FINAL REPORT

Leveraging Integrated Data Systems to Examine the Effect of Housing and Neighborhood Conditions on Kindergarten Readiness

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Abstract

In many big cities, substantial numbers of children enter kindergarten already well behind in their cognitive and social development, presenting a major challenge for public education systems. 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 in children's own homes and the immediately surrounding areas factor into their school readiness. Drawing on two Integrated Data Systems (IDSs), this longitudinal, population-based study examines the influence of 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 mediated by child maltreatment incidences, residential instability, and elevated blood lead levels. Communities are advised to pay more attention to distressed housing as a cause of disparities in early child development and school readiness. IDSs that incorporate detailed housing and property information, especially for the youngest children, can be used to target areas where there is elevated risk and coordinate local efforts to prevent the adverse effects of distressed housing stock on early child development.

Leveraging Integrated Data Systems (IDS) to Examine the Effect of Housing and Neighborhood Conditions on Kindergarten Readiness

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, which draws on Integrated Data System (IDS) covering children and properties, has two main purposes: (1) To examine the influence of early childhood housing conditions on school readiness for all children entering kindergarten over a four year period in a big city school system (Cleveland OH), and (2) To demonstrate the cost-effectiveness of using IDSs that link administrative data on both individual children and residential properties to investigate housing and early childhood policy concerns.

The focus of this study on 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 in low-income households and children growing up in poor neighborhoods experience these negative conditions at higher rates compared to children from more affluent circumstances, which contributes to well-documented disparities in educational outcomes. However, little is known specifically about how housing conditions and risks during the pre-school years affect students' abilities as they enter kindergarten. Particularly for school systems that have large numbers of disadvantaged students, this type of information could be useful in educational planning for children entering kindergarten and for shaping public policies that incorporate housing and

neighborhood stabilization strategies into efforts to improve the educational success of children in urban areas.

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). A limitation of federal housing policy in the US is that it mainly focuses on broad principles of home ownership and housing affordability, while problems with housing deterioration fall primarily on local governments with insufficient resources to enforce housing codes or assist with repairs and renovations. However, recent research has called into question whether homeownership and affordability *per se* have positive effects on child development outcomes over and above factors responsible for selection (Barker & Miller, 2009; Holupka & Newman, 2012). However, for policies at the intersection of housing, urban development and education, it is vital to understand how a broad range of housing characteristics and market conditions in the areas surrounding their residential locations influence children's experiences and cognitive development.

In addition to its substance, the unique methods of this study are important because they begin to overcome a limitation of research that is sample-based rather than population-based. National samples do not allow a full evaluation of housing influences *in situ,* yet the reality of the housing experience for families and children is not restricted to the families' residence but also the nearby houses and attributes of the surrounding neighborhood. The importance that housing has for the well-being of young children is difficult to quantify based on studies of samples where the population is statistical rather than real. This study includes complete coverage of public school kindergartners and properties in an entire city, yielding a fuller picture of housing influences within that context. This longitudinal structure of the research allows us to model and account for time-varying housing and neighborhood conditions, reducing bias in our estimates of housing effects.

Finally, this project demonstrates how a method to overcome the strictures of policy data silos can inform policymaking. Much of the published research on the effects of housing policy on children is based on longitudinal household surveys that have limited housing information or studies of housing program participants that leave out unsubsidized households (Newman, 2008). Recently, though, there is growing interest in the role that the analysis of linked administrative records can play in exploring solutions to complicated problems such as those related to housing and educational disparities. States have made considerable progress establishing longitudinal data systems that include records of K-12 schooling. Some human service departments have built IDSs linking records across child welfare, public assistance, homeless services and juvenile justice agencies (Fantuzzo, Culhane, Rouse, & Henderson, 2015). Linked data from these systems have strong potential to answer policy questions, but existing IDSs generally lack detailed information on housing. This project is among the first to link records from fully functioning child and property level IDSs to conduct policy relevant research.

