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Temporal Effects of Distressed Housing on Early Childhood Risk Factors and Kindergarten Readiness

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Temporal effects of distressed housing on kindergarten readiness and early childhood risk factors

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Abstract

Poor housing quality and housing crises have been linked to adverse outcomes for children. However, few studies have focused on the early childhood period or been able to pinpoint how the timing and duration of housing problems contributes to early educational success. This longitudinal study draws on linked administrative records from housing, education, social service and health agencies to examine the influence of exposure to housing and neighborhood conditions since birth on school readiness of all children entering kindergarten over a four-year period in a big city school system. Using marginal structural models that properly account for dynamic housing and neighborhood selection, we find that children exposed to problematic housing and disadvantaged neighborhoods have lower kindergarten readiness scores after accounting for other factors. The negative effects of housing problems on kindergarten readiness are partially due to increased risk of child maltreatment, residential instability, and exposure to lead among poorly housed families. Communities are advised to pay more attention to distressed housing as a cause of disparities in early child development and school readiness.

1. Introduction

Children in many big cities in the US are already at an educational disadvantage when they enter kindergarten, presenting a major challenge for public education systems. In fact, socio-economic inequalities in children's cognitive skills at school entry are significantly higher in the US than in the UK, Canada or Australia (Bradbury, Corak, Waldfogel, & Washbrook, 2015). While it is generally acknowledged that the environment in which children spend their early years is crucial, little is known specifically about how housing conditions, both in children's own family homes and the immediately surrounding areas, factor into disparities in early development and kindergarten readiness. This longitudinal, population-based study, has two main purposes: (1) To examine the cumulative impact of housing distress on school readiness for all children entering kindergarten over a four- year period in a big city school system, and (2) To explore the influence of housing problems on selected risk factors for early development: child maltreatment, residential instability and lead exposure.

The focus of this study on housing and kindergarten readiness is justified because there is considerable evidence that early exposure to stressful circumstances, environmental hazards and less than optimal early environments negatively affect early cognitive and socio-emotional development (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005; Martin, Razza, & Brooks-Gunn, 2011), that these influences are cumulative (Appleyard, Egeland, Dulmen, & Alan Sroufe, 2005; Evans, 2003) and that disadvantages shown at kindergarten entry tend to persist over time (Duncan et al., 2007; Hart, Petrill, Deckard, & Thompson, 2007). Children growing up in low-income households and poor neighborhoods experience these negative conditions at higher rates compared to children living in better circumstances, which contributes to well-documented disparities in educational outcomes. However, little is known specifically about how

housing conditions and hazards during the pre-school years affect students' abilities as they enter kindergarten. This study adds to our knowledge about the role that housing plays in early development because it examines the influence of a wide range of housing experiences and exposures on the young child, both in the residential home and from the surrounding properties. These include characteristics of the housing stock and indicators of disinvestment such as foreclosure, vacancy and abandonment. Such indicators of housing distress grew enormously following the mortgage crisis in the late 2000's, but the effects on early childhood have yet to be examined, even though more than 2 million children are estimated to have been touched by foreclosure (Lovell & Isaacs, 2008).

2. Background and conceptual framework

Based on a detailed review of the literature on housing and child development, Leventhal and Newman (2010) argue that macro-level forces influence housing and neighborhood conditions, which in turn affect family processes and child outcomes. Additionally, they contend that family background factors play a role in families' selection into housing and neighborhoods and numerous child characteristics influence family processes and child development outcomes. We adapt this framework to focus on housing-related effects on early school readiness and the micro and macro processes uniquely captured in our administrative data on children and properties (See Figure 1).

INSERT FIGURE 1 HERE

2.1 Housing and early school success: Theory and mechanisms

From an ecological-developmental perspective (Bronfenbrenner & Evans, 2000), educational success in the early grades is influenced by a number of factors, including those emerging from home and neighborhood environments (Duncan & Magnuson, 2011; Shonkoff &

Phillips, 2000). Multiple pathways appear to account for the connection between ecological disadvantage in early childhood and markers of school achievement (Dupere, Leventhal, Crosnoe, & Dion, 2010). Of greatest relevance to the current study are those mechanisms that plausibly link the experiences of families with their housing and surrounding properties to early education success: family stress, residential instability, and toxic environmental exposures.

2.1.1 Family stress and child maltreatment

Housing problems can affect early school success through disruptions to adequate parenting (Leventhal & Newman, 2010). Attentive, responsive and consistent parenting is critical to early childhood development, but is often compromised for those in disadvantaged circumstances (Evans, 2004). Housing problems and neighborhood conditions undoubtedly bear some of the responsibility for lapses in parenting through their impact on parent's stress levels and mental health (Klebanov, Brooks-Gunn, & Duncan, 1994) and the everyday chaos that occurs in difficult housing circumstances (Evans et al., 2005). One of the few housing studies that focused on young children found that elevated levels of behavioral problems could be explained in part by the adverse influence of bad housing conditions on mother's psychological distress (Coley, Leventhal, Lynch and Kull, 2013)

Child maltreatment, arguably an indicator of extreme parenting failure, might be an additional explanation for the link between housing problems and school readiness. Children who are the subject of child maltreatment investigations have been shown to have diminished chances of early school success (Fantuzzo & Perlman, 2007), and a number of studies demonstrate that neighborhoods with distressed housing have increased rates of child maltreatment (Coulton, Crampton, Irwin, Spilsbury, & Korbin, 2007). Housing crises may also contribute to parenting stress and child maltreatment as suggested by a recent study that found an

increased risk of child maltreatment investigations in households that were in the process of mortgage foreclosures (Berger et al., 2015).

2.1.2 Residential instability

Another pathway through which housing problems can affect early learning outcomes is the disruptions associated with frequent moves. Though evidence suggests that residential movement *per se* is not harmful once other risk factors are taken into account (Hango, 2006), frequent mobility has been shown to have negative consequences for child development (Astone & McLanahan, 1994; Pribesh & Downey, 1999, Wood et al., 1993). In studies of young children, residential instability shows a negative impact on cognitive and social development at age 5, (Ziol-Guest & McKenna, 2014) and has direct effects on parental behaviors that are considered abusive or neglectful and on self-reported parenting stress levels (Warren & Font, 2015).

Housing problems undoubtedly play a role in the high levels of residential instability that have been documented among poor households (Gasper, DeLuca, & Estacion, 2010; Pribesh & Downey, 1999). In particular, housing crises rather than strategic choices to relocate to better neighborhoods or employment opportunities are responsible for a large portion of moves in low-income neighborhoods (Coulton, Theodos, & Turner, 2012). For example, families in a Baltimore study pointed to problems such as mold, lack of heat, crumbling walls, leaks, electrical problems, and vermin, as important reasons for relocating (DeLuca, Rosenblatt, & Wood, 2011).

2.1.3 Environmental exposures

The physical deterioration of housing may affect child health and development through increasing the risk of contact with harmful substances (Breysse et al., 2004; Shaw, 2004). Housing that has been vacant or the focus of disinvestment tends to have serious maintenance deficiencies that can pose significant risk for exposure to lead and other environmental hazards

in the home (Clark et al.,11985; Evans, 2006). The negative effect of lead exposure on early cognitive development is well established, and studies show that young children with elevated blood lead levels score lower on school readiness and early developmental assessments (Dilworth-Bart & Moore, 2000; Krieger & Higgins, 2002; Lanphear et al., 2005). General trends suggest that prolonged disinvestment and lack of maintenance are key factors that persist in explaining economic disparities in deleterious environmental exposures such as lead among young children (Jacobs, Wilson, Dixon, Smith, & Evens, 2009).

2.2 Macro and market forces affecting urban housing

The concept of "housing niches" is a useful framework for thinking about the connection of macro-social and market forces to the lived experiences of families and children with housing (Saegert & Evans, 2003). Niches imply a contingent view of households being sorted into housing units and neighborhoods and the constraints this imposes on their experience in a cumulative fashion. In many metropolitan areas, persistent lines of race and class segregation structure these niches (Sharkey, 2013) and shape the contexts that accordingly have unequal impact on the lives of residents. In recent years, the impact of the so-called mortgage crisis has been felt unequally in housing niches occupied by minority household that disproportionately received subprime and predatory loans that had a high probability of going into default (Rugh, Albright, & Massey, 2015).

