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Moving to Opportunity and Mental Health: Exploring the Spatial Context of Neighborhood Effects

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Abstract

Studies of housing mobility and neighborhood effects on health often treat neighborhoods as if they were isolated islands. This paper argues that conceptualizing neighborhoods as part of the wider spatial context within which they are embedded may be key in advancing our understanding of the role of local context in the life of urban dwellers. Analyses are based on mental health and neighborhood context measurements taken on over 3,000 low-income families who participated in the Moving to Opportunity for Fair Housing Demonstration Program (MTO), a large field experiment in five major U.S. cities. Results from analyses of two survey waves combined with Census data at different geographic scales indicate that assignment to MTO's experimental condition of neighborhood poverty <10% significantly decreased average exposure to immediate and surrounding neighborhood disadvantage by 97% and 59% of a standard deviation, respectively, relative to the control group. Escaping concentrated disadvantage in either the immediate neighborhood or the surrounding neighborhood, but not both, was insufficient to make a difference for mental health. Instead, the results suggest that improving both the immediate and surrounding neighborhoods significantly benefits mental health. Compared to remaining in concentrated disadvantage in the immediate and surrounding neighborhood, escaping concentrated disadvantage in *both* the immediate and surrounding neighborhood on average over the study duration as a result of the intervention predicts an increase of 25% of a standard deviation in the composite mental health scores.

Keywords

USA; Neighborhoods; Moving to Opportunity; spatial context; disadvantage

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The study of neighborhood effects on residents' mental wellbeing has a long history (e.g. (Faris and Dunham, 1939; Kawachi and Berkman, 2003; Ross et al., 2001, 2000). While some studies have found neighborhood effects on mental health to be small or absent (Kim, 2008; Propper, 2005), increasing evidence suggests that certain neighborhoods do have social and structural features that are beneficial for residents' mental health. While much of the evidence is cross-sectional, there are important longitudinal and experimental studies that similarly suggest that neighborhood factors shape individuals' health (e.g. Astell-Burt et al 2015; Kling et al., 2007; Willson et al., 2007). Further, residential environmental and social contexts have critical consequences for mental and cognitive health, not just in the short run but across the life course (Aneshensel and Sucoff, 1996) and across generations (Sharkey and Elwert 2011), underscoring the cumulative effects of past residential contexts (Duncan and Raudenbush, 1999; Wheaton and Clarke, 2003).

A persistent debate in the neighborhood effects literature across multiple disciplines pertains to the definition and measurement of neighborhoods (Hipp, 2007; Sampson et al., 2002). Some discussions have centered on the appropriate size, boundaries, and shape of neighborhoods, whether administratively or more subjectively defined (Grannis, 2005). Others note that independent of appropriate neighborhood definitions, people often navigate a geographic and cultural space that cuts across neighborhood boundaries (Diez Roux and Mair, 2010; Graif, et al., 2014; Sampson, 2008; Sampson et al., 1999). Further, recent research has utilized the idea of the “perceived neighborhood”, whereby respondents determine their own idea of what constitutes their neighborhoods (in terms of boundaries) rather than using administratively defined or researcher defined conceptualizations (Vallée et al. 2011; Chaix et al. 2012). Another study compares various methods of neighborhood measurement to understand the spatial context of deprivation (Rae, 2009). In short, the measurement and meaningful conceptualization of neighborhoods has become an area of study in its own right, as it is plausible that “alternative” neighborhood definitions matter for health outcomes and processes.

An emerging theme from this literature is the importance of neighborhoods' spatial contexts, whether measured in terms of adjacency or distance to other neighborhoods, or conceptualized as activity spaces or other extended neighborhood contexts (Graif 2015, 2016). For example, Patillo (Pattillo-McCoy, 1999) brings to light important evidence that social mobility among Chicago's black middle class is undermined by spatial proximity to pockets of concentrated poverty and crime. In contrast, deprived areas proximal to advantaged areas have been found to have higher rates of anxiety/mood disorder treatment (Pearson, 2013). Other studies have examined how spatial integration of deprived neighborhoods affects health outcomes other than mental health (Allender et al, 2012; Cuaghy et al., 2007; Chen et al., 2010; Lorant et al., 2001; Sridharan, 2007; Zhang et al, 2011; Zhang et al, 2013).

Increasingly, work on the spatial clustering of neighborhood characteristics and change within cities (Graif and Sampson, 2009; Sampson et al., 1999) shows a significant potential for spatial spillovers among nearby neighborhoods. A limited number of studies explore this idea at the individual level. Among the few is Morenoff's (2003) study in Chicago, which indicates that the level of interpersonal exchange in nearby areas can interact with the

corresponding levels in the neighborhood of residence in increasing birth weight. In a similar vein, Crowder and South (Crowder and South, 2008) present evidence that the racial composition of the extra-local area interacts with neighborhood composition in predicting whites' moving out of a neighborhood. Other studies demonstrate the importance of extra-local contexts on depression by comparing advantaged and disadvantaged residents within advantaged and disadvantaged contexts, noting that while smaller activity spaces are conducive to better mental health for advantaged residents in advantaged contexts, they are linked to higher rates of depression for disadvantaged individuals within disadvantaged contexts. However, interestingly, larger activity spaces are beneficial for the mental health of disadvantaged residents as they are more able to access extra-local services and social networks compared to their counterparts using smaller activity spaces, highlighting the importance of relative deprivation within local and extra-local geographic areas (Vallée et al., 2011).