BACKGROUND AND LITERATURE REVIEW

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 IDS data on children and properties. First, we discuss the mechanisms through which housing experience may affect children's school readiness. Second, we touch on the some of the macro and market forces that have contributed to housing problems and the unequal structure of housing opportunities within urban areas.

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 the home and neighborhood environments (Duncan & Magnuson, 2011; Shonkoff & Phillips, 2000). Children exposed to adverse circumstances in their early years often experience delays on a number of abilities that contribute to academic achievement (Sampson,

Sharkey, & Raudenbush, 2008), and these disadvantages tend to persist throughout their schooling and into adulthood (Duncan, Magnuson, Kalil, & Ziol-Guest, 2012). 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 (proximal influences) and surrounding properties (distal influences) to early education success: family stress, residential instability, and toxic environmental exposures.

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 property 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). In one of the few studies to focus on housing of young children, Coley, Leventhal, Lynch and Kull (2013) found that poor housing quality contributed to children's behavioral problems, in large part due to its impact on mother's psychological distress.

Using a randomized design, the Moving to Opportunity (MTO) experiment attempted to study the effects of the living environment on important family outcomes. MTO families that received vouchers to move from public housing to low poverty neighborhoods expressed, on average, increased satisfaction with their housing and also showed improvement on mental health measures (Gennetian et al., 2012; Orr et al., 2003). More recently, Chetty, Hendren and Katz (2015) found that children under the age of 13, whose families were randomly assigned housing vouchers through MTO, now in their mid-twenties, earned significantly higher incomes and had higher rates of college attendance and marriage compared to those who did not receive a voucher. Furthermore, despite the fact that previous studies found no short-term labor market effects of the MTO program, two recent studies find significant neighborhood effects from MTO on outcomes such as labor force participation and employment (Aliprantis & Richter, 2015;

Pinto, 2015). However, the MTO experiment could not isolate the causal effect of housing quality improvements from the voucher-related relocation to a low poverty neighborhood. Additionally, because most MTO families used housing subsidies, their units had to pass housing inspections that reduced their exposure to severely dilapidated and hazardous structures that often plague non-subsidized, low-income households.

Child maltreatment is potentially an indicator of extreme parenting failure and 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).

Residential instability

Another pathway through which housing problems can affect early learning outcomes is the disruptions associated with frequent moves. Though evidence seems to suggest that residential movement *per se* is not harmful once 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). One of the few studies that focused specifically on early childhood found residential instability to be inversely associated with cognitive and social development at age 5, particularly for children in low-income families (Ziol-Guest & McKenna, 2014). Additionally, residential instability in the early years has been shown to have 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, research shows that 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,

many families report that harmful housing conditions such as mold, lack of heat, crumbling walls, leaks, electrical problems, and vermin, were reasons for relocating in a qualitative study of low-income movers (DeLuca, Rosenblatt, & Wood, 2011).

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 (Evans, 2006). The negative effects of lead exposure on early cognitive development are well established, and studies show that young children with elevated blood lead levels score lower on school readiness and developmental assessments (Dilworth-Bart & Moore, 2000; Krieger & Higgins, 2002; Lanphear et al., 2005). Although lead paint particles and dust in and around the home are a major source of lead exposure, less is known about how the risk of lead exposure relates to housing and neighborhood conditions more broadly. However, one study along these lines found that low-income children living in private market housing that was old and dilapidated had elevated blood lead levels at a significantly higher rate than children that lived in public housing (Clark et al., 1985). 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).