At the household level, there is scant research on the effects of foreclosure on children. However, households involved in foreclosures were found to have increased school instability in New York (Been, Ellen, Schwartz, Stiefel, & Weinstein, 2011) and child maltreatment incidents in Wisconsin (Berger et al., 2015). In the wake of the foreclosure crisis are large numbers of housing units that are sold to investors (or speculators) at extremely low prices, and then rented

out or “flipped” several times with very few improvements (Coulton, Schramm, & Hirsh, 2008, 2010; Immergluck, 2013). Families with children that move into these homes face problems of poor housing quality along with the possibility of environmental hazards from the surrounding blight. Beyond their own households, there is also reason to believe that neighborhood properties that become vacant and blighted following foreclosure may have spillover effects that impact children in their vicinity (Immergluck, 2012; Immergluck & Smith, 2005, 2006).

3. The current study

Cleveland, the location for the current study, is a city where the macro and market forces described above have affected many homes and neighborhoods (Coulton et al., 2010; Whitaker & Fitzpatrick, 2013). Foreclose filings in the Cleveland area grew exponentially from 2003 to 2007 when they leveled off at previously unprecedented heights. REO (i.e., real estate owned by banks) inventory, vacancy and abandonment rose and sale prices fell as a result, bringing as little as 10 cents on the dollar of the market value prior to the crisis. Cleveland is also highly segregated by race (Iceland, Weinberg, & Steinmitz, 2002) and the impact of foreclosure was most severe in African American neighborhoods that were heavily leveraged with subprime mortgages. The children in this study, the majority of whom are African American, started life during this period of housing crises and rapid disinvestment, which continued unabated as they entered kindergarten.

The study follows several cohorts of children from birth through kindergarten and includes a nearly continuous record of exposure to housing problems and neighborhood context along with the timing of potential mediators of context on kindergarten readiness, such as child maltreatment, residential mobility and lead exposure. Far from being randomly assigned, neighborhood and housing conditions are determined in part by household characteristics, which

are in turn influenced by past living conditions. This process takes place over time, invalidating the use of standard regression models that are unable to handle time-varying confounders of treatment. Thus, we use an auxiliary model of dynamic selection to reduce the bias from time-varying confounders and to estimate time-varying effects of neighborhoods on educational outcomes (Robins et al., 2000; Wodtke, Harding, & Elwert, 2011).

The study focuses on four main hypotheses. First, cumulative exposure to poor quality housing and disadvantaged neighborhoods during early childhood negatively affect school readiness at kindergarten entry. Second, markers of housing market distress such as foreclosure and disinvestment are additional contributors to lack of kindergarten readiness that is observed during the study time period. Third, child maltreatment, residential instability and lead poisoning are negatively associated with school readiness. Fourth, problematic housing conditions and housing market distress dynamically contribute to the likelihood of child maltreatment, residential instability and lead poisoning in the early childhood period.

4. Methods

4.1 Study population and design

This study population includes all children that entered kindergarten for the first time in the Cleveland Metropolitan School District (CMSD) during the 2007-2010 academic years (N=13,762). We compiled monthly address histories for the children in the study from a combination of administrative records, which allowed for the assessment of the timing and duration of numerous measures related to their housing location and conditions, neighborhood context and residential mobility. Other records supplied data on maternal and child characteristics at birth, the timing of selected experiences and exposures from birth to kindergarten, and the outcome of the study, the kindergarten readiness assessment. The analytic

approach for this study allows for a temporal and life course perspective on the effects of housing and neighborhood on school readiness and various mediating processes, and for the dynamic modeling of households' selection into housing and neighborhoods.

4.2 Data sources and procedures

This study draws on two relatively unique data resources for the Cleveland region maintained by the Center on Urban Poverty and Community Development, Case Western Reserve University. The first, the ChildHood Integrated Longitudinal Data (CHILD) system, links administrative records data at the level of the individual child from health and human services agencies, early childhood programs and K-12 education. The records in CHILD are linked together through probabilistic matching techniques within a highly secure research environment (Lalich, Anthony, Richter, Coulton, & Fischer, 2015). Importantly for this study, all residential addresses from the agency records are stored and date stamped. The CHILD system operates under a protocol approved by the CWRU Institutional Review Board (IRB).

The second data resource is a geographic information system (GIS) based tool that links records at the parcel level from multiple public sources as to housing type, conditions, values, land use codes, public housing and project based section 8 units, mortgage originations, sales and deed transfers, foreclosure filings and sales, vacancy status, housing code violations, demolitions, tax delinquencies, and crime reports. This property integrated data system contains information on all residential and non-residential parcels, along with shape files, centroids, and census geography identifiers for the parcels (Hirsh, Schramm, & Coulton, 2012).

In order to link the housing information to children's monthly residential addresses, we converted the street addresses to parcel numbers for matching. We applied an address standardization protocol and then utilized a parcel-address look-up file that we built for our

research. This match allowed the retrieval of parcel-based housing variables for each residential location tied to the time-period the child was at that address. For each address, we also specified a buffer of 500, 1000 and 1500 feet around the child's house to capture the housing market conditions in the surrounding area. Known as "ego-centric" or sliding neighborhood units, we chose these buffers based on previous studies that suggested a gradient of spatial influence and the need for sensitivity testing at various geographic scales (Chaix et al., 2005; Koschinsky, 2009; Matthews, 2011). Additionally, we identified the census tract for each residential address for the purpose of obtaining demographic and socio-economic attributes of the population from census data sources.

4.3 Measures

The measures we used for this study all come from the integrated administrative records databases described above. Reliance on these existing data sources presents some limitations in that the data elements recorded by the agencies may not include the full range of measures that would be ideal for research. Nevertheless, because these records are available for the population rather than a sample, we can interpret our findings with respect to their systemic importance and demonstrate what communities and policy makers can learn from this relatively efficient method of conducting longitudinal research on existing records. The study measures and data sources are summarized in Table 1.

INSERT TABLE 1 ABOUT HERE

4.3.1 Child and family characteristics

Low birth weight is a child development risk factor that is determined from the birth certificate and defined as <2500 grams. *Gender*, *race or ethnicity*, whether English is a second *language* and the child's *age at kindergarten* entry are control variables determined from school

records. *Disability* status of the child is determined from a record of participation in the early intervention program for special needs children ages 0-3 (authorized under the Individuals with Disabilities Education Act, Part C).

We determine the *mother's age* and *education* at the time of birth from the child's birth certificate. The family's *poverty status* is determined monthly based on records of participation in the Supplemental Nutrition Assistance Program (SNAP). Households that are eligible for SNAP fall below approximately 130 percent of the poverty threshold set by the U.S. government.

4.3.2 Neighborhood and housing measures

We measure the socio-economic conditions in the broader neighborhoods (i.e. census tracts) using standard US Census variables. Specifically, we rank all of the census tracts in the county on a widely used *concentrated disadvantage factor score* (Sampson, Raudenbush, & Earls, 1997), derived from a principal components factor analysis. The variables included in the factor are welfare receipt, poverty, unemployment, female-headed households, racial composition (percentage black), and density of children (less than age 18).

Children's housing experiences are determined monthly based on their residential addresses. The housing measures are divided into two groups: Indicators of housing conditions and markers of housing market distress. *Housing condition rating* is based on the classification rating system provided by the county tax assessor. We classify housing units that are rated as poor, very poor or unsound as being in poor condition. A limitation of reliance on the county ratings is that they come from periodic external inspections, and may miss recent changes in property conditions or damage to the inside of the houses that are not part of an overall picture of deterioration. To this, we add a second indicator of poor housing conditions, *very low-market*

value, possibly reflecting market appraisals of the state of repair of the buildings. We set the threshold at $30,000 (in 2010 dollars), which represents the 30th percentile of housing unit values in our study. We also include a marker for whether housing units are in *public or project-based subsidized* housing. Such units fall outside the market valuation protocols that we rely on as markers of property conditions for the private market housing in which the majority of our study population lives.[1]

We also developed measures for several housing market events that can destabilize housing or are markers for disinvestment in the properties. First, we demarcate *foreclosure spells* based on the date that a property went to foreclosure sale. The typical foreclosure takes about 18 months to complete in our county, so we consider the foreclosure spell to cover the 18 months prior to the sale. The foreclosure process can cause distress to the occupants of the home and may be a marker of disinvestment by owner occupants or landlords. Another signal of housing distress is the acquisition of a foreclosed and vacant housing unit by a speculator (i.e., *speculator owned*). As part of a previous study, we developed a method of using patterns of grantee (buyer) and grantor (seller) names on deeds to identify property transfers that have a high likelihood of involving housing speculators. We found that most speculator owned houses were poorly maintained and rented out with few improvements (Coulton et al., 2010). *Tax delinquency* spells are a final marker of housing disinvestment (Whitaker & Fitzpatrick, 2013). We define the tax delinquent spell as encompassing the period from the quarter before the arrearages were posted through the point at which they were resolved.[2]