Despite promising initial evidence, the literature applying a spatial framework for thinking about neighborhoods is surprisingly sparse. Yet, treating neighborhoods as if they were islands, independent units separate from the larger area in which they are embedded can limit our understanding of the role of neighborhoods in the lives of individuals, especially for those with scarce resources to buffer them against spatial adversity.

Another important issue within the place and health literature is the incorporation of time together with space, hence a spatio-temporal approach. Indeed, a recent review article by Auchincloss et al. (2012) highlighted the need for a focus on the temporal dimension in space and health research, as this is an understudied aspect within the literature. It is important not only to account for larger spatial contexts, but also temporal exposures to these different contexts (Matthews and Yang, 2013). Indeed, research has demonstrated the importance of accounting for neighborhood contexts across generations (Sharkey and Elwert, 2011) and the individual life course (Aneshensel and Sucoff, 1996) when investigating associations between the mental health and place.

Motivated by this literature, and responding to the gaps therein, we use a spatial framework to integrate extended neighborhood characteristics and duration of exposure to analyze neighborhood effects on mental health. While we expect that the extended neighborhood environment may make a difference on multiple dimensions of health, we focus in this study on mental health because, even though the MTO effects on mental health and wellbeing have been demonstrated before (Kling et al., 2007; Ludwig et al., 2012), the underlying extended spatial mechanisms have not been explored.

This analysis focuses on poverty due to its importance for health, and because of previous literature highlighting the sensitivity of neighborhood poverty measurements to different spatial scales (Auchincloss et al., 2007; Bell et al., 2008; Booth, 2001; Chaix et al., 2005b). Moreover, observed environmental effects may differentially affect distinct outcomes at various spatial scales. Indeed, a study in Sweden (Chaix et al., 2006) found that mental disorders due to psychoactive substance use varied on larger scales in space than did neurotic disorders. Drawing on this literature, we test the hypothesis that proximity to the ghetto, measured based on the disadvantage level of the area surrounding one's

neighborhood of residence or as the presence of a ghetto area within walking distance, will decrease mental health even when one lives in a non-ghetto residential neighborhood.

Analyses are based on over 3,000 participants in the *Moving to Opportunity for Fair Housing Demonstration Program* (MTO), a large field experiment in five major U.S. cities, New York, Los Angeles, Chicago, Boston, and Baltimore (Orr et al. 2003; Orr 2011). We examine families' residential contexts throughout the study in terms of the larger spatial contexts within which they are embedded, resulting in a unique investigation of the implications of “cumulative spatial disadvantage” for mental health.

Methods

The Moving to Opportunity Experiment

The MTO experiment, a federal housing mobility initiative, was mandated by Congress and carried out by the US Department of Housing and Urban Development (HUD) in five cities: Boston, Chicago, New York, Los Angeles, and Baltimore. Its first stage started between 1994 and 1998. Families were eligible to participate in the program if they lived in public housing or private assisted housing in inner city neighborhoods with more than 40% poverty rates, had very low incomes, and children under 18 years old. Eligible families who applied to participate in this program were next randomly assigned to one of three groups. Respondents in the low poverty voucher (LPV) group received a housing voucher that they could use only in census tracts with poverty rates below 10%. Those in the traditional voucher (TRV) group received a housing voucher without any geographic restriction, while those in the control group received no voucher or additional incentives to move or stay, but continued to receive project-based assistance. Baseline data was collected on 4,248 adults. In addition, administrative data was collected and matched to their residential locations throughout the whole period of the study and a second survey was conducted with 3,526 adults in 2002. Most adult respondents were female (98%), African American (64%) or Hispanic (29%), never married, in the neighborhood for 5 years or more, did not own a car, did not have family in the neighborhood, and invoked getting away from gangs and drugs as the main reason for moving (Table 1).

Outcome measures

Mental health was measured during the second wave as a composite index, an equally weighted average of standardized scores on five self-reported measures of distress, depression, anxiety, peacefulness, and sleep.

Psychological distress was measured as the proportion of six mental health symptoms that adult sample members reported having experienced at least some of the time during the past month: a) so sad that nothing could cheer you up, b) nervous, c) restless or fidgety, d) hopeless, e) that everything was an effort, f) worthless.

Depression was measured based on adult reports of having experienced major depression at some point during the past year, based on the World Health Organization's Composite Diagnostic Interview Short-Form (CIDI-SF) Major Depressive Episode Scale (Kessler et al., 1998). Respondents' scores were coded as ‘one’ when they responded affirmatively to

questions about a) being on antidepressant medication or b) durable and intense feelings of sadness, blues or depression, together with a lack of concentration, sleep and interest in hobbies, work and activities, about feeling more tired or low in energy than usual, about losing or gaining weight or thinking about death during the depressive episode.

Anxiety, worrying, or tenseness, during the past year was assessed also using items from the CIDI-SF Generalized Anxiety Disorder scale (Kessler et al., 1998), questions about having experienced a) a month or longer when most of the time the respondent felt worried, tense, or anxious or b) a time when s/he worried a lot more than most people would in the same situation.

Feeling peaceful and calm all or most of the time in the past month and sleeping at least 7 and less than 9 hours per night were the last two measures included in the composite index.

All five items were coded such that the summary score would increase with more positive aspects of mental health. We standardized the units of each component of the composite measure of mental health to represent differences from the control group mean divided by the standard deviation of the control group for comparability with previously published MTO analyses of mental health (Kling et al. 2007).