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 structure this imposes on their experience in a cumulative fashion. In many metropolitan areas, persistent lines of race and class structure these niches (Sharkey, 2013) and the market forces that accordingly have unequal impact on the lives of households. In recent years, working class and minority neighborhoods in big cities have been at the epicenter of the foreclosure and vacancy crisis. Studies show that patterns of racial segregation have contributed to the high rates of subprime lending (Hyra, Squires, Renner, &

Kirk, 2013) and foreclosure (Rugh & Massey, 2010) in many metropolitan areas. The impact of the so-called mortgage crisis has been greatest on those minority households, housing units, and neighborhoods 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. However, one study in New York City found that children in foreclosed housing units switched schools more frequently than their peers, perhaps due to the residential instability family stress that ensued (Been, Ellen, Schwartz, Stiefel, & Weinstein, 2011). Additionally, a Wisconsin study reported that children in foreclosed homes were more likely to experience child maltreatment (Berger et al., 2015). Beyond their own households, there is reason to believe that neighborhood properties that become vacant and blighted following foreclosure may negatively affect children (Immergluck, 2012). Cumulatively, these distressed properties have spillover effects and result in loss of housing value and personal assets for many households within the hard hit niches (Immergluck & Smith, 2005a, 2005b, 2006). In the wake of foreclosure crisis are also 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 low housing quality and instability along with the possibility of environmental hazards from the surrounding blight. These conditions correlate negatively with early child development at the neighborhood level (Kohen, Leventhal, Dahinten, & McIntosh, 2008), although the effects on children who live in these homes have yet to be fully explored.

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 loss of assets due to 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 CURRENT STUDY

The current study follows several cohorts of children from birth through kindergarten and includes a nearly continuous record of housing experiences along with markers for possible mediators of housing problems such as family stress, residential instability, and environmental exposures. It overcomes several limitations of previous research. First, few 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.

Second, research on housing and child development suffers from limitations in the measurement of housing. A review of early childhood studies concludes that most focus narrowly on only a few aspects of the housing context, such as neighborhood poverty rates or income levels, and make suppositions about housing problems or conditions in relation to income (Nettles, Caughy, & O'Campo, 2008). Those studies that do include housing variables have tended to focus on residential tenure or structure rather than directly measuring housing conditions. Studies that have gathered housing quality information often suffer from common methods variance because they rely on self-reports of housing perceptions provided by the same individuals that self-report on parenting behaviors or child outcomes (Evans, Wells, & Moch, 2003). In a critical summary of research on how housing matters for poor families, Newman calls inadequate housing measures the "elephant in the room" (Newman, 2008, p. 917). She also notes that research has not explored how the duration of housing problems affects outcomes, a question of particular relevance for the developing child. This study overcomes these limitations by using administrative records data to capture multiple measures of housing conditions for all the children's residential addresses over time. Thus, it avoids the problem of common methods variance and takes into account the duration of exposure on a number of dimensions of the housing experience.

Third, there is a disconnection in the literature between macro-structural and market influences and housing as experienced by families and children, even though the conceptual framework discussed earlier articulates their importance. When studies do include a broader

context, it is typically represented by a limited set of static variables (e.g., home ownership rates) for fixed geographic units such as census tracts. Yet, housing markets are dynamic and operate at various geographies that cannot be assumed to follow fixed boundaries (Koschinsky, 2009). This study does not rely on fixed units of geography or estimates from a single point-in-time. Instead, we evaluate measures of quarterly housing market distress at various distances from children's homes to see where points of influence peak or recede.

Fourth, limitations on research design have made it difficult to examine the influence of a full range of housing experiences on young children. Analyses from national surveys face the problem of selection bias, because it is difficult to control for all of the factors that may predispose households to their housing experiences. Experimental studies, the most rigorous design for establishing causality, have been limited to housing program participants who volunteer for random assignment with the possibility that they will be relocated and do not adequately represent the large population of households that do not receive housing assistance. Acknowledging the limits of both national surveys and mobility experiments, DeLuca and Dayton (2009, p. 481) argue that one way to gain deeper understanding of selection into housing and neighborhoods and to model impact is "to conduct single-city panel studies, because these studies reduce heterogeneity and control for some hidden bias." Similarly, Newman (2008, p. 901), calls for "rich geocoded longitudinal data with solid measures of poverty, disadvantage and health as well as housing". This study combines the advantages cited in both of these review articles. It draws on a rich and detailed, geocoded, longitudinal data base containing information on family background, maternal and child health, residential locations, a number of housing measures and school readiness assessments for all children entering kindergarten in a large city over a four-year period. The analysis estimates the effects of time-varying neighborhood and housing exposures through marginal structural models (Robins, 2000) that account for dynamic selection of housing and neighborhoods from birth until kindergarten entry.