4.3.3 Mediating events

This study also includes several child-level risk factors that we hypothesize will have a negative effect on kindergarten readiness and that may be influenced by housing problems. We

ascertain the occurrence of *child maltreatment* events from the records of child abuse and neglect reports that were accepted for investigation by the County's Department of Children and Family Services. Allegations that result in acceptance for investigation have been shown to reflect serious concerns about family functioning and ability to care for children (Coulton et al., 2007; Slack, Holl, McDaniel, Yoo, & Bolger, 2004; Stith et al., 2009). We calculate this variable based on whether or not the child was the subject of a report of maltreatment each year from birth to kindergarten. *Residential instability* is a count of the number of address changes experienced by the child each year. We use records of lead testing from the Ohio Department of Health to determine whether the child ever had an *elevated blood lead level*. We use the threshold for concern set by the state that is defined as having a level greater than 5 μg/dL. According to Centers for Disease Control and Prevention, this reference level is set at the 97.5th percentile of blood lead levels in U.S. children aged 1–5 years (CDC, 2012, 2013).

4.3.4 School readiness

The score on a test of *kindergarten readiness* is the main dependent variable for the study. During the study period, Ohio utilized the Kindergarten Readiness Assessment-Literacy (KRA-L) to evaluate children entering school. The KRA-L, developed by the Ohio Department of Education (ODE) is a standardized screening instrument that measures early language and literacy skills (ODE, 2005). School districts in Ohio must administer the assessment to all children entering kindergarten within the first six weeks of school. The KRA-L consists of 25 items that include important subsets of literacy such as oral language, phonological awareness and print awareness (ODE, 2005). Reading skills tapped by these subsets have been shown to be moderately to strongly related to future reading achievement (Logan, Justice, & Pentimonti, 2014; National Early Literacy Panel, 2008). According to ODE (2005, p.11), the reliability and

the validity of the KRA-L conforms to the standards jointly recommended in 1999 by the American Educational Research Association, the American Psychological Association and the National Center for Measurement in Education. Total possible scores on KRA-L range from 0 to 29 points.

4.4 Analytic techniques

The overall goal of our analysis is to use our detailed longitudinal data to understand the influence of housing and neighborhood conditions during the entire period of early childhood development culminating in the readiness for kindergarten. Our analytic methods are designed to represent these cumulative effects while also taking into account the dynamic selection of households into housing units and neighborhoods.

4.4.1 Dynamic selection into treatment models

We aim to understand the influences of housing conditions over time on kindergarten readiness. Thus, our model needs to consider that individual covariates that influence housing choice will in turn influence subsequent housing conditions and other time-varying individual covariates. We hypothesize that cumulative exposure to housing distress derived from this dynamic process of housing selection and individual characteristics has a negative influence on kindergarten readiness as measured by the KRA-L score. However, housing choices are not made independently of neighborhood selection. Housing and neighborhoods are best seen as bundles among which individuals make selections given their past exposure to housing and neighborhood, as well as a series of other covariates. We describe the model specified under these assumptions using a Directed Acyclic Graph (DAG) shown in Figure 2. DAGs are commonly used to represent causal relations among variables via directed arrows (causal effects) between nodes (variables) and to evaluate the identifiability of these relationships (Pearl, 2009).

Though we have a yearly panel of children until their entry into kindergarten (five or six years per child), the DAG illustrates a two-period model for simplicity. This setting is similar to the analysis of temporal neighborhood effects by Wodtke et al. (2011), although our model accounts for the simultaneous selection of housing and neighborhood by households.

INSERT FIGURE 2 HERE

In Figure 2, we denote housing and neighborhood exposure at year *t* by NH_t, covariates by *Xt*, and test score outcome by *Y*. Time invariant variables in X_t include variables for mother's education, age of the mother, child's birth weight, gender, disability status, and race. Time-varying covariates include poverty status, past residential mobility and child maltreatment reports. These covariates influence all housing and neighborhood choices NH_1, and NH_2, subsequent covariates X_2, and outcome *Y*. Finally, *u* represents unobserved characteristics that influence covariates and the outcome.

As Wodtke et al. (2011) point out, typical regression models fail to identify the full effect of housing and neighborhoods on the outcome in the presence of variables that are simultaneously mediators and confounders. This is the case of X_2, which mediates the relation between NH_1 on *Y* but confounds the relation between NH_2 and *Y*. Controlling for X_2 to handle confounding will block the indirect path through which NH_1 affects *Y* and so we are unable to estimate the full effect of *NH* on *Y*. We address this identification problem by estimating inverse probability of treatment weights within the context of a marginal structural model (Robins et al., 2000). The selection model used to estimate the probability of treatment is a pooled multinomial regression on child-year observations. A similar selection model from birth to age three is used to estimate the effects of early housing conditions on elevated lead levels.

We define NH_t as a multilevel variable reflecting neighborhood and housing conditions. Specifically, neighborhoods are dichotomized into two levels: being above or below the 70th percentile of the concentrated disadvantage factor within the entire county. Housing is divided into three categories: (1) being deemed in poor condition, (2) not deemed in poor condition but having very low value, or (3) not deemed in poor condition and not having a very low value. This classification defines six categories of neighborhood and housing conditions that we denote by NH_{it}, where i indexes the child and t denotes the age of the child. In 2006, 18% of the housing units in our data were classified as being in poor condition and another 18% were not deemed to be in poor condition but were of very low value.

4.4.2 Marginal Structural Models of housing and neighborhood effects

Following Wodtke et al. (2011), we define the average causal effect on the outcome of a neighborhood and housing trajectory relative to another as the expected difference in test scores when children are counterfactually subject to each of the two neighborhood and housing trajectories. A trajectory is defined over the course of the five or six years in the life of a child prior to taking the kindergarten readiness test. Therefore, if we code six possible levels of neighborhood and housing conditions in each year, we arrive at 6^5=7,776 possible trajectories and not enough data to estimate treatment effects for all possible pairs. Thus, we specify a more parsimonious parametric model that measures effects of cumulative exposure to housing and neighborhood conditions. In order to account for time-varying confounders that affect treatment, we estimate this model weighted by the inverse probability weights (IPW) estimated through the selection model. In essence, observations so weighted form a pseudo-population in which time-varying covariates no longer confound the relationship between treatment (housing and neighborhood conditions) and tests scores. In this model of cumulative exposure, we gradually

include markers of housing market distress that are also symptomatic of physical distress along with cumulative measures of the mediator variables such as lead poisoning, housing instability, and child maltreatment reports.

4.4.3 Model specification

The neighborhood and housing selection model is specified as a multinomial logit on the categorical variable NH_{it} taking values between 0 and 5, for child i in period t.

$$\frac{P(NH_{it}=k)}{P(NH_{it}=0)} = exp\left[\left(X_i, \bar{Z}_{it}, \bar{N} \times \bar{H}_{i(t-1)}, T_{it}\right)\beta^{(k)}\right],\ k = 1, \ldots, 5 \quad (1)$$

Where,

NH_{it}: neighborhood and housing distress for child i at period t (categorical)

X_i: time-invariant characteristic for child i

$\bar{Z}_{it}$: current and lagged time dependent characteristics

$\bar{N} \times \bar{H}_{i(t-1)}$: lagged interaction of neighborhood distress and housing distress

T_{it}: dummy variables indicating time period and kindergarten entry cohort

We proceed by computing the inverse probability of treatment weights using predicted probabilities obtained from model (1). The probability of treatment refers to the likelihood that household i selected into its actual housing and neighborhood trajectory. The inverse probability weights are multiplied by a stabilizing factor as seen in equation (2).

$$SW_i = \prod_{t=1}^{T} \frac{P(NH_{it}=k_{it}\,|\bar{N}\times\bar{H}_{i(t-1)}=\bar{k}_{i(t-1)},\, Z_{i1}=z_{i1})}{P(NH_{it}=k_{it}|\bar{N}\times\bar{H}_{i(t-1)}=\bar{k}_{i(t-1)},\, \bar{Z}_{it}=\bar{z}_{it})} \quad (2)$$

Where:

SW_i is the stabilized IPW for child i

k_{it}, represent the actual values of the housing and neighborhood variable

Z_{it} are other characteristics for child i during period t, whereas as before, $\bar{Z}_{it}$ represents current and lagged characteristics

The probabilities in the denominator are estimated directly from equation (1). The numerator is meant to stabilize weights and is estimated from a model similar to model (1) with the variables $\bar{Z}_{it}$ replaced by Z_{i1}, the characteristics in period one. Appendix 3 presents selected percentiles of the stabilized weights, showing that they center around one.