Neighborhood Measures

To understand the neighborhood and citywide contexts of individuals, we match respondents' residential locations wherever they moved across the country with U.S. Census tract data for 2000 and 1990 normalized to the 2000 boundaries and the Neighborhood Change Data Base (GeoLytics, 2003). Since census tracts can change boundaries over time, boundary normalization is important to account for neighborhood change over time, intercensal estimation, and for duration and spatial weighting (Reibel, 2007; Miles et al., 2015, Weden et al., 2015). We also use Census 2000 Tiger/line files for analyses of geographic distance between census tracts. Census tracts are small subdivisions of counties or equivalent entities of between 1,200 and 8,000 people and their spatial size varies based on population density.

In addition to the neighborhood poverty rates (proportion of census tract residents in poverty) predominantly used in previous MTO analyses, we also examine neighborhood disadvantage. Poverty is often compounded by related problems such as high unemployment rates and family disintegration (Wilson, 1987). Disadvantage was thus calculated as a composite index calculated as a factor score generated from a principal component analysis of tract data on poverty rate and measures that typically correlate with it, the proportion of female-headed households with children, the proportion of households with public assistance, and the proportion of persons in the civil labor force who are unemployed (Sampson et al., 1997). This analysis was based on all census tracts in the US, pooled across the 1990 and 2000 censuses. Concentrated disadvantage is calculated based on whether the average neighborhood's disadvantage level a respondent was exposed to during the study was in the 95th percentile of disadvantage of all US tracts.

We use a duration weighted function to measure exposure to neighborhood disadvantage and to poverty. Duration weighting takes into account the neighborhood disadvantage level experienced by a family during the years of residence in any particular neighborhood of residence, weighs it by the duration of residence in that neighborhood, and averages the disadvantage levels across all the different residential spells during the study period. We calculate the specific neighborhood disadvantage level during the time of residence for each family and each residential spell based on linear interpolation between census years 1990 and 2000 and extrapolation to 2002. Linear interpolation and duration weighting are common in studies estimating accumulated exposures over time (Kling et al. 2007; Ludwig et al. 2012; Wodtke et al. 2011). Potential issues in using interpolation and estimating neighborhood change have been discussed in Miles et al., (2015) and Weden et al., (2015).

Spatial Context

We define *immediate neighborhoods* as respondents' census tract of residence at a given time, while the *surrounding neighborhood* was defined as the four census tracts situated closest to the immediate neighborhood of residence. To determine which four census tracts constitute the surrounding neighborhood, we measured distances between the immediate neighborhood and the surrounding neighborhoods based on the geographic coordinates of tract centroids. Based on these distances, we identified the four tracts closest to a respondent's immediate tract of residence and calculated measures of surrounding poverty and disadvantage as an equally weighted average of poverty or disadvantage scores nearby. Based on tract-to-tract distances on all US tracts, we also identified the most proximate neighborhood of extreme poverty or disadvantage in order to capture more information about broad neighborhood spatial context.

Modeling Cumulative Spatial Disadvantage Effects

We first tested for differences in mean mental health scores between the randomized groups, and then used randomization as an instrumental variable (IV) for exposure to poverty or disadvantage in the immediate or surrounding neighborhood (in main analyses). The IV approach is more appropriate than structural equation modeling in estimating neighborhood effects, but it assumes that the effect of the mediator (e.g., neighborhood poverty exposure) is the same across all participants. The multivariate models included site fixed effects and controls for a large set of individual, household, and neighborhood level baseline covariates (all listed in Table 1). As expected, baseline characteristics were largely consistent across the random assignment conditions. The overwhelming majority (89%) of households lived in areas of concentrated disadvantage and most (64%) were additionally exposed to extended neighborhood concentrated disadvantage at baseline

We first replicated prior analyses of the effects of a voucher offer on outcomes. The basic estimation model is as follows. The ITT (intent-to-treat) estimates the differences between treatment and control group means, based on a simple OLS model: $Y = Z\pi_1 + X\beta_1 + \varepsilon_1$, where π_1 is the estimated intent-to-treat ITT effect. Z indicates assignment to treatment. X is a matrix of covariates measured at the baseline, which help improve the precision of the estimation by controlling for chance differences between groups before the random assignment (Kling et al., 2007; Orr et al, 2003). The ITT estimate indicates the positioning

of the treatment group mean relative to the distribution of the control group. The TOT (treatment-on-the-treated) is estimated using two-stages least square. The offer of a voucher (Z) is used as an instrumental variable for the endogenous variable of actual use of a subsidized voucher offered through the program (the V indicator): $Y = V\gamma_2 + X\beta_2 + \varepsilon_2$, where γ_2 *is* the TOT parameter, equal to the ITT parameter divided by the regression adjusted compliance rate. We used this procedure in preliminary analyses (not shown) in order to replicate the treatment effects presented in a previous study (Kling et al, 2007) with similar results.