Conceptual model and hypotheses

This study takes a longitudinal perspective on housing and neighborhood context over the period of early childhood from birth to kindergarten. As diagramed in Figure 1, the premise is that family background factors play a role in housing and neighborhood selection and, along with children's risk factors, contribute to school readiness. Exposure to poor housing conditions and

housing market problems beginning at birth, along with neighborhood disadvantage, can undermine school readiness when children enter kindergarten. Housing problems also increase the risk of child maltreatment, residential instability and elevated blood lead levels, which are additional factors that undermine kindergarten readiness scores.

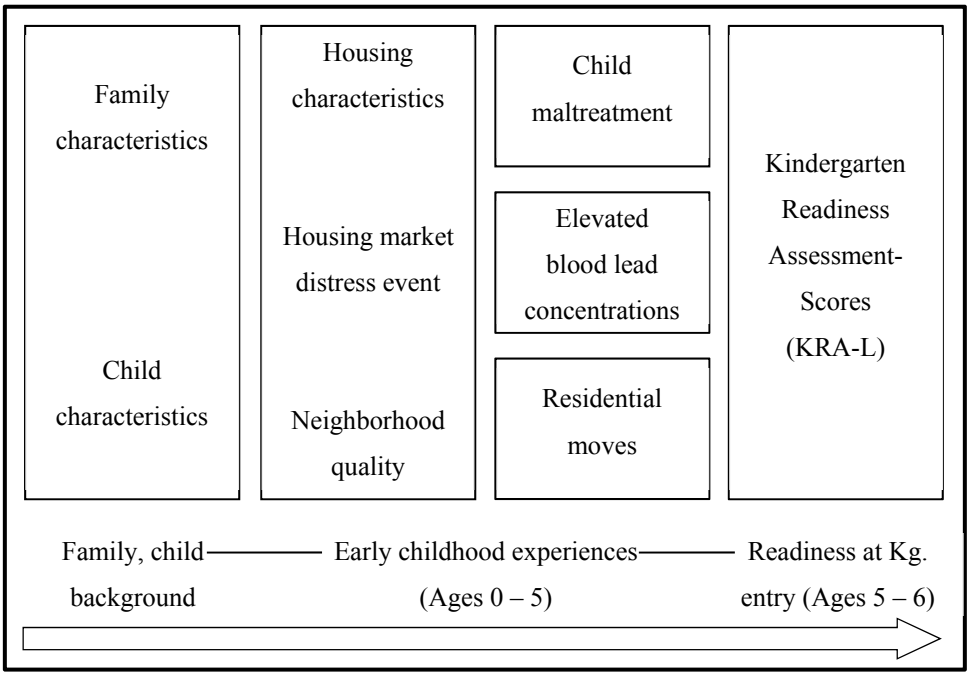

Figure 1. Hypothesized relationships between housing, mediators and kindergarten readiness.

Figure 1 presents a static version of the hypothesized relationships between housing and kindergarten readiness. In the methods section, we use a Directed Acyclic Graph (DAG) (Figure 2) to illustrate a simplified version of the dynamic mechanism by which neighborhoods and housing may affect school readiness. 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 methods developed by Robins et al. (2000) to reduce the bias from time-varying confounders. These dynamic selection methods have been widely used to estimate time-varying effects of neighborhoods on educational outcomes (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 related contributors to lack of kindergarten readiness that is observed during the study time period. Third, child maltreatment incidents, residential instability and lead poisoning are negatively associated with school readiness. Fourth, problematic housing conditions and housing market distress are positively associated with the likelihood of child maltreatment, residential instability and lead poisoning in the early childhood period.