Finally, we are able to estimate the following marginal structural model of cumulative exposure through a weighted OLS procedure:

$$Y_i = \sum_{j=1}^{L} X_{ij}\,\beta_j + \sum_{j=L+1}^{J} \bar{X}_{ij}\,\beta_j \qquad (3)$$

$$\bar{X}_{ij} = \frac{\sum_{k=1}^{T} d_k\, x_{ijk}}{\sum_{k=1}^{K} d_t} \qquad (3.1)$$

Where:

i: child, j: characteristic, t: period/age of child

d_t: fraction of year for period t

x_{ijt}: j_{th} time-varying characteristics for child i in period t

X_{ij}: j_{th} time-invariant characteristics for child i

Y_i: KRA-L test score for child i

The term $\bar{X}_{ij}$ (3.1) represents duration-weighted exposure to poverty, neighborhood and housing distress.

4.4.4 Models of the direct effect of housing on mediators

We are also interested in understanding the effects of housing and neighborhood conditions on the potential mediators of school readiness: child maltreatment, residential instability and elevated blood lead levels. For the time-varying maltreatment and residential mobility outcomes, we specify fixed effects panel models. These models control for unobserved

heterogeneity or selection factors at the child-household level that are time invariant as well as time effects that are homogeneous across children. In essence, they estimate the effect of change in housing and neighborhood conditions on change in the likelihood of these events. Fixed effects models address the problem of selection into treatment by estimating within-and not between-individual effects due to changes in the treatment. Rather than explicitly modeling selection based on observables and 'undoing' it via inverse probability of treatment weights, a fixed effects panel model differences-out unobservables that may be responsible for selecting into specific levels of treatment. This approach is possible because the dependent variable is measured over time, unlike in the case of test scores or lead test outcomes, which are measured once during the entire period of study.

For the outcome of lead, the underlying process of lead level elevation is cumulative in young children. Once a child tests positive, the lead elevation is known to be present and will not be reduced by change in exposure. Moreover, the time of testing does not necessarily coincide with the point of elevation but tends to be dictated by screening protocols and medical visits. Therefore, we adopt the same approach that we used to control for selection in the previous models of kindergarten readiness. We estimate the effects of early housing and neighborhood conditions –from birth to three[3]- on having a positive lead test result. As with the KRA-L model described above, we estimate inverse probability weights from a birth-to-age three-selection model, which are then used to estimate a marginal structural model of lead exposure using a multinomial logit specification on a three-leveled variable (not tested, tested negative, tested positive).

4.4.5 Missing data imputation

Only about 62% of children have full non-missing data on all model variables and over the entire study period. Thus, we perform our analysis over 30 imputed data sets generated with a multiple imputation by chained equations algorithm in Stata (Royston & White, 2011). This algorithm allows each variable to have its own imputation model specification depending on whether variables are continuous, categorical, or discrete. We perform all analyses on these imputed data sets.

5. Results

5.1 Descriptive findings on study variables

The descriptive statistics for the study variables are provided in Table 2. Section A of the table displays time invariant and time varying variables. We report the time varying variables for children at yearly age intervals, from birth until kindergarten entry. It should be noted that the length of the final period varies by individual based on their age at the time they entered kindergarten. Therefore, the descriptive statistics for each interval are weighted for the number of months each child is observed. In Section B, we report cumulative exposures for the time varying variables.

INSERT TABLE 2 ABOUT HERE

As can be seen in Table 2, the children entering this public school system are predominately African-American (69%) and more than three-quarters come from low-income families. Nearly half their mothers had not graduated from high school by the time of their birth, and the rates of low-birth weight and teen motherhood are disproportionately high in this population compared to state averages. Approximately 11 percent of the children have been identified as having special needs through the early intervention services program. The typical child enters kindergarten about halfway through their fifth year of life.

These children also experience a number of environmental disadvantages during their years prior to kindergarten. The average child lives in neighborhoods that are above the 75th percentile for the region on the concentrated disadvantage factor. The incidence of living in houses that are in poor condition according to county records falls as children age (ranges from 22.5% in the first year of life to 11.5 percent in the year of entering kindergarten). Still, nearly one third live in extremely low value units, a sign of disinvestment that further suggests that they are not likely to be kept in good repair. On average, children experience one or more of the markers of housing market distress for one out of five years of their lives (22% of the time) before entering kindergarten, although there is variation in the trends across the specific indicators.

The child maltreatment incidence rate in this population is high (approximately 12.5 percent) although this rate declines by the year the children enter kindergarten. The national incidence rate for child maltreatment is less than one percent (US Department of Health and Human Services, 2014). On average, study children move about once every two years. Almost 40 percent of the children are found to have an elevated blood lead level test result prior to entering kindergarten.

The mean KRA-L score for the study population is 15.8 out of a possible total of 29 points. This mean falls at the lower end of the range that the state considers suggestive of the need for targeted intervention and support (ODE, 2005). It is also noteworthy that only 18 percent of the study population falls into the upper score band width (24-29) on KRA-L. This is the only range that is considered not to be in need of special attention.

5.2 Cumulative effects of housing, neighborhood and other risk factors on kindergarten readiness

In this section, we examine the dynamic effects of housing and neighborhood conditions on Kindergarten readiness (KRA-L). Table 3 displays the estimates of our marginal structural models that control for dynamic selection of housing and neighborhood quality each year. The coefficients for the time varying variables represent the weighted average effects over the period from birth to kindergarten entry. In order to adjust for the fact that children vary in the exact number of months in the final period before entering school, the variables are calculated as average yearly rates. Then, for example, we can think that if a child enters kindergarten the day after her fifth birthday, a 0.2 cumulative exposure to housing market distress represents exposure in a total of one out of those five years.

INSERT TABLE 3 ABOUT HERE

Model I focuses on the effect of housing and neighborhood conditions, controlling for family and child characteristics. The effects of child and family characteristics are generally as expected, with a few exceptions. Low birth weight children have lower KRA-L scores, females' scores are higher than males, older children score somewhat higher, children for whom English is a second language or who have special needs have lower scores. In this population, children classified as Hispanic, white or other, have lower KRA-L scores than African American children (the reference group) after controlling for other factors. As expected, children whose mothers were high school graduates at the child's birth score higher on the KRA-L. Somewhat unexpectedly, we see that children of a teen mother also score slightly higher than children of older mothers. However, a simple tabulation of scores by teen and high school status of mothers reveals that the score advantage of teen over non-teen mothers only applies for mothers who are not high school graduates at the point of the child's birth. In such circumstances, these young, mothers may still be in school and their children may be receiving additional support provided

by family or social services. The number of months spent in poverty is associated with lower KRA-L scores. Cumulative exposure to neighborhoods of concentrated disadvantage has a negative effect on kindergarten readiness. Also, the time spent in housing units that are in poor condition has a negative effect on KRA-L scores. Living in low market value housing does not show any additional effect.

Model II adds housing market distress events to the analysis. The time spent living in housing units that are tax delinquent, in foreclosure or owned by speculators all have significant negative effects on kindergarten readiness. The density of these distressed properties within a 500-foot buffer around the children's own houses also has a negative effect on KRA-L scores. The spillover effects of surrounding housing units were still significant but weaker for 1000 and 1500 foot buffers (not shown). After adding these markers of housing market distress, the effect of poor housing condition, as recorded by the county, becomes weaker. The market distress indicators, which change quarterly, may be picking up deterioration in the condition of the house that may not yet figure into the tax assessor rating or the estimated market values.

The final model (Model III) incorporates the direct effects of child maltreatment, residential mobility and elevated lead levels on kindergarten readiness. These variables are known risk factors for lack of school readiness, but are also potential mediators of poor housing and neighborhood conditions. All three of these factors have negative effects on KRA-L scores as predicted. Children with one or more incidents of maltreatment score lower on KRA-L than those who are not victimized. The number of residential relocations is negatively related to kindergarten readiness scores. In addition, children that have elevated lead levels, and those who are not tested, have lower KRA-L scores than children who test negative for lead exposure. Moreover, the incorporation of these risk factors into the models result in some reduction in the

coefficients for the housing and neighborhood variables, suggesting the possibility of partial mediation.