In the main analyses we adapted the IV approach to estimate the effect of exposure to poverty or disadvantage on outcomes. In these analyses, the "treatments" being instrumented using the randomization status are cumulative neighborhood disadvantage indices. The main equation is: $Y = W\gamma_3 + X\beta_3 + \varepsilon_3$, where W represents a disadvantage index like immediate neighborhood poverty. The interpretation of γ_3 should not be the effect of varying spatial index scores holding constant other characteristics. Instead, it is more appropriate to view γ_3 as the effect of moving to a neighborhood or area with a lower poverty level and the set of associated neighborhood differences. Considering that the selection into a neighborhood with a certain disadvantage rate might be endogenous (i.e. there might be some feedback from the outcome-e.g. mental health problems- back into the predictor- disadvantaged neighborhood) the effect of immediate poverty or disadvantage was estimated by using site-by-treatment interactions as instrumental variables and including site main effects as controls (Kling et al, 2007). Using site-by-treatment interactions as instrumental variables is more useful than using only the treatment as it capitalizes on cross site variation in how the voucher offer shaped the quality of the neighborhood exposures and through them, the outcome. The assumption underlying this approach is that treatment assignment (the offer of a voucher) does not directly affect an individual outcome, but rather that the effect is indirect, via changing individuals' exposure to spatial disadvantage, and not through other omitted variables. In other words, treatment assignment is assumed not to shape an individual outcome if it does not change individuals' exposure to neighborhood distress.

Because surrounding and immediate characteristics like poverty and disadvantage are highly correlated (r = .78 and .82 respectively), including them in the same model leads to multicolinearity. We thus estimated the role of surrounding poverty and disadvantage in two different ways. First, surrounding neighborhood indices were included on their own (without immediate indices) in models otherwise similar to the ones estimating the effects of immediate poverty and disadvantage. Second, surrounding neighborhood indices were included with immediate neighborhood indices as mutually exclusive cross-classified categories rather than continuous variables.

Results

As shown in Table 2, about 19% of the control respondents reported at follow up to have experienced a major depressive episode at some point during the past year. In contrast, 15% of those in the low poverty voucher group (LPV) group and 17% of the traditional voucher (TRV) group did the same. About 40% of the control group reported anxiety, compared to 36% of the LPV group and 38% of the TRV group. Further, nearly 47% of those in the

control group reported feeling calm and peaceful, compared to 53% and 48% in the LPV and TRV groups respectively. Lastly, while 48% of the control group reported normal sleeping patterns 52% of the LPV group and 51% of the TRV group did the same. These descriptive statistics lend some early evidence that more affluent residential contexts are associated with better mental health conditions. For instance, of those living in less disadvantaged immediate and surrounding neighborhoods 54% reported peacefulness and 53% sleeping well, compared to 49% and 50%, respectively among those in surrounding and immediate neighborhoods of concentrated disadvantage.

We also observe differences between groups in immediate neighborhood poverty and disadvantage. While those in the control group experience on average a duration weighted poverty of 44% between the two waves of this study, those in the LPV and TRV groups experience 33% and 35%, respectively. The same pattern of differences among the three groups emerge when comparing the surrounding neighborhoods with the LPV and TRV groups living on average surrounded by 28% and 31% poverty, in contrast to the 35% among the control group. Similar patterns are seen when comparing immediate and surrounding disadvantage levels among the three groups.

Sociospatial Organization of Disadvantage

We find correspondence between participants' immediate and surrounding neighborhoods in terms of poverty and disadvantage, reflecting a pattern common to low-income residents in many large cities. Indeed, our exploratory maps (not included) show strong patterns of spatial clustering in disadvantage emerge throughout New York City, Chicago, Baltimore, and Los Angeles. This was reflected in respondents' experience of extended environments (immediate and surrounding neighborhood) of extreme poverty and disadvantage. About 58% of the control group experienced disadvantage levels in the upper 95th percentile of US tracts in both their immediate and surrounding neighborhoods as shown in Table 2. By comparison, only 36% of the LPV group and 43% of the TRV group did so. In contrast, 19% of the control families experienced disadvantage levels below the 95th percentile in their immediate and surrounding neighborhoods compared to 47% of the LPV group and 36% of the TRV group (Table 2).

Intent-to-Treat effects—Compared to the control group, the LPV members had higher mental health scores overall. Specifically by item, simple intent-to-treat analyses of group differences, without baseline covariates show significant differences in *peacefulness* between the LPV and the controls of about 13% of a standard deviation ($p < .05$), with a 95% confidence interval (CI) between 4% and 21%. *Psychological distress* differed between the LPV and the control groups by about 10% of a standard deviation ($p < .01$), with a 95% CI between 1% and 20%. Differences in *depression* were marginally significant between the LPV and the control groups by about 8% of a standard deviation ($p < .10$, two-tail test), with a 95% CI between 0% and 17%. Mean differences in *anxiety* and *sleep* were 6% and 7% respectively but not statistically significant. Still, the upper bound of their 95% CI suggests variation in these differences up to 15% and 16%, respectively. Tests were also conducted with the scale without either anxiety or sleep and the patterns in the results did not change. ITT analyses show that the significant difference between the LPV and the control in the

mental health index is robust to controlling for the full set of baseline covariates (Table 3). In contrast, the TRV effects on mental health are small and statistically insignificant after controls, suggesting that the LPV effects are more related to improved neighborhood exposures than the vouchers.

The ITT analyses also show that the effects of treatment assignment on exposure to poverty and disadvantage in immediate and surrounding neighborhoods are graded across treatment groups. Specifically, compared to the control families, the LPV group is exposed to about 11 percentage points lower immediate neighborhood poverty and 7 additional percentage points lower in surrounding neighborhood poverty. The corresponding ITT differences between the TRV group and the control group are about 9 and 4 percentage points lower poverty in immediate and surrounding neighborhood poverty, respectively.