METHODS

Study population and design

This is a longitudinal study of 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). This population was followed from birth through kindergarten entry utilizing administrative records data from two IDSs further described below. We compiled monthly address histories for the children in the study from a combination of these administrative records, which allowed for the assessment of the timing and duration of numerous measures related to their housing 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.

Data sources and measures

This study draws on two relatively unique data resources for Cleveland and Cuyahoga County 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 public health, public assistance and social services agencies, early childhood programs and K-12 education. This system contains records from these agencies that are linked together through probabilistic matching techniques and made available in de-identified data sets for approved research (Lalich, Anthony, Richter, Coulton, & Fischer, 2015). Importantly for this study, all residential addresses

from the agency records are stored and date stamped. This enables tracking residential mobility and the creation of spells for each residential location. 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 in the county, 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.

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 (on the next page).

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 indicators of residence		
Year built	Built before 1978 (Yes=1)	H1
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		
Literacy development	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)

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).

Family background characteristics appear in the second section of Table 1. We determine the mother's age and education at the time of birth from the child's birth certificate. The family's low-income 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. A limitation of this measure is that some low-income families may not apply for benefits, and would not be included in this administrative data set.

Housing and neighborhood measures

Children's housing experiences are determined monthly based on their residential addresses. The housing measures are divided two groups: Indicators of housing conditions and markers of housing market distress. The first indicator under housing conditions is a rating of the condition of the housing unit provided by the county tax assessor. We classify housing units that are rated as poor, very poor or unsound as being in bad 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 values, 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 are inspected on a regular schedule, are required to meet specified standards and 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. A limitation of our foreclosure records is that we cannot tell whether a member of our study child's household was the homeowner or whether the family was renting the housing unit during their occupancy period. Nevertheless, the foreclosure process can cause distress to the occupants of the home due to the uncertainty that is engendered and the fact that the occupants may face a residential move that is unplanned. Additionally, foreclosures in rental units may be markers for disinvestment by the landlord. Another sign of housing distress is when a housing unit passes into the hands of 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] In order to capture market destabilization in the context surrounding children's houses, we calculate the number of foreclosed, speculator-owned and tax delinquent properties within 500, 1000 and 1500 foot buffers surrounding the houses ever occupied by a child in the study.

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 *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). The results of the factor analysis appear in Appendix 1.

Potential mediators

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 serious enough to result in acceptance it 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).

Kindergarten 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) and implemented in public school districts beginning in 2004, 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, maintain individual score sheets with the child's records, and report individual student composite scores for KRA-L via the Educational Management Information System (ODE, 2009). This assessment not only evaluates skill areas important to becoming a successful reader but also helps teachers plan for lessons that encourage reading (ODE, 2009). 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.

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. We begin with a descriptive analysis of how families and children in this population change over time in their exposure to housing and neighborhoods conditions. We follow this with a series of statistical models of the effects of housing and neighborhood conditions on kindergarten readiness that take advantage of the longitudinal design in an effort to account for dynamic selection to the extent possible.

Housing and neighborhood trajectories

To provide a description of the trajectories of children across the various levels of housing and neighborhood conditions, we use the group-based statistical methodology developed by Nagin (2010). Group-based trajectory models are a special type of finite mixture models that assume that individual differences in trajectories can be summarized by a finite set of polynomial functions of developmental age. The parameters of these polynomials, as well as each child's probabilities of membership to each group, are estimated via maximum likelihood. Thus, the shape of each group's trajectory (subject to model specification) and the proportion of children comprising each group are estimates of interest derived from this methodology. We present group trajectory estimates for exposure to neighborhood quality measured on a scale of 0 to 100. We also estimate group trajectories for exposure to two binary variables characterizing housing quality: being in a house deemed in poor condition, being in a low value house (below $30, 0000 per-unit assessed value).