5.3 Effects of housing and neighborhood on child maltreatment, residential mobility and elevated blood lead levels

Given the negative effects of child maltreatment, residential mobility and elevated blood levels on kindergarten readiness shown in the previous models, we undertake an examination of the influence of neighborhood and housing characteristics on these risk factors. For the lead test model, we control for the effects of dynamic selection into housing and neighborhoods. For the time-varying child maltreatment and residential mobility outcomes, we apply fixed effects panel models. These models control for unobserved heterogeneity or selection factors that are not time-varying. In essence, they estimate the effect of a change in housing and neighborhood conditions on the likelihood of these events, holding constant differences among families and children that time invariant.

INSERT TABLE 4 ABOUT HERE

The top section of Table 4 presents the fixed effects model for child maltreatment. We see that an increase in the proportion of time spent in poverty increases the likelihood of a child maltreatment report. Child maltreatment incidents are also positively related to families living in houses that are in poor condition, being in the foreclosure process, and entering public or project-based Section 8 housing. Incidents of child maltreatment are not significantly related to changes in neighborhood concentrated disadvantage, low market value of housing, tax delinquency or speculator ownership.

The residential mobility fixed effects model appears in the second column of the top section of Table 4. The share of time spent in poverty during the year increases rates of residential mobility as does living in poor housing conditions or public and project-based

subsidized housing. As expected, all of the housing market distress markers add to the chances that the household will relocate within the year. Accounting for the above variables, living in neighborhoods of concentrated disadvantage or in housing with low market value reduces rates of residential mobility in this population.

In the bottom section of Table 4, we display estimates from the cumulative lead poisoning models incorporating the inverse probability weights for selection for housing and neighborhoods up to the age of three. Specifically, we report the marginal effects estimates for the multinomial model of elevated lead levels. The coefficients in these models represent the change in the probability of having an elevated lead level due to a change in the independent variables. Low birth weight, female, and Hispanic children have lowered chances of elevated lead tests. The chances of lead poisoning are higher for children of less educated mothers and those that spend more time in poverty, poor housing conditions and low market value housing. Greater exposure to housing units touched by market distress such as tax delinquency, foreclosure and speculator ownership increases rates of lead poisoning in children.

6. Discussion

This study examined the effects of housing and neighborhood conditions on kindergarten readiness scores for all of children that entered school over a four-year period in a big city school system. A unique aspect of the study is that it relies exclusively on administrative records and brings together linked records beginning at birth on children and all of the properties that they occupied before entering kindergarten. By focusing on entire kindergarten entry cohorts within one location and time period, it holds constant systemic and housing market factors that often vary in other kinds of longitudinal research. Few previous studies of housing have focused specifically on the early childhood period or had the ability to evaluate the sequence of housing

experiences along with other circumstances and events that might also contribute to school readiness. Moreover, the study evaluates numerous aspects of housing markets and conditions at a granular level of geography, overcoming limitations that have previously been identified in the literature on housing and child development (DeLuca & Dayton, 2009; Evans, Wells, & Moch, 2003; Newman, 2008; Nettles, Caughy, & O'Campo, 2008).

At the time of this study, the entering students were similar to those in many central city public primary schools. Their kindergarten readiness scores fell in the low range compared to the state averages. The students were disproportionately African-American and Hispanic and members of low-income households. The children's home neighborhoods were quite disadvantaged relative to the neighborhoods in the region. Moreover, the housing units occupied by much of the study population fell at the lower end of the housing market with respect to quality and market valuation. The housing stock in Cleveland is generally old (e.g. over 90 percent of the children lived in housing units built before 1970), and a large majority of the children lived in privately owned housing units, most of which are one to four-family structures. Many of the dwellings were touched by the foreclosure and vacancy crisis that was in force during the study period. While children in the study relocated frequently, most of them tended to move within the same quality of houses and neighborhoods.

We estimated a series of models that looked at the influence of housing and neighborhood conditions on kindergarten readiness scores and potential mediators including child maltreatment, residential instability and elevated blood lead levels. In all instances, we adopted analytic methods that arguably control for dynamic selection into poor quality housing and disadvantaged neighborhoods. This allows us to have a degree of confidence that the effects we estimate in our models are less subject to bias due to time-varying confounding than standard

OLS models. We found that kindergarten readiness scores were negatively affected by children's cumulative exposure to poor quality housing and disadvantaged neighborhoods. Housing market crisis events, such as foreclosure and disinvestment, had consistently negative effects on kindergarten readiness scores. Moreover, we identified some spillover effects from nearby distressed properties on children's kindergarten readiness. Our housing quality measures, poor condition rating and low market value, became insignificant after the inclusion of housing market stress events. We suspect that these former metrics, which are updated only periodically, may be less sensitive than our housing market stress events to the rapidly changing conditions of properties during the economic and housing market conditions in place at the time of this study. Finally, the incidences of child maltreatment, residential mobility and lead poisoning all had negative effects on kindergarten readiness, after controlling for neighborhood and housing conditions.

We found a few variables in our models to have unexpected effects on kindergarten readiness scores. Once exposure to neighborhood disadvantage and poor housing conditions were accounted for, African American children scored slightly higher than white children in our sample. This suggests that African American children's apparent disadvantages in school are partially due to the structural disadvantages that they face in a highly segregated metropolitan area such as Cleveland. The positive effect of teen motherhood on kindergarten readiness scores was also contrary to expectation. The administrative data that we used did not allow us to determine whether children lived in multi-generational households, but it is possible that many teen mothers were continuing their schooling and received family supports that were not measured in this study.

We also evaluated the impact of housing and neighborhood conditions on several known risk factors that we considered potential mediators of housing and neighborhood effects. In our fixed effects panel model of child maltreatment, we found that living in public or project-based section 8 housing, private market units in poor condition, or houses that were in the process of foreclosure increased the chances of a child maltreatment report in the early childhood years. Berger et al. (2015) similarly found that foreclosure increased the risk of a maltreatment report among children of all ages using administrative records data from Wisconsin. The increased risk of child maltreatment in relation to public housing might be due to lagged effects of housing problems that occurred in prior years prompting families to make application for housing assistance. Since there is often a waiting period, the move to public housing could have come after a prolonged period of family distress.

Residential instability was found to increase when families lived in housing units that were in poor condition or had been through housing market dislocations such as foreclosure, vacancy and disinvestment. The results of this fixed effects model is consistent with other literature that links housing problems to frequent mobility in low- income families (DeLuca, Rosenblatt & Wood, 2011). Unexpectedly, we found that living in housing that was of low market value or in a neighborhood of concentrated disadvantage lowered mobility rates. Given that most of the families in our study population had low incomes but live in private market-rate housing, they may have been reluctant to give up affordable units even when conditions were less than ideal.

Finally, we found cumulative effects of poor housing conditions and housing market stress events in children's own homes and in the surrounding area on the likelihood of children having elevated blood lead levels. This link between lead exposure and substandard housing has

been documented in prior studies (Evans, 2006), but our research design has the advantage of measuring housing conditions and events continuously from birth and controlling for time-varying confounding though our dynamic selection modeling. In fact, we estimate that children that spent all of their pre-school years in poor housing and neighborhood conditions were 25 percentage points more likely to have an elevated lead level than those who avoided such circumstances, controlling for other factors. At the 10th and 90th percentiles of housing, neighborhood and housing disadvantage, the difference in the probability of high lead levels was 23 percentage points, at 0.28 and 0.51, respectively.

The above summary points to several aspects of neighborhood and housing contexts that have measureable impacts on kindergarten readiness scores and other early childhood risk factors. However, in reality these attributes of the urban context do not exist in isolation. Housing crises, deterioration and devaluation can be part of a cycle of neighborhood decline. To illustrate the combination of all of these contextual effects, we calculate average predicted kindergarten readiness scores for various levels of housing and neighborhood distress with all other variables held constant at their mean. We present these estimates in Figure 3, for children with and without lead poisoning. Children with elevated blood lead levels score lower on kindergarten readiness assessments than other children within each level of housing and neighborhood disadvantage. We have already seen that children living with housing problems are almost twice as likely to have elevated lead levels. As can also be seen in Figure 3, in the points designated by an asterisk (*), children with the highest exposure to problematic housing and neighborhood conditions (i.e. 90th percentile) and positive lead tests are estimated to score 15 percent lower on KRA-L than those living in the best conditions (10th percentile) with negative lead tests. It should be noted that poverty in this population is relatively high at all

points on the continuum since children on average spent 75 percent of their early childhood in poverty (using the marker of SNAP participation). While poverty is strongly interrelated with housing and neighborhood conditions, our model allows us to estimate the *additional effects* of housing conditions on kindergarten readiness scores for this poor population at varying levels of housing distress.

