LPV group	0.41	1
Traditional voucher group	0.29	
Control group	0.31	
Covariates Used as Control Variables in All Table 3 Models		
Age on May 31, 1996, years		
<25	0.15	0.15
25–34	0.45	0.44
35–44	0.29	0.29
Male sex	0.02	0.01
Study site[b]		
Baltimore, Maryland	0.15	0.15
Boston, Massachusetts	0.23	0.23
Chicago, Illinois	0.21	0.21
Los Angeles, California	0.16	0.16
Race/ethnicity		
African-American (non-Hispanic)	0.63	0.63
Hispanic	0.30	0.30
Other	0.04	0.04
Marital and parental status		
Never married	0.62	0.62
Teenage parent	0.25	0.25
Employment and welfare status		
Working for pay	0.26	0.27
Receiving AFDC/TANF	0.75	0.74
Educational status		
Enrolled in school	0.16	0.16
Completed high school	0.38	0.4
Received General Equivalency Diploma	0.19	0.17
Possession of a car	0.17	0.17
Household member victimized by crime during past 6 months	0.42	0.43
Household size		
No teenage (ages 13–17 years) children	0.61	0.6
No. of household members		
≤2	0.21	0.22
3	0.31	0.31
4	0.23	0.23
Mobility history		
Lived in neighborhood for ≥5 years	0.61	0.6
Moved >3 times in past 5 years	0.09	0.09
Neighborhood characteristics		
Very dissatisfied with his/her neighborhood	0.47	0.47
Street near home very unsafe at night	0.5	0.49
Chatted with neighbor at least once a week	0.52	0.52
Very likely to tell neighbors if he/she saw their kids getting into trouble	0.56	0.55
No other family members living in the neighborhood	0.64	0.65
No friends living in the neighborhood	0.41	0.41
Mobility motivation		
Very sure he/she would find an apartment in a different area of city	0.46	0.46
Getting away from gangs or drugs was primary or secondary reason for moving	0.77	0.77
Access to better schools was primary or secondary reason for moving	0.48	0.47
Had applied for Section 8 rental assistance voucher before	0.42	0.42

Abbreviations: AFDC, Aid to Families with Dependent Children; LPV, low-poverty voucher; TANF, Temporary Assistance for Needy Families.

[a] One adult respondent was selected from each household. Values are weighted.

[b] Reference site: New York, New York.

Households with more than 2 children could have included a nonsampled sick child. Because children were randomly sampled within families, misclassification of these households would have also occurred at random, making our associations of interest harder to detect. As a sensitivity analysis, we refitted models using a sample restricted to households with 2 or fewer children.

About 60 LPV households had invalid child health responses for all eligible children, and 119 LPV households had missing data on all child-related questions because their children had become older than age 19 years by the time of the second wave. We created a dichotomous measure to flag those observations and used it as a control variable in our estimations. Alternative models in which observations with missing data were dropped led to similar results.

In supplementary analyses, we assessed the predictive power of a global household health question, which asked, "Is there anyone living with you who has a health problem or mental problem that keeps him/her from doing normal activities like walking, getting dressed, housework, or

Table 2. Neighborhood Outcomes (Mean (SE)) in the Low-Poverty Voucher Group at Waves 1 and 2 According to Child Health Problems at Baseline Among Households in the Moving to Opportunity Program, 1994/1997–2002[a]

	Child's Health Status				
	All LPV Households With Valid Health Data	LPV Households Without Baseline Child Health Problems	LPV Households With Baseline Child Health Problems	Difference Between Group Means (Health Problem vs. No Health Problem)	*P* Value[b]
Proportion that moved with the program	0.49 (0.01)	0.50 (0.01)	0.38 (0.04)	−0.12[c]	0.004
Poverty rate in neighborhood of take-up (estimated using intercensal interpolation[d]), %	10.77 (0.19)	10.57 (0.19)	13.05 (0.83)	2.48[c]	0.004
Duration-weighted poverty, average %[e]	31.95 (0.45)	31.60 (0.47)	34.97 (1.48)	3.37[f]	0.030
Proportion of time spent in neighborhoods with <10% poverty during the study (1994/1997–2002)	0.17 (0.01)	0.18 (0.01)	0.12 (0.02)	−0.06[f]	0.011
No. of moves during the study (1994/1997–2002)	2.76 (0.04)	2.79 (0.04)	2.50 (0.1)	−0.28[f]	0.010

Abbreviations: LPV, low-poverty voucher; SE, standard error.
[a] Excludes households missing valid data on child health at baseline. Values are weighted but unadjusted for other baseline covariates.
[b] *t* test for difference between mean values.
[c] $P < 0.05$.
[d] Analyses of LPV compliers only.
[e] Duration-weighted poverty was an average of poverty percentages experienced across all neighborhoods in which a participant lived during the study, weighted by the proportion of time spent in each particular neighborhood relative to the total amount of time spent in the study.
[f] $P < 0.01$.

working?" In the LPV group, 19 cases had missing data on this question.