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. Under these assumptions, we describe the model we plan to estimate using the DAG shown in Figure 2. DAGs are commonly used to represent causal relations among variables via directed arrows between nodes 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.

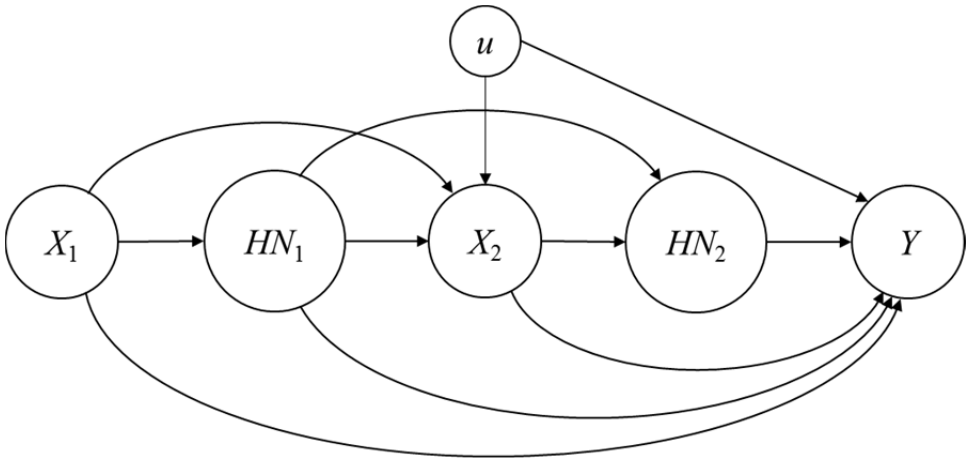

Figure 2. A two-period model of the effect of housing and neighborhood distress on Kindergarten test scores. Past housing and neighborhood exposure (HN_1) influences future exposure (HN_2) and test score outcome (Y). Covariates included in X are exposure to lead, mobility rate, being victim of neglect 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.

In Figure 2, we denote housing and neighborhood exposure at year t by HN_t, covariates by X_t, 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, past residential mobility and being victim of child maltreatment. These covariates influence all housing and neighborhood choices HN_1, and HN_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 HN_1 on Y but confounds the relation between HN_2 and Y. Controlling for X_2 to handle confounding will block the indirect path through which HN_1 affects Y and so we are unable to estimate the full effect of HN 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.

A Marginal Structural Model of housing and neighborhood effects on school readiness

We proceed to define treatment as a multilevel variable reflecting neighborhood and housing conditions. Specifically, neighborhoods are classified into two levels: being above or below the 70th percentile of neighborhood disadvantage within the entire county. Housing is classified into three categories: (1) being deemed in bad condition, (2) not deemed in bad condition but having very low value, or (3) not deemed in bad condition and not having a very low value. This classification defines six categories of neighborhood and housing conditions that we denote by HN_{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 bad condition and another 18% were not deemed to be in bad condition but were of very low value.

Following Wodtke et al. (2011), we define the average causal effect on test scores 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 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.

Model specification

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

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

HN_{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

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

T_{it}: dummies for time period and kindergarten entry cohort

We present estimates of this model for the first imputation in Appendix 2.

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 model (2).

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

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 model (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:

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

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

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.

Models of the direct effect of housing on child maltreatment, residential mobility, and lead poisoning

We are also interested in understanding the effects of housing and neighborhood conditions on the potential mediators of child maltreatment, residential instability and elevated blood lead levels. For the time-varying 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 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. So 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.

For the outcome of lead, we cannot rely on fixed effects because 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 through 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).

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.

RESULTS

Descriptive findings on study variables

The descriptive statistics for the study variables are provided in Table 2. Section A (on the next page) 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.

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 a special need 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. Their housing is uniformly old, with almost all of the housing units built before 1978, the year that lead was removed from paint via federal mandate. The incidence of living in houses that are in very bad 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.