Assignment to the LPV group also contributes to about 23 percentage points lower prevalence of living under concentrated disadvantage in both the immediate and surrounding neighborhoods compared to the control group. The corresponding TRV difference from the control is about 16 percentage points lower prevalence. Assignment to the LPV group contributes to a higher prevalence of living *below* concentrated disadvantage in both immediate and surrounding neighborhoods by about 28 percentage points compared to the control. The TRV effect is about 18 percentage points higher prevalence relative to the control group.

Spatial Patterning of Health

Table 4 presents results from two-stage least squares estimation of the effects of immediate and surrounding neighborhood poverty and disadvantage on mental health. Each row represents estimated parameters from a separate model that uses site-by-treatment interactions as instruments for exposure to poverty. Estimations are based on weighted data and robust standard errors. Alternative estimations under different assumptions, such as based on maximum likelihood probit estimation, yield the same substantive results. The results indicate that more disadvantaged immediate neighborhoods lead to significantly lower mental health scores. In terms of extended neighborhood effects, lower duration-weighted surrounding neighborhood poverty and disadvantage was beneficial for mental health as well. Results from two- stage least square models for each mental health item show patterns substantively consistent with the main findings, though some items showed weaker precision in their coefficients, perhaps due to their infrequency. Still, when excluding items one-by-one from the mental health composite index, analyses showed full or marginal significance in their statistical associations with immediate and surrounding disadvantage under two-tail tests. Moreover, the surrounding poverty and disadvantage show an association with the mental health index larger in absolute magnitude than the immediate poverty, suggesting that the surrounding poverty adds to the effect of immediate poverty on mental health,.

Although the MTO's design was experimental, it randomized only on features of the immediate neighborhood rather than both immediate and surrounding neighborhoods. Our extended neighborhood analyses are thus observational and therefore inherently vulnerable to selection biases. To assess the extent of this threat, we conducted several robustness tests.

We first regressed mental health on exposure to immediate neighborhood poverty (or extreme disadvantage, respectively) among the control group only and found marginally significant associations, suggesting that immediate poverty or extreme disadvantage is inconsequential or contributes to slightly better mental health. However, since among the control members, neighborhood selection is allowed to operate freely, these associations may be due to confounding factors, such as friends or kin living in poor neighborhoods and helping with childcare, thus keeping participants in poor neighborhoods while also increasing their' mental health. When using the instrumental variable approach to capitalize on the random assignment in dealing with neighborhood selection, the effect of exposure to immediate poverty or extreme disadvantage becomes significant and negative. If the typical neighborhood selection processes contribute to similar bias with respect to the surrounding neighborhood exposures, then the extended neighborhood effects may be underestimated under the MTO's design.

The immediate and surrounding poverty (or disadvantage) cannot be included in the model simultaneously because of multicollinearity problems. As a way to avoid multicollinearity while assessing their role together, in the following models, we distinguished three mutually exclusive categories of immediate-surrounding interaction that are based on presence or absence of extreme poverty or concentrated disadvantage, as described above.

Table 5 presents two-stage least squares estimates of neighborhood poverty and disadvantage on mental health with binary predictors that help characterize residential areas at different spatial scales. The first marker represents residential location in areas where both the immediate and the surrounding neighborhoods exhibit concentrated disadvantage (in the upper 95^{th} percentile). The second marker represents residential location in areas with a mix of presence/absence of concentrated disadvantage in the immediate and the surrounding neighborhoods. The third marker indicates residential location in areas where neither the immediate neighborhood nor the surrounding neighborhood exhibits concentrated disadvantage.

The findings suggest that compared to living under extended concentrated disadvantage in both the immediate and surrounding neighborhoods, living in a mixed area yields little benefit for mental health. Statistically significant benefits, nonetheless, emerge when living in an improved extended context of immediate and surrounding neighborhoods without concentrated disadvantage, suggesting improvements in our composite mental health measure of 25% of a standard deviation above those living in extended concentrated disadvantage. In comparison, for instance, being in school (rather than not) at baseline contributes to 11% of a standard deviation higher mental health score; additionally, having any household member (versus none) with a health problem at baseline contributes to 16% of a standard deviation lower mental health by the second survey wave. Improvements in both local and extra-local spatial contexts seem thus to be meaningfully beneficial for mental health.

Discussion

MTO families randomized to the low-poverty voucher condition (based on the immediate neighborhood) were able to gain and maintain a slight but significant spatial advantage over time both in terms of immediate and surrounding neighborhood contexts. This spatial advantage over time encompassed not only less poor and disadvantaged immediate neighborhoods but also less poor and disadvantaged surrounding neighborhoods. Specifically, for the low poverty treatment group the duration weighted immediate poverty level decreased by over 11 percentage points compared to the control while disadvantage decreased by close to a standard deviation. Moreover, a corresponding decrease was also observed for surrounding poverty (reduction of about 7 percentage points) and for surrounding disadvantage (reduction equivalent to 60% of a standard deviation). As importantly, our findings support the hypothesis that surrounding as well as immediate neighborhoods matter for mental health. Specifically, in this study, compared to living in extended neighborhoods in the upper 95th percentile of disadvantage on average, living in extended neighborhoods where both the immediate and surrounding tracts are below the 95th percentile of concentrated disadvantage threshold were found to be associated with 25% of a standard deviation higher scores on a composite measure of mental health. In contrast, simply lowering the disadvantage level either in the immediate or the surrounding neighborhoods but not both, does not make a significant difference for mental health. These results underscore the importance of accounting for spatial contexts broader than immediate tracts of residence in understanding neighborhood effects on health. They also highlight that policies and programs that aim to improve immediate neighborhood environments may be insufficient without improving the surroundings as well. Prior findings of weaker than expected effects from MTO on earnings and education (Orr et al., 2003) may be related to the original design defining treatment too narrowly from a geographic perspective and perhaps missing the larger picture of poverty exposures.