INSERT FIGURE 3 HERE

Although these examples are provided for children at selected levels of disadvantage, it should be kept in mind that the actual population of children entering kindergarten in this study tended to fall more toward the disadvantaged end of the housing continuum. Thus, these comparisons suggest the benefits that could be achieved if children in the worst housing and neighborhoods were instead exposed to the kinds of environments that the most fortunate children in the school system experience. This is not as big a leap as might be assumed, since the housing and neighborhoods occupied by the most advantaged students' families are still relatively affordable compared to the region.

7. Conclusions

In closing, it is important to acknowledge several limitations of this study. First, because we focused on the population of school children in one large city during a particular time, the results cannot be readily generalized to other times and places. However, Cleveland shares many similarities with other northern industrial cities that have been hard hit by poverty, concentrated disadvantage and housing market dislocations. As such, it may suggest how these conditions are likely to affect children in similar school systems and cities.

Second, the study reliance on administrative records limited our choice of study variables. We were not able to incorporate subjective perceptions of housing and neighborhood

quality, take into account other members of the household besides the mother and child, or to make direct observation of housing and neighborhood quality. Moreover, our direct measures of poor housing conditions relied on ratings provided by the tax assessor and estimated market values. This information is updated on a schedule driven by tax assessment purposes and may be insensitive to housing problems that are recent, temporary or not readily visible. We believe that our markers of housing market events, such as foreclosure and tax delinquency, are probably picking up deterioration in housing quality that happens quickly when houses have periods of vacancy, especially in cities with weak housing markets.

Third, several of our key outcome variables have limitations. The KRA-L test focuses on kindergarten readiness related to literacy skills. There are other aspects of early development that are also pertinent to early school success, including socio-emotional and physical development. Our lead testing data provides the residential location of the child when the blood lead level was obtained, but does not definitively indicate where and when the lead exposure occurred. Additionally, the measure of child maltreatment is based on cases that are reported to the authorities and screened-in for investigation, but some maltreatment undoubtedly goes unreported.

Finally, although we used a rich set of variables and various methods to control for selection bias and confounding, we could not rule out all possibilities. The ideal experiment is touted as one that randomly assign families to the full range of housing and neighborhood conditions available to this population and then observes the effects on outcomes. However, even with initial random assignment, subsequent moves would introduce selection and confounding effects, and it can be seen that this is a mobile population. We used inverse probability of selection methods to overcome the problem of time-varying confounders due to dynamic

residential mobility and controlled for a series of variables that influence selection, but we had to establish thresholds for defining problematic housing and neighborhoods, when the reality is that these exist on a continuum. We chose relatively severe restrictions of the 70th percentile on neighborhood disadvantage and about the 20th percentile on housing condition.[4] Moreover, the administrative records contained only some of the variables that would be ideal for modeling selection. In particular, we did not know whether the family owned their home, was renting or whether they were using a housing choice voucher, and this could be an important aspect of housing and neighborhood selection.

These limitations not withstanding, this study demonstrates that housing quality and market distress are important factors in understanding the ecological context for early educational success. By looking at a continuous record of neighborhood and housing exposure, month-by-month during the pre-school years, this study addresses a need identified in the literature for contextual studies that adopt a longitudinal and developmental framework (Sampson et al., 2008; Wodtke et al., 2011). Young children are probably unique in the vital role that housing can play because they spend much of their time in the home setting and are quite vulnerable to housing problems that raise parental distraction and distress. Toxic exposures that young children experience in the home, such as those resulting in lead poisoning, set the stage for future development. Numerous studies have suggested the deleterious effects of neighborhood socio-economic disadvantage on early development, but this research shows that the state of disrepair of families' housing units within neighborhoods are proximal influences that further hampers kindergarten readiness. It is important that future research pays closer attention to the role that housing quality and market conditions play in early childhood

development and investigates ways to prevent young children's prolonged exposure to deteriorated and unstable housing units.

The findings of this study are pertinent to stimulating policy discussions that fully connect housing and neighborhood conditions to the well-being of young children in urban areas. In particular, current policies that address housing market stabilization and housing quality do not take into account children's housing experiences in their investment strategies or allocation of resources. Similarly, policies directed at early childhood education and risk reduction do not incorporate neighborhood and housing conditions into their planning and implementation. Greater attention to the role of housing in educational success could lead to policies and programs to promote school readiness that involve school districts, municipal building and environmental health departments, early childhood programs, housing providers, and community development agencies. Residential instability, child maltreatment and elevated lead levels, which are exacerbated by housing problems, could be a target for early detection and prevention. Early care and education providers could potentially be a source of information to parents on the importance of housing quality and stability for their young children. Health and human service providers could also play a role in screening for housing problems and in referring at risk families for assistance.

Notes

[1] We evaluated the year that the housing unit was built as a possible indicator of housing quality for this study. However, year built was problematic for several reasons. Less than 5 percent of our study population lived in housing built since 1978 (the year that lead was removed from paint by federal statute), and the average housing unit was approximately 80 years old. Most of the newer housing that our population lived in was concentrated in just a few census tracts, and was often in public or subsidized housing buildings.

[2] Taxes in arrearage beyond a certain point may be sold off as tax lean certificates. At that point, the taxes show as paid on county records. We used an additional data set of tax lien foreclosure to identify these instances, and were able to fill in the quarters as still involving an owner who was delinquent on the taxes.

[3] Lead testing is typically done at ages 18 months through 3 years, a peak period for possible exposure because children are becoming mobile, touching many things in their environments and putting their fingers in their mouths. Children on Medicaid are required to be tested at 12 and 24 months. A minority of children are delayed in getting their screenings and are not tested until 4 or 5 years old. However, it is not possible to determine from the lead screening precisely when or where the exposure occurred. Nevertheless, it is most likely that it occurred during the peak period. Therefore, we organize our modeling to account for all of the housing and neighborhood exposures cumulatively to the 3rd year regardless of when the lead screening was completed. We made this choice to avoid erroneously attributing effects to housing conditions that occurred after children's lead levels were already elevated.

[4] We experimented with neighboring cut points and found very similar results in all cases.

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Table 1. Study Variables and Measures

Concepts	Measures (Unit)	Sources
Child characteristics		
Low birth weight	Less than 2500 grams (Yes=1)[a]	S
Gender	Female (Yes=1)	E1
Race/ethnicity	Reference (Yes=1, Non-Hispanic Black), Hispanic (Yes=1), Non-Hispanic Whites and Other (Yes=1)	E1
Age	Age at kindergarten (Month)	E1
Language	English as a second language (Yes=1)	E2
Disability	Early intervention status (Yes=1)	C1
Family characteristics		
Teen mother	Age below 18 at child birth (Yes=1)[a]	S
Mother's education	Mother has high school degree at child birth (Yes=1)[a]	S
Poverty status	Month in SNAP (Month)	C2
Neighborhood quality		
Concentrated disadvantage	Factor score of six items[b] (Rank, 0-100)	N
Housing characteristics		
Housing condition	Poor condition (Yes=1)	H1
Low market value	Market value below $30,000 adjusted inflation of 2010 (Yes=1)	H1
Public/subsidized housing	Public housing or project based Section 8 (Yes=1)	H4,H5
Housing market distress event		
Tax delinquent	Parcel with tax delinquency	H1
Foreclosure	Parcel in foreclosure	H2
Speculator owned	Parcel owned by speculator[c]	H3
Mediators		
Child maltreatment	Child neglect/abuse investigation (Yes=1)	C1
Residential instability	Number of address changes (Number)	E1,C1,C2
Elevated blood lead	Highest lead level in blood >5 μg/dL (Yes, No, and No test)[a]	S
Educational outcome		
Kindergarten Readiness	Kindergarten Readiness Assessment-Literacy score (0-29)	E1,E2

Sources
E1: Cleveland Metropolitan School District (CMSD)
E2: Ohio Educational Management Information System (EMIS)
C1: Cuyahoga County Department of Child and Family Services (CCDCFS)
C2: Cuyahoga County Job and Family Services (CCJFS)
S: Ohio Department of Health (ODH)[c]
H1: Cuyahoga County tax assessor H2: Cuyahoga County Sheriff's department
H3: Cuyahoga County recorder deed transfers H4: Cuyahoga Metropolitan Housing Authority (CMHA)
H5: Department of Housing and Urban Development (HUD)
N: 2000 Decennial Census and 2009 American Community Survey (ACS)-5 year estimates (www.census.gov)

[a] Birth (and/or Lead) data provided by Ohio Department of Health (This should not be considered an endorsement of this study or these conclusions by the ODH).