Neighborhood poverty rates were assessed for households' census tract of residence at baseline, at the time of the move with the program after randomization, and again in 1997, 2000, and 2002. We matched households' residential locations during the study with 1990 and 2000 Census-tract poverty rates and also calculated interpolated poverty values, following the methods of Orr et al. (21) and Ludwig et al. (14). To estimate tract characteristics at the specific time that a family lived there, census data were linearly interpolated for the years between 1990 and 2000 and extrapolated to 2002. The main analyses relied on interpolated estimates of poverty rates, though we also used 2000 decennial Census information in sensitivity analyses to ensure that findings were not sensitive to our choice of poverty measure. Duration-weighted average tract characteristics for respondents' address history during the study were calculated such that characteristics at any new location were weighted by the proportion of time respondents had lived there (14). Neighborhood poverty indices did not have a normal distribution. Supplementary analyses using the natural logarithm of 1 plus the neighborhood poverty rate yielded the same substantive results as those performed on untransformed data.

At baseline, adult respondents also provided information on household composition and structure, education and employment history, race/ethnicity, sex, age, motivations for moving, possession of a car, neighborhood satisfaction and perception, and history of trying to obtain Section 8 rental assistance vouchers in the past. Previous articles have described this full panel of control variables (14, 15), which we included in all fully adjusted models.

Statistical analysis

To understand whether mean neighborhood poverty rate in 2002 differed among LPV households according to baseline child health problems, we estimated the difference in group means and computed *t* statistics to assess the null hypothesis that the difference was zero. We compared poverty rates at the time of take-up, estimated using census interpolation, for households that did and did not report at least 1 child health problem at baseline. We also tested for group differences in the proportion of households that used an LPV voucher to move with the program, as well as for differences in duration-weighted poverty and time spent in low-poverty neighborhoods (<10% poverty).

To test whether family structure, socioeconomic or demographic factors, neighborhood perception, or motivation to move confounded the association between baseline child health problems and neighborhood poverty exposure at follow-up, we fitted a series of covariate-adjusted linear regression models. We applied this framework in predicting interpolated estimates of neighborhood poverty rate at the take-up location, duration-weighted poverty between baseline and 2002, the

proportion of time spent in low-poverty neighborhoods over the same period, and the number of residential moves during the study period. We used logistic regression to predict, among LPV households, the odds of moving in accordance with the program that were associated with having a baseline child health problem in the household. All models fully adjusted for the covariates described above (and listed in Table 1), and results were weighted using inverse probability weighting to account for differences among sites and over time in treatment assignment likelihood (14, 21).

RESULTS

MTO recruited poor, predominantly young minority female-headed households (Table 1). Safety was a crucial concern of participants, with 77% reporting that getting away from gangs or drugs was a primary or secondary motivation for wanting to move, over 40% reporting that someone in the household had been victimized by crime in the past 6 months, and nearly half reporting that their street was unsafe at night. At baseline, only 26% of adult respondents were working for pay, fewer than 20% had a car, and approximately 75% were receiving some type of welfare support for families with children. Fewer than 10% reported a child health problem in the household. Of the 4,248 households studied, 41% were randomly assigned to the experimental condition and were offered housing vouchers that could be used in neighborhoods with poverty rates below 10%.

Among the 1,550 households that were assigned to receive housing vouchers for use in low-poverty neighborhoods and had valid child health data, only 759 (49%) actually took up the intervention by moving with the experiment (Table 2). LPV households dealing with a child health problem at baseline were significantly less likely ($P = 0.004$) to take up the intervention (38%) than were those not reporting a health problem (50%), accounting for randomization weights. Among the 747 households that did move with the program and for which information on census-tract poverty level was available, those with a child suffering some type of health problem moved to poorer neighborhoods ($P = 0.004$) than did compliers without such health problems in the household. Duration-weighted poverty was also about 3 percentage points higher ($P = 0.030$) and proportion of time spent in affluent neighborhoods lower ($P = 0.011$) for households with (versus without) child health problems.