Table 2.A. Descriptive Analysis

	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							
Built before 1978 (Yes=1)		96.9%	96.4%	95.9%	95.1%	94.7%	94.4%
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).

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, with the rate being 9.4 victims per 1,000 children (US Department of Health and Human Services, 2014). On average, study children move about once every two years. Almost 40 percent of the children have at least one elevated blood level tests 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) that is considered not in need of special attention.

Children's trajectories on housing conditions and neighborhood disadvantage

The above descriptors of housing and neighborhoods where children live provide a static cross-sectional description of children in our study. However, this study is interested in the dynamic and cumulative aspects of children's exposure to housing and neighborhoods. There are

two main sources of housing and neighborhood dynamics. First, many households relocate each year, and some will move to better or worse neighborhoods or houses compared to the prior period. Second, neighborhoods and housing conditions can improve or worsen over time so even non-movers might be exposed to changes in their environment over time. However, changes in neighborhoods and housing stock generally occur slowly, although conditions may deteriorate more rapidly in a housing market crisis such as the one during this study period.

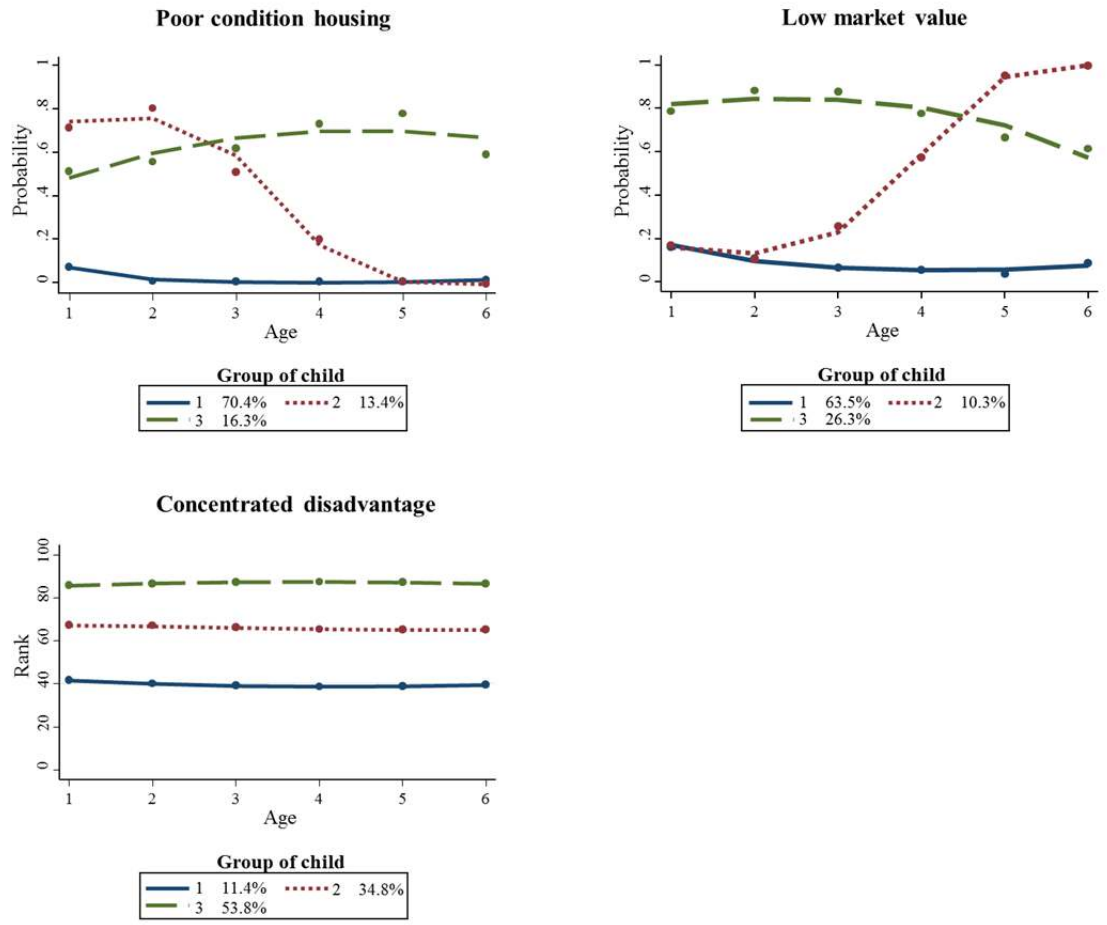

Figure 3. Housing and neighborhood trajectories: Birth to Kindergarten.

In this section, we present the results of a trajectory analysis of the housing and neighborhood conditions that we use in our dynamic selection model. The analysis identifies unique patterns of change over time and provides estimates of the proportions of children whose housing and neighborhood quality trends follow each of the identified patterns. The results are displayed in Figure 3. The first graph shows trajectories on exposure to neighborhoods with extreme disadvantage. The large majority of children remain in extremely disadvantaged

neighborhoods their entire early childhood. There is a much smaller group that consistently does not experience extreme disadvantage. It is relatively uncommon for children that begin life in extremely disadvantaged neighborhoods to escape them during their pre-school years. When it comes to housing, however, children's trajectories are more likely to change over time. About 14% of children that start with high levels of exposure to housing deemed to be in bad conditions, end up moving to higher quality housing. On the other hand, when identifying groups by their trajectories regarding exposure to low-value housing, we find that about 10% of children go from little to almost full exposure to this housing. It is important to note that most of the children in the population do not fall into the group that sees an improvement in their housing conditions, but rather, experience constant levels of exposure to good or bad condition housing.

Kindergarten readiness: Cumulative effects of housing, neighborhood and other risk factors

In this section, we examine the dynamic effects of housing and neighborhood conditions on Kindergarten readiness (KRA-L). Table 3 (on the next page) presents 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.