Our analysis has limitations. The sample design does not permit generalization to all low-income households. Analyses on other cities and based on other samples would be important avenues for future research. The intervention focused on moving families to immediate neighborhoods of low-poverty. For this reason, results based on surrounding neighborhoods are best interpreted as exploratory and associational. Until research and policies start to use factorial experimental designs randomize based on surrounding and immediate poverty, however, our remaining best option is randomization on immediate poverty.

Furthermore, there are limitations in our measurement of spatial contexts, as distance from Census tract centroids does not account for within tract heterogeneity and the modifiable area unit problem, or MAUP (Fotheringham and Wong, 1991; Openshaw, 1984). Census boundaries do not necessarily reflect natural neighborhood divisions and results may be skewed if resident subjects live closer to the boundaries of tracts.

Another limitation may be our assumption that the offer of a voucher does not directly affect individual outcome but has its effect through indirectly changing exposure to spatial disadvantage. Some research in the UK has instead indicated that moves generally improve life satisfaction (in particular housing satisfaction) and this could potentially influence the

measures of mental wellbeing in this study (Findlay et al, 2012; Nowok et al, 2013). Moreover, unlike small laboratory experiments, large field experiments are inevitably fraught with issues of compliance, attrition, and secondary moves, which make it difficult to assess the full impact of treatment.

Despite these limitations, our analysis contributes a unique examination of the effects of cumulative spatial adversity over time. It also improves our understanding of neighborhood effects on health by focusing on neighborhood concentrated disadvantage in addition to poverty – a broader indicator or neighborhood quality that is consistent with Wilson's insights on concentration effects (Wilson, 1987), the social disorganization literature (Sampson and Groves, 1989), a recent analysis of delinquency among MTO youth (Graif 2015a), and research on the neighborhood effects on other health outcomes in varying social groups and countries (Allender et al, 2012; Caughy et al, 2007; Sridharan et al, 2007; Zhang et al, 2011; Zhang et al, 2013). Our results show that exposure to residential neighborhood disadvantage is associated with worse mental health, as expected. As mentioned in the introduction, some studies have found small or absent effects of neighborhood disadvantage on mental health, suggesting the importance of future studies in continuing to examine spatial and neighborhood effects in other contexts (Kim, 2008; Propper, 2005).

Several mechanisms may account for the role of surrounding neighborhood poverty and disadvantage on low-income parents' health. The first may be simply that expanding the view out from the administratively defined tract boundaries may improve capturing the actual residential neighborhoods to which people are exposed. Second, many people spend their awake time out of their home or residential neighborhoods when they go to work, to parks, or when they use health services, recreational facilities, or other organizations nearby. Spending time in a nearby neighborhood means increased exposure to nearby risk factors, either as a result of interpersonal interactions with nearby residents, using resources, or fearing crime or feeling safer nearby. Third, independent of neighborhood definitions or where people actually spend their time, the extra-local environment may exert influence on how people go about their lives, for instance, a gang turf nearby may affect parent's stress levels and worries about their children's safety even if they never have to walk through it. Finally, selective migration may have contributed to the association between surrounding neighborhood disadvantage and health. In other words, within the LPV and TRV groups, those that moved to neighborhoods with lower disadvantage in both the immediate and surrounding areas may have already been relatively more advantaged in ways that affected their mental health.

Much debate exists on defining the appropriate scale or boundaries of residential neighborhoods (Grannis, 2005; Hipp, 2007; Sampson et al., 2002). While this is an important debate, the definition of the spatial context of housing is not simply a measurement issue as much as it is fundamentally a conceptual issue (Chaix et al., 2006; Crowder and South, 2008; Graif et al., 2014; Morenoff, 2003). Yet the conceptual and empirical work that builds on these recent insights is still in its infancy. The core need lies beyond understanding where neighborhoods start and where they end, towards an understanding of the extent to which -- even when meaningfully distinct from the neighborhood of residence -- surrounding areas might shape the wellbeing of individuals and

families. The analyses here respond to this need and show evidence indicating that in addition to the immediate neighborhood, the surrounding neighborhood may also play a significant role in individuals' mental health.

This analysis suggests that neighborhood effects on health are conditioned by broader sociospatial contexts, beyond the census tracts in which people live. The extent to and the ways in which spatial contexts matter, and extent to which this varies from one outcome to another, is a rich and valuable avenue for further theory and research. Reorienting neighborhood effects scholarship and housing policy toward a spatially informed framework of thinking and decision making may indeed prove fruitful for improving health.