The average neighborhood poverty level at take-up for LPV group members who moved with the program was 10.8%. This average exceeded the cutpoint used to determine eligible low-poverty neighborhoods (poverty rate <10%) according to the 1990 Census (21), because poverty data were interpolated between 1990 and 2000 decennial censuses to correspond to the time of the move. The average

Table 3. Likelihood of Experimental Group Members' Uptake of the Intervention and Quality of Neighborhood Throughout the Program Among Households Randomly Assigned to the Low-Poverty Voucher Group, Moving to Opportunity Program, 1994/1997–2002[a]

Outcome	Odds Ratio	β	*P* Value[b]	95% Confidence Interval
Predictor: Child Health Problem in the Household				
Moved with the program (yes = 1, no = 0)	0.62[c]		0.015	0.42, 0.91
Poverty rate in neighborhood of take-up (estimated using intercensal interpolation[d]), %		2.49[e]	0.002	0.90, 4.07
Proportion of time spent in neighborhoods with <10% poverty during the study (1994/1997–2002)		−0.05[c]	0.025	−0.10, −0.01
Duration-weighted poverty, average %[f]		3.38[c]	0.019	0.47, 6.30
No. of moves during the study (1994/1997–2002)		−0.26[c]	0.018	−0.47, −0.04
Predictor: Any Health Problem in the Household				
Moved with the program (yes = 1, no = 0)	0.87		0.357	0.64, 1.18
Poverty rate in neighborhood of take-up (estimated using intercensal interpolation[d]), %		1.57[e]	0.005	0.47, 2.67

Abbreviation: LPV, low-poverty voucher.

[a] All models incorporated weights and relied on robust standard errors. Unless otherwise noted, the sample size was 1,716, representing all households in the LPV group. All models controlled for the full set of baseline covariates listed as such in Table 1: age group (as of May 31, 1996), sex, study site, race/ethnicity, marital and parental status, employment and welfare status, educational status, possession of a car, victimization of a household member, household size, mobility history, baseline neighborhood characteristics (including perceived neighborhood safety), and motivation to move.

[b] *t* test from regression models with multiple controls.

[c] $P < 0.01$.

[d] There were 806 households in the LPV group who moved using the program voucher.

[e] $P < 0.05$.

[f] Duration-weighted poverty was an average of poverty percentages experienced across all neighborhoods in which a participant lived during the study, weighted by the proportion of time spent in each particular neighborhood relative to the total amount of time spent in the study.

neighborhood poverty level during the duration of the program was 19% among the LPV families who took up the program and 44% among those who did not comply.

In addition to the differences in child health status reported above, LPV compliers were younger, had smaller households, and were more dissatisfied with their baseline neighborhood than noncompliers. They were also more likely to be white, pursuing an education at baseline, and receiving federal welfare assistance (Aid to Families with Dependent Children, now called Temporary Assistance for Needy Families).

After adjustment for all covariates enumerated in Table 1, which could help explain crude associations between baseline health and mobility outcomes, a child health problem in the household remained a robust predictor of complying with the experimental condition, with nearly 40% lower odds (odds ratio = 0.62, 95% confidence interval: 0.42, 0.91; $P = 0.015$) (Table 3). Among compliers, a child health problem in the household predicted a 2.5-percentage-point higher neighborhood poverty rate by the time of the second evaluation (95% confidence interval: 0.94, 4.07; $P = 0.002$) in comparison with families without such problems (Table 3). Over the course of the study, baseline reports of a child health problem also predicted less time spent in low-poverty neighborhoods and higher duration-weighted neighborhood poverty. To illustrate these differences in real terms, experimental group families without child health problems spent about 391 days in nonpoor neighborhoods, on average, while those with such problems spent 116 fewer days in such neighborhoods, net of controls.

In contrast to findings on child health status, reporting any household health problem did not predict lower odds of program uptake ($P = 0.357$), though it was associated with moving to a higher-poverty neighborhood among compliers (95% confidence interval: 0.47, 2.67; $P = 0.005$). All child health estimates were robust to adjustment for household health.