[b] Variables were interpolated between 2000 and 2010. Six items are comprise of individual poverty, unemployment, children, African-American, single-householder, and welfare receipt

[c] REO sales deeds applied text recognition to identify individuals, companies and LLCs with pattern of buying REO at low values including bulk and individual purchases.

REO (Real Estate Owned), SNAP (Supplemental Nutrition Assistance Program)

Table 2.A. Descriptive analysis of study variables

	Time Invariant	Time variant by age					
		0-1	1-2	2-3	3-4	4-5	5- K. entry
	M (SD) or %	M (SD) or %	M (SD) or %	M (SD) or %	M (SD) or %	M (SD) or %	M (SD) or %
Child characteristics							
Low birth weight (Yes=1)	12.3%						
Gender (Female=1)	49.5%						
Race/ethnicity (Reference=African American)	69.0%						
(Non-Hispanic White)	18.2%						
(Hispanic)	11.7%						
(Other)	1.1%						
Age at kindergarten (Months)	65.7 (3.9)						
English as a second language (Yes=1)	7.7%						
Disability (Yes=1)	10.9%						
Family characteristics							
Teen mother (Yes=1)	16.0%						
Mother has high school degree (Yes=1)	57.0%						
Family below poverty line (Yes=1)[a]		77.4%	76.9%	77.2%	77.8%	79.1%	78.9%
Neighborhood characteristics							
Concentrated disadvantage factor score (0-100)		74.3 (18.5)	74.6 (18.6)	74.5 (18.7)	74.3 (19.1)	74.0 (19.3)	73.9 (19.8)
Housing characteristics							
Poor condition housing (Yes=1)		22.5%	21.1%	18.7%	16.4%	14.4%	11.5%
Low value housing (<$30,000) (Yes=1)[b]		32.6%	31.2%	29.8%	29.9%	29.5%	32.0%
Public housing or project based Section 8 (Yes=1)		9.5%	10.0%	10.5%	10.6%	10.7%	9.7%
Housing market distress events							
Parcel with tax delinquency (Yes=1)		18.9%	15.6%	13.9%	13.0%	14.0%	10.1%
Parcel in foreclosure (Yes=1)		4.3%	6.1%	7.6%	7.9%	7.4%	5.3%
Parcel owned by speculator (Yes=1)		2.2%	3.2%	4.6%	6.3%	8.1%	8.1%
Any housing market distress events (Yes=1)		22.8%	21.3%	21.4%	22.0%	24.1%	19.7%
Buffer 500ft- Avg. number of parcels							
With tax delinquency		12.3 (9.7)	10.1 (7.8)	9.1 (6.9)	9.0 (7.0)	9.4 (7.2)	9.9 (7.9)
In foreclosure		2.4 (2.3)	3.3 (3.1)	4.0 (3.3)	4.1 (3.3)	3.8 (3.2)	3.4 (3.0)
Owned by speculator		1.0 (1.4)	1.5 (1.8)	2.1 (2.4)	2.9 (3.3)	3.8 (3.9)	4.5 (4.4)
Mediators							
Child neglect/abuse investigation (Yes=1)		13.7%	12.1%	13.5%	13.0%	12.1%	8.0%
Residential moves (Number)		0.5 (0.7)	0.5 (0.8)	0.5 (0.8)	0.5 (0.7)	0.5 (0.7)	0.2 (0.5)
Lead level in blood >5 µg/dL (Yes)	38.6%						
(No)	46.7%						
(Not tested)	14.8%						
Educational outcome: KRA-L score	15.8 (7.2)						

Note. N=13,758 (First imputation). [a]=Family below poverty line for at least halt the year, [b]=Inflation adjusted

Table 2.B. Descriptive Analysis of Average Exposure from Birth to Kindergarten Entry

	M	(SD)
Family characteristics		
Poverty (Share of time below poverty line)	0.75	(0.35)
Neighborhood quality- Share of years exposed to		
Concentrated disadvantage score above 70p	0.66	(0.41)
Housing characteristics -Share of years exposed to		
Poor condition housing	0.18	(0.29)
Low value housing (<$30,000 inflation adjusted)	0.31	(0.34)
Public housing or project based Section 8	0.10	(0.25)
Housing mkt distress- Share of years exposed to		
Parcel with tax delinquency	0.15	(0.23)
Parcel in foreclosure	0.07	(0.15)
Parcel owned by speculator	0.05	(0.15)
Buffer 500ft- Avg. number of parcels		
With tax delinquency	9.95	(6.30)
In foreclosure	3.51	(2.17)
Owned by speculator	2.46	(2.28)
Mediators		
Child neglect/abuse investigation (Share of years with investigation)	0.13	(0.19)
Residential moves (Average per year)	0.46	(0.42)
Lead level in blood >5 μg/dL	0.39	(0.49)

Note. N=13,758 (First imputation).

Table 3. Marginal Structural Models for the Relationship between KRA-L and Housing Conditions weighted by the Inverse Probability of Treatment

	I			II			III		
	b	*se*		*b*	*se*		*b*	*se*	
Child characteristics									
Low birth weight (Yes=1)	-0.72	0.21	***	-0.72	0.21	***	-0.74	0.21	***
Gender (Female=1)	1.60	0.12	***	1.59	0.12	***	1.58	0.12	***
Race/ethnicity (Reference=Non-Hispanic Black)									
(White)	-0.65	0.19	***	-0.65	0.19	***	-0.45	0.19	*
(Hispanic)	-2.28	0.27	***	-2.30	0.28	***	-2.29	0.28	***
(Other)	-0.13	0.63		-0.16	0.63		-0.15	0.62	
Age at kindergarten (Months)	0.27	0.02	***	0.26	0.02	***	0.26	0.02	***
English as a second language (Yes=1)	-2.42	0.32	***	-2.44	0.32	***	-2.57	0.32	***
Disability (Yes=1)	-2.47	0.21	***	-2.47	0.21	***	-2.28	0.21	***
Family characteristics									
Teen mother (Yes=1)	0.42	0.19	*	0.43	0.19	*	0.50	0.19	*
Mother has high school degree (Yes=1)	1.58	0.15	***	1.57	0.15	***	1.37	0.15	***
Poverty (Share of time below poverty line)	-1.90	0.19	***	-1.80	0.19	***	-1.41	0.22	***
Neighborhood quality- Share of years up to Kindergarten exposed to									
Concentrated disadvantage score above 70th p.	-0.71	0.20	***	-0.77	0.22	***	-0.74	0.22	***
Housing characteristics -Share of years up to Kindergarten entry exposed to									
Poor condition housing	-0.43	0.23	†	-0.34	0.24		-0.13	0.24	
Low value housing (<$30,000 inflation adjusted)	-0.13	0.20		-0.33	0.20		-0.25	0.20	
Public housing or project based Section 8				-0.17	0.29		-0.15	0.29	
Housing mkt distress- Share of years up to Kindergarten entry exposed to									
Parcel with tax delinquency				-0.78	0.28	**	-0.52	0.29	†
Parcel in foreclosure				-1.39	0.44	**	-1.01	0.44	*
Parcel owned by speculator				-1.54	0.39	***	-1.25	0.39	**
Buffer 500ft- Avg. number of parcels									
With tax delinquency				0.05	0.02	**	0.05	0.02	*
In foreclosure				-0.11	0.05	*	-0.11	0.05	*
Owned by speculator				0.02	0.05		0.03	0.05	
Mediators									
Child neglect/abuse investigation (share of years up to K. with investigation)							-2.21	0.34	***
Residential moves (average per year)							-0.45	0.17	*
Lead level in blood >5 µg/dL (Reference: Negative)									
(Positive)							-0.84	0.14	***
(Not tested)							-0.78	0.20	***
Intercept	-1.11	1.10		-0.63	1.11		-0.38	1.11	

Note $^{\dagger}p<.10$, $^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$. N=13,689 (Multiple imputation, m=30). All models included a dummy variable for the year of entry into kindergarten.