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Research highlights

- Randomized intervention re-visits neighborhood effects on mental health
- Explored multiple scales and configurations of neighborhood poverty and disadvantage
- Concentrated disadvantage in neighborhoods was compared to improved conditions
- Declines in disadvantage at both spatial scales yielded mental health benefits
- We conclude that both surrounding and immediate neighborhoods matter for health

Table 1

Baseline characteristics of adults surveyed at waves 1 and 2, the MTO experiment 1994/1997-2002

	All		Control		LPV		TRV	
	Proportion	**SE**	**Proportion**	**SE**	**Proportion**	**SE**	**Proportion**	**SE**
Age < 25 years old (as of 05/31/96)	.146	(.007)	.152	(.013)	.151	(.011)	.134	(.012)
Age 25 to 34 (as of 05/31/96)	.448	(.010)	.446	(.017)	.447	(.015)	.450	(.018)
Age 35 to 44 (as of 05/31/96)	.286	(.009)	.293	(.015)	.287	(.014)	.277	(.017)
Male	.015	(.002)	.017	(.004)	.010	(.002)	.019	(.005)
Baltimore site	.151	(.007)	.153	(.012)	.152	(.011)	.149	(.012)
Boston site	.218	(.008)	.213	(.013)	.219	(.013)	.223	(.015)
Chicago site	.228	(.008)	.220	(.015)	.233	(.012)	.230	(.016)
Los Angeles site	.157	(.007)	.164	(.011)	.158	(.011)	.148	(.012)
African American (non-Hispanic)	.643	(.009)	.638	(.016)	.652	(.015)	.636	(.017)
Hispanic	.291	(.009)	.292	(.015)	.283	(.014)	.301	(.017)
Other	.038	(.004)	.042	(.007)	.036	(.007)	.038	(.007)
Never married	.623	(.009)	.626	(.016)	.622	(.015)	.622	(.018)
Teen parent	.252	(.008)	.243	(.014)	.250	(.012)	.266	(.016)
Employment and education								
Working for pay	.267	(.009)	.254	(.015)	.286	(.014)	.253	(.016)
Receiving AFDC/TANF	.746	(.009)	.752	(.015)	.740	(.014)	.747	(.016)
Enrolled in school	.157	(.007)	.154	(.013)	.160	(.011)	.156	(.012)
Completed high school	.375	(.009)	.349	(.016)	.391	(.015)	.380	(.018)
General Equivalency Diploma	.180	(.008)	.194	(.014)	.170	(.012)	.179	(.014)
Household characteristics								
Had a car	.161	(.007)	.143	(.011)	.173	(.012)	.163	(.014)
Health problem in the household	.163	(.007)	.160	(.013)	.163	(.011)	.167	(.014)
A household member victimized by crime during past 6 months	.417	(.009)	.410	(.017)	.416	(.015)	.426	(.018)
No teen (age 13-17) children	.608	(.009)	.626	(.016)	.591	(.015)	.613	(.018)
Household size is 2 or smaller	.217	(.008)	.207	(.014)	.230	(.014)	.208	(.015)
Household size is 3	.309	(.009)	.321	(.016)	.302	(.014)	.305	(.017)

	All		Control		LPV		TRV	
	Proportion	**SE**	**Proportion**	**SE**	**Proportion**	**SE**	**Proportion**	**SE**
Household size is 4	.226	(.008)	.223	(.014)	.229	(.012)	.226	(.015)
Neighborhood and housing								
Lived in neighborhood for 5 or more years	.620	(.009)	.621	(.016)	.612	(.014)	.632	(.018)
Moved more than 3 times in past 5 years	.091	(.005)	.107	(.010)	.079	(.008)	.091	(.012)
Very dissatisfied	.463	(.010)	.462	(.017)	.460	(.015)	.470	(.018)
with his/her neighborhood								
Street near home very unsafe at night	.487	(.010)	.492	(.017)	.482	(.015)	.491	(.018)
Chats with neighbor at least once a week	.526	(.010)	.549	(.017)	.524	(.015)	.503	(.018)
Very likely to tell neighbors if saw their kids getting into trouble	.549	(.010)	.564	(.017)	.537	(.015)	.550	(.018)
No family living in the neighborhood	.641	(.009)	.648	(.016)	.652	(.014)	.616	(.018)
No friends living in the neighborhood	.395	(.009)	.405	(.017)	.400	(.015)	.378	(.018)
Very sure would find an apartment in a different area of city	.458	(.010)	.448	(.017)	.448	(.015)	.482	(.018)
To get away from gangs or drugs was primary or secondary reason for moving	.769	(.008)	.782	(.014)	.770	(.013)	.756	(.016)
Access to better schools was primary or secondary reason for moving	.486	(.010)	.474	(.017)	.475	(.015)	.515	(.018)
Had applied for Section 8 voucher before	.416	(.009)	.447	(.017)	.413	(.015)	.388	(.018)
N	*3499*		*1071*		*1440*		*988*	