Sensitivity analyses

To ensure that our findings were robust to different model specifications, we reran the analyses with the following changes. We tested whether the results were sensitive to removing the weights or adding weights that adjusted for the follow-up survey sampling design. The results were robust in both cases. Findings were also consistent when our sample was restricted to households with 2 or fewer children. Finally, we estimated coefficients at the child level, rather than the household level, among all children included in the second wave ($n = 6{,}683$; ages 5–19 years in 2001) while adjusting for within-household clustering and the same full set of covariates as those listed in Table 1. Child-level results were consistent with the household-level findings reported in Tables 2 and 3, even after including additional child-level controls, such as age and sex.

DISCUSSION

We present evidence that child health problems in a household prior to MTO randomization predicted lower program uptake among families randomized to the low-poverty treatment arm and predicted selection into poorer neighborhoods among experimental compliers. For every 10 days spent in low-poverty neighborhoods by families without child health problems, those with child health problems spent only 7. In fact, a child health problem was a stronger predictor of neighborhood poverty than was having no high school diploma.

Seemingly small differences in mean poverty rates, which were 2.5 and 3.4 percentage points at take-up and averaged across the study, respectively, may have meaningful health implications. For example, mean duration-weighted poverty among LPV households with a child health problem (versus without one) was roughly 35% as compared with 32% (Table 2). To contextualize the clinical relevance of this difference, causal modeling of nationally representative data has shown that when neighborhood poverty exceeds 20%, each additional 10 percentage points in neighborhood poverty is associated with an 89% increase in the odds of mortality (26).

Our finding that health predicts neighborhood outcomes is in line with results from a previous natural experimental analysis of a cohort of Hurricane Katrina survivors with high postdisaster displacement rates (5). In that setting, predisaster health status differentiated neighborhood poverty exposure 4–5 years after the storm, such that persons in poorer health ended up in neighborhoods that were poorer by over 3 percentage points. While the specific mechanisms behind health selection patterns found among MTO families versus Hurricane Katrina survivors may differ, support to help families struggling with health challenges make and sustain neighborhood gains seems to be a crucial but overlooked component of housing mobility and disaster recovery efforts alike. A qualitative study of the Gautreaux Two housing mobility program, which offered poor families living in Chicago's public housing the chance to move to less economically deprived and racially isolated areas, also noted that health problems acted as barriers that prevented some families from moving to higher-opportunity neighborhoods (27).

Qualitative research on obstacles faced by MTO families randomized to the LPV condition is informative with regard to mechanisms that could explain our quantitative results (28). For example, interviews with MTO participants highlighted the many onerous barriers to leasing apartments in affluent areas that might have overwhelmed families already grappling with health problems. The labor-intensive process of finding a suitable unit, navigating cumbersome portability procedures, and facing discrimination from landlords contributed to families' inability to comply with the program (28). In short, insights into the mobility process suggest that moving to more affluent neighborhoods required families to invest considerable time and energy into often unsuccessful housing searches, making it less likely that many of the already burdened families would be able to do so.

While uptake of the experimental condition did not differ by a global measure of householders' health limitations, this measure did predict modestly higher poverty rates among compliers' uptake neighborhoods. It has been found previously that child (versus adult) health plays a different role in shaping neighborhood outcomes, with prior research showing that children's health problems predicted moves to lower-income neighborhoods while parents' health problems predicted moves to higher-income neighborhoods (9). We did not have the data needed to explain how children's health as opposed to any householder's health shapes neighborhood outcomes; this question may be an interesting area for future

mixed-methods research. The global household health measure was inclusive of children yet showed fewer and weaker associations with mobility and neighborhood outcomes, suggesting that child health may have driven associations between any householder's health and neighborhood. Indeed, in supplementary analyses with both indices included simultaneously, child health yielded a larger standardized estimate than did household health.

Despite the experimental design of MTO, participants were not randomly assigned health status, so it is possible that baseline child health status was not a causal factor driving selective migration. Despite our efforts to control for prior common causes of both baseline health status and subsequent migration patterns, including family structure, socioeconomic and demographic factors, and other covariates, associations of interest may have been confounded by unmeasured factors. Thus, our results should not be interpreted as causal estimates but rather associations meant to motivate additional research.

Using MTO data to explore health as a driver of neighborhood outcomes helps us isolate important facets of the selective migration process—for example, by minimizing unmeasured differences in desire to move or in external financial and emotional support for the move, and by allowing us to examine uptake separately from persistence in poor neighborhoods. Well-known limitations of MTO's baseline questions related to health (12) prevented us from assessing differences in outcomes by severity of the household's health problem, which we might expect to see if relationships were causal.