Table 4. The Relationship between Housing and Key Mediators

	Child maltreatment			Residential moves		
Fixed Effects Linear Probability Models- Full Panel	*b*	*se*		*b*	*se*	
Family characteristics						
Poverty (Share of year below poverty)	0.054	0.005	***	0.337	0.011	***
Neighborhood quality						
Concentrated disadvantage factor score (Rank 0-100)	0.002	0.004		-0.091	0.009	***
Housing characteristics						
Poor condition (Yes=1)	0.016	0.004	***	0.417	0.009	***
Low value housing (<$30,000 inflation adjusted)	-0.001	0.004		-0.092	0.007	***
Public housing or project based Section 8 (Yes=1)	0.017	0.007	*	0.292	0.013	***
Housing market distress events						
Parcel with tax delinquency (Yes=1)	0.010	0.004	*	0.249	0.008	***
Parcel in foreclosure (Yes=1)	0.025	0.005	***	0.241	0.011	***
Parcel owned by speculator (Yes=1)	0.007	0.006		0.401	0.013	***
Buffer 500ft- Avg. number of parcels						
With tax delinquency	0.000	0.000		0.000	0.001	
In foreclosure	0.001	0.000	**	0.007	0.001	***
Owned by speculator	-0.001	0.001	†	0.004	0.001	**
Intercept	0.090	0.007	***	0.106	0.012	***
Multinomial Lead Model -Inverse Probability Weighted Exposure						
Dependent variable values: Tested Positive, Negative, Not Tested						
Margins for probability of testing positive	*dy/dx*	*se*				
Child characteristics						
Low birth weight (Yes=1)	-0.045	0.014	***			
Gender (Female=1)	-0.022	0.008	**			
Race/ethnicity (Reference=Non-Hispanic Black)						
(White)	-0.010	0.012				
(Hispanic)	-0.035	0.018	*			
(Other)	-0.053	0.044				
English as a second language (Yes=1)	-0.038	0.021	†			
Disability (Yes=1)	0.051	0.013	***			
Family characteristics						
Teen mother (Yes=1)	0.004	0.012				
Mother has high school degree (Yes=1)	-0.070	0.009	***			
Poverty (Share of years below poverty line up to age 3)	0.204	0.012	***			
Neighborhood quality-Share of years up to age 3 exposed to						
Concentrated disadvantage score above 70th p.	0.086	0.013	***			
Housing characteristics - Share of years up to age 3 exposed to						
Poor condition housing	0.038	0.012	**			
Low value housing (<$30,000 inflation adjusted)	0.054	0.011	***			
Public housing or project based Section 8	-0.008	0.017				
Housing mkt distress -Share of years up to age 3 exposed to						
Parcel with tax delinquency	0.057	0.014	***			
Parcel in foreclosure	0.051	0.024	*			
Parcel owned by speculator	0.046	0.027	†			
Buffer 500ft- Avg. number of parcels						
With tax delinquency	0.003	0.001	***			
In foreclosure	0.010	0.003	**			
Owned by speculator	0.000	0.004				

Note. $^{\dagger}p<.10$, $^{*}p<.05$, $^{**}p< .01$, $^{***}p<.001$. N=13,758 children over all periods for child maltreatment and residential moves panel models. N=13,681 children for lead model (Multiple imputation, m=30). Fixed effects models include an age variable; lead model controls for year of birth.

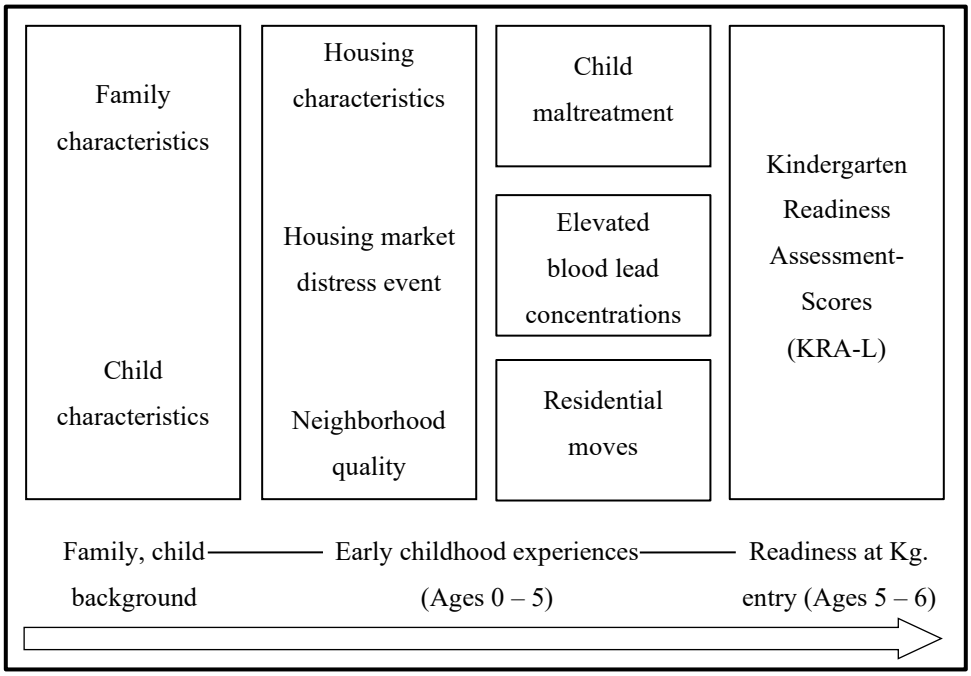

Figure 1. Hypothesized relationships between housing, mediators and kindergarten readiness.

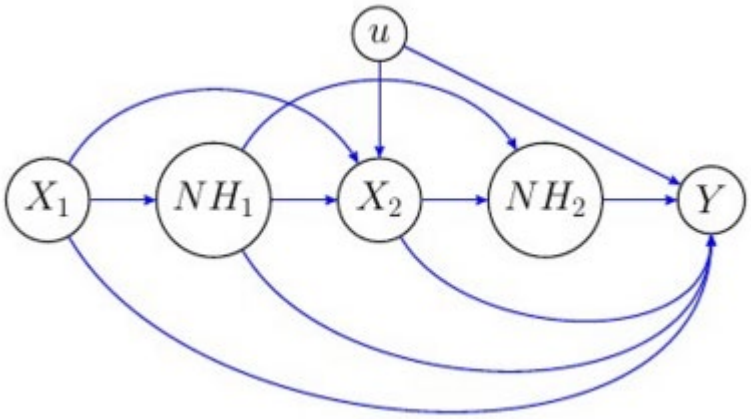

Figure 2. A two-period model of the effect of housing and neighborhood distress on Kindergarten test scores. Past housing and neighborhood exposure (NH_1) influences future exposure (NH_2) and test score outcome (Y). Covariates included in X are exposure to lead, mobility rate, being victim of neglect or maltreatment. *u* presents unobserved characteristics that influence covariates and the outcome. Time invariant characteristics such as gender, race, mother's education at birth of child and being born at low birth weight are also included as covariates.

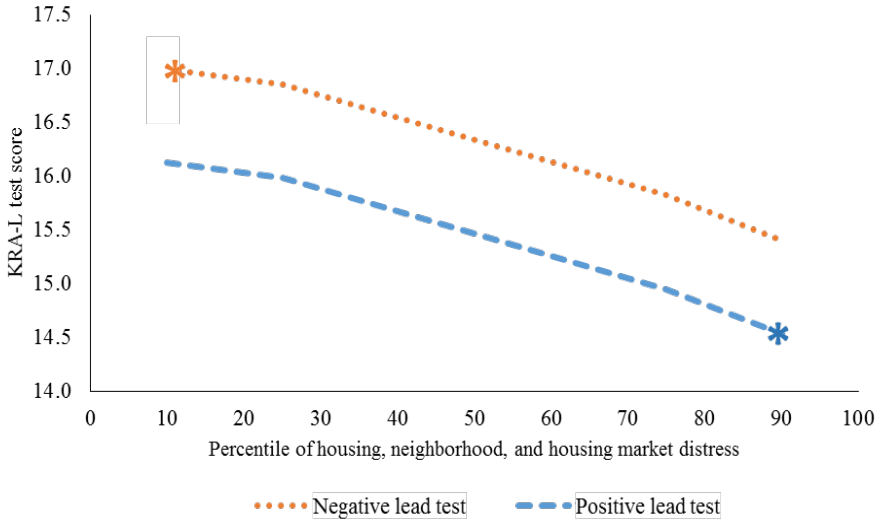

Figure 3. Average predicted test scores for levels of housing and neighborhood distress.