Table 2

Selected characteristics of MTO participants by treatment group at follow up

	Control Group (C)				Low Poverty Group (LPV)				Traditional Voucher Group (TRV)			
	Mean	**SE**	**[95%**	**CI]**	**Mean**	**SE**	**[95%**	**CI]**	**Mean**	**SE**	**[95%**	**CI]**
Mental health	-.010	(.025)	-.060	.040	.086	(.020)	.048	.125	.030	(.027)	-.023	.083
Psychological distress	.042	(.040)	-.036	.119	-.070	(.030)	-.129	-.011	.000	(.041)	-.081	.082
Depression	.189	(.014)	.161	.217	.150	(.011)	.129	.171	.172	(.015)	.142	.201
Anxiety	.397	(.017)	.363	.430	.364	(.015)	.335	.392	.380	(.018)	.344	.416
Peacefulness	.467	(.017)	.433	.502	.532	(.015)	.502	.562	.484	(.019)	.446	.521
Sleep	.481	(.018)	.447	.515	.517	(.015)	.487	.547	.505	(.019)	.467	.543
Duration weighted immediate poverty *(a)*	.443	(.006)	.432	.453	.329	(.005)	.319	.340	.351	(.005)	.341	.362
Duration weighted surrounding poverty *(b)*	.346	(.004)	.338	.354	.275	(.004)	.268	.283	.307	(.004)	.298	.316
Duration weighted immediate disadvantage *(a)*	3.225	(.053)	3.121	3.328	2.263	(.052)	2.161	2.366	2.416	(.051)	2.315	2.516
Duration weighted surrounding disadvantage *(b)*	2.328	(.040)	2.250	2.406	1.744	(.038)	1.669	1.819	1.985	(.044)	1.898	2.072
Concentrated disadvantage in immediate and surrounding neighborhoods *(c)*	.577	(.017)	.544	.610	.361	(.015)	.332	.390	.427	(.019)	.390	.465
Mixed concentrated and non-concentrated disadvantage in immediate and surrounding neighborhoods *(c)*	.229	(.014)	.202	.256	.174	(.012)	.151	.197	.213	(.016)	.182	.243
Non- concentrated disadvantage in immediate and surrounding neighborhoods *(c)*	.194	(.013)	.168	.220	.465	(.015)	.435	.495	.360	(.018)	.324	.396
n	1003				1367				919			

Notes:

(a) Duration weighted immediate neighborhood indices is calculated as an average of corresponding scores (e.g., poverty rate) for all known neighborhoods a respondent resided in during the study time, weighted by the duration of residence. The scores for all neighborhood of residence are calculated at the time of residence based on intercensal interpolation between 1990 and 2000 or extrapolation to 2002.

(b) Duration weighted surrounding neighborhood indices are calculated like the corresponding immediate indices but as averages of nearby neighborhood scores.

(c) Concentrated disadvantage is calculated based on whether the average neighborhood's disadvantage level a respondent was exposed to during the time of the study was in the 95th percentile of disadvantage of all US tracts.

Table 3

Intention-to-treat estimates of treatment effects on health and on exposures to neighborhood poverty and disadvantage (adjusted for all covariates, weighted, and using robust standard errors)

	Low Poverty Group - Control Group					Traditional Voucher Group - Control Group				
	Coef.	**SE**	**[95%**	**CI**	**]**	**Coef.**	**SE**	**[95%**	**CI**	**]**
Mental health	.081	(.031)	.021	.141	**	.032	(.034)	-.035	.099	
Duration weighted immediate poverty	-.113	(.007)	-.126	-.100	***	-.092	(.006)	-.105	-.079	***
Duration weighted surrounding poverty	-.070	(.005)	-.079	-.061	***	-.039	(.005)	-.049	-.030	***
Duration weighted immediate disadvantage	-.974	(.060)	-1.093	-.856	***	-.839	(.058)	-.952	-.725	***
Duration weighted surrounding disadvantage	-.591	(.041)	-.672	-.511	***	-.365	(.045)	-.453	-.277	***
Concentrated disadvantage in immediate and surrounding neighborhoods	-.227	(.017)	-.260	-.194	***	-.158	(.019)	-.194	-.122	***
Mixed concentrated and non-concentrated disadvantage in immediate and surrounding neighborhoods	-.053	(.016)	-.085	-.021	***	-.022	(.019)	-.059	.015	
Non-concentrated disadvantage in immediate and surrounding neighborhoods	.281	(.018)	.244	.317	***	.180	(.019)	.142	.217	***

Notes:

*** $p < .001$,

** $p < 0.01$,

* $p < 0.05$.

Table 4

Two-stage least square estimations of associations between adult mental health at follow up and immediate and surrounding exposures to poverty and disadvantage

	Mental Health						
	Coef.	**SE**	**z**	**P>z**	**[95%**	**CI]**	
Immediate neighborhood							
Duration weighted immediate poverty	-.659	(.249)	-2.640	.008	-1.147	-.170	**
Duration weighted immediate disadvantage	-.075	(.028)	-2.660	.008	-.130	-.020	**
Surrounding neighborhoods							
Duration weighted surrounding poverty	-1.045	(.412)	-2.540	.011	-1.851	-.238	*
Duration weighted surrounding disadvantage	-.121	(.050)	-2.440	.015	-.218	-.024	*

Notes: Each row represents result from a separate TSLS model, controlling for baseline covariates. SE represents standard errors.

** $p < 0.01$,

* $p < 0.05$.

Table 5

Two-stage least square estimation of associations between adult mental health at follow up and immediate and surrounding exposures to concentrated disadvantage

	Mental Health						
	Coef.	**SE**	**z**	**P>z**	**[95%**	**CI]**	
Extended neighborhood							
Concentrated disadvantage in immediate and surrounding neighborhoods	*[reference]*						
Mixed concentrated and non-concentrated disadvantage in immediate and surrounding neighborhoods	.033	(.242)	.140	.890	-.441	.508	
Non-concentrated disadvantage in immediate and surrounding neighborhoods	.248	(.117)	2.110	.035	.018	.478	*

Notes: The results come from a TSLS estimation using site-by-treatment instrumental variables and the full set of baseline covariates as control. Extended concentrated disadvantage in the immediate and surrounding neighborhoods is the reference category. SE represents standard errors.

** $p < 0.01$,

* $p < 0.05$.