These findings are not in conflict with published articles from the MTO experiment that describe how the offer of a low-poverty voucher affects health. Previous efforts to understand selection within the MTO experiment have focused on estimating neighborhood effects on individual outcomes (29, 30) rather than exploring selection as a substantive process. Intent-to-treat analyses that show meaningful neighborhood effects on health (12, 13) take into account the fact that respondents comply with the intervention differentially. Although randomized trials are increasingly considered the gold standard of neighborhood and health research (31), our results help demonstrate that meaningful selection processes operate within observational and randomized studies alike. While data from randomized social science trials like MTO can be analyzed to provide robust estimates of average causal effects, they cannot fully resolve questions of who benefits from a given intervention and why. In contrast, insight from this analysis may help clarify who is most likely to benefit from the policy intervention implemented by MTO, suggesting specifically that families with healthy children are most able to take advantage of low-poverty voucher offers. Likewise, accepting neighborhoods as having causal effects on health does not undermine the evidence of health selection presented in this analysis. Rather, both processes appear to be at play, and both have important policy implications.

Epidemiologists have long noted overlapping geographic patterns of concentrated poverty and poor health, using information about the spatial distribution of contextual risk factors to understand the contribution of neighborhood disadvantage to poor health. By comparison, researchers rarely explore the possibility that poor health constrains neighborhood choices, creating a positive feedback loop between concentrated poverty and ill health. This oversight may lead us to undervalue direct investment in health care as a poverty deconcentration tool that could give poor families more social and economic choices. To the extent that illness holds families back from upward socioeconomic and residential mobility, interventions designed to improve health and lessen caregiving burden may be important complements to upstream efforts to reduce health disparities through improvement in neighborhood conditions.

ACKNOWLEDGMENTS

Author affiliations: Department of Social and Behavioral Sciences, Harvard T. H. Chan School of Public Health, Boston, Massachusetts (Mariana C. Arcaya, S. V. Subramanian); Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts (Mariana C. Arcaya); Department of Sociology and Criminology, College of Liberal Arts, Pennsylvania State University, University Park, Pennsylvania (Corina Graif); Population Research Institute, Pennsylvania State University, University Park, Pennsylvania (Corina Graif); and Department of Sociology, Faculty of Arts and Sciences, Harvard University, Cambridge, Massachusetts (Mary C. Waters).

M.C.A. and C.G. contributed equally to this article as lead authors.

M.C.A. was supported by the Yerby Postdoctoral Fellowship Program at the Harvard T. H. Chan School of Public Health. C.G. was supported by the National Science Foundation and by Pennsylvania State University's Social Science Research Institute and Population Research Institute (Eunice Kennedy Shriver National Institute of Child Health and Human Development award R24 HD041025). S.V.S. and M.C.W. were supported by Robert Wood Johnson Foundation Investigator Awards in Health Policy Research.

The contents of this article are our own views and do not necessarily reflect the views or policies of any supporting institution.

Conflict of interest: none declared.

REFERENCES

1. Roberts SA. Socioeconomic position and health: the independent contribution of community socioeconomic context. *Annu Rev Sociol*. 1999;25:489–516.
2. Diez Roux AV, Merkin SS, Arnett D, et al. Neighborhood of residence and incidence of coronary heart disease. *N Engl J Med*. 2001;345(2):99–106.
3. Subramanian SV, Chen JT, Rehkopf DH, et al. Racial disparities in context: a multilevel analysis of neighborhood variations in poverty and excess mortality among black populations in Massachusetts. *Am J Public Health*. 2005;95(2):260–265.
4. Kawachi I, Berkman LF. *Neighborhoods and Health*. New York, NY: Oxford University Press; 2003.
5. Arcaya MC, Subramanian SV, Rhodes JE, et al. Role of health in predicting moves to poor neighborhoods among Hurricane Katrina survivors. *Proc Natl Acad Sci U S A*. 2014;111(46):16246–16253.

6. Diez Roux AV. Investigating neighborhood and area effects on health. *Am J Public Health*. 2001;91(11):1783–1789.
7. Grafova IB, Freedman VA, Lurie N, et al. The difference-in-difference method: assessing the selection bias in the effects of neighborhood environment on health. *Econ Hum Biol*. 2014;13:20–33.
8. Zick CD, Hanson H, Fan JX, et al. Re-visiting the relationship between neighbourhood environment and BMI: an instrumental variables approach to correcting for residential selection bias. *Int J Behav Nutr Phys Act*. 2013;10:27.
9. Dunn EC, Winning A, Zaika N, et al. Does poor health predict moving, move quality, and desire to move? A study examining neighborhood selection in US adolescents and adults. *Health Place*. 2014;30:154–164.
10. Sampson RJ, Morenoff JD, Gannon-Rowley T. Assessing "neighborhood effects": social processes and new directions in research. *Annu Rev Sociol*. 2002;28:443–478.
11. Katz LF, Kling JR, Liebman JB. Moving to Opportunity in Boston: early results of a randomized mobility experiment. *Q J Econ*. 2001;116(2):607–654.
12. Ludwig J, Sanbonmatsu L, Gennetian L, et al. Neighborhoods, obesity, and diabetes—a randomized social experiment. *N Engl J Med*. 2011;365(16):1509–1519.
13. Kessler RC, Duncan GJ, Gennetian LA, et al. Associations of housing mobility interventions for children in high-poverty neighborhoods with subsequent mental disorders during adolescence. *JAMA*. 2014;311(9):937–948.
14. Ludwig J, Duncan GJ, Gennetian LA, et al. Neighborhood effects on the long-term well-being of low-income adults. *Science*. 2012;337(6101):1505–1510.
15. Kling JR, Liebman JB, Katz LF. Experimental analysis of neighborhood effects. *Econometrica*. 2007;75(1):83–119.
16. Raina P, O'Donnell M, Schwellnus H, et al. Caregiving process and caregiver burden: conceptual models to guide research and practice. *BMC Pediatr*. 2004;4:1.
17. Casey P, Goolsby S, Berkowitz C, et al. Maternal depression, changing public assistance, food security, and child health status. *Pediatrics*. 2004;113(2):298–304.
18. King G, King S, Rosenbaum P, et al. Family centered caregiving and well-being of parents of children with disabilities: linking process with outcome. *J Pediatr Psychol*. 1999;24(1):41–53.
19. Chou K-R. Caregiver burden: a concept analysis. *J Pediatr Nurs*. 2000;15(6):398–407.
20. Kuhlthau K, Hill KS, Yucel R, et al. Financial burden for families of children with special health care needs. *Matern Child Health J*. 2005;9(2):207–218.
21. Orr L, Feins JD, Jacob R, et al. *Moving to Opportunity: Interim Impacts Evaluation (Moving to Opportunity for Fair Housing Demonstration Program: Interim Impacts Evaluation)*. Washington, DC: Office of Policy Development and Research, US Department of Housing and Urban Development; 2003:21.
22. Orr L. *Moving to Opportunity (MTO) for Fair Housing Demonstration: Interim Impacts Evaluation, Tier 1 Restricted Access Data, 1994–2001 [United States] (ICPSR 31661)*. Version 1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research; 2011. http://doi.org/10.3886/ICPSR31661.v1. Accessed November 30, 2014.
23. National Research Council, Institute of Medicine. *Children's Health, the Nation's Wealth: Assessing and Improving Child Health*. Washington, DC: National Academies Press; 2004.
24. Stein RE, Gortmaker SL, Perrin EC, et al. Severity of illness: concepts and measurements. *Lancet*. 1987;2(8574):1506–1509.
25. Starfield B. Child and adolescent health status measures. *Future Child*. 1992;2(2):25–39.
26. Do DP, Wang L, Elliott MR. Investigating the relationship between neighborhood poverty and mortality risk: a marginal structural modeling approach. *Soc Sci Med*. 2013;91:58–66.
27. Pashup J, Edin K, Duncan GJ, et al. Participation in a residential mobility program from the client's perspective: findings from Gautreaux Two. *Hous Policy Debate*. 2005;16(3-4):361–392.
28. Edin K, DeLuca S, Owens A. Constrained compliance: solving the puzzle of MTO's lease-up rates and why mobility matters. *Cityscape*. 2012;14(2):163–178.
29. Clampet-Lundquist S, Massey DS. Neighborhood effects on economic self-sufficiency: a reconsideration of the Moving to Opportunity experiment. *Am J Sociol*. 2008;114(1):107–143.
30. Ludwig J, Liebman JB, Kling JR, et al. What can we learn about neighborhood effects from the Moving to Opportunity experiment? *Am J Sociol*. 2008;114(1):144–188.
31. Oakes JM. The (mis)estimation of neighborhood effects: causal inference for a practicable social epidemiology. *Soc Sci Med*. 2004;58(10):1929–1952.