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 †*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.

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 would 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 moms only applies when mothers are not high school graduates. In such circumstances, these young, uneducated mothers 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 bad 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 a speculator 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.

Child maltreatment, residential mobility and elevated blood lead levels: Effects of housing and neighborhood

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. In all three models, we adopt methods to 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.

The top section of Table 4 (on the next page) 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 bad 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.

Table 4. The Relationship between Housing and Key Mediators

Fixed Effects Linear Probability Models- Full Panel	Child maltreatment			Residential moves		
	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			
Marginal effects 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. †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.

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. 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 market distress such as tax delinquency, foreclosure and speculator owned houses, both for the housing unit and for the surrounding properties, increases rates of lead poisoning.

DISCUSSION

Summary and discussion of findings

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.

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, and a large majority of the children lives 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, a trajectory analysis showed that most of them tended to move within the same quality of houses and neighborhoods. Several other studies also have shown this pattern of the overall stickiness of poverty status at both the neighborhood (Sharkey, 2013) and housing unit (Theodos, Coulton, & Pitingolo, 2015) levels. This may be due to the fact that low income families with children typically move in reaction to circumstances, and strategic moves to better housing units and neighborhoods are much less common (Coulton et al., 2012). Moreover, this study followed families for only about 5 years, but neighborhoods change slowly and rental-housing units are seldom upgraded appreciably when they are occupied. Thus, it is not surprising that those who did not move also experienced little change in the measures of housing and neighborhood quality over time. Nevertheless, we did identify a small group of families that displayed a positive trajectory suggesting that their housing, more than their neighborhood conditions, improved over the entire pre-school period.

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 linear 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, also had negative effects on kindergarten readiness scores. Moreover, we identified some spillover effects from nearby distressed properties on children's kindergarten readiness. Two of our housing quality measures,

bad condition rating and low market value, became insignificant in some models that included housing market stress events. We suspect that these former metrics, which are updated only periodically, may be less sensitive to the rapidly changing conditions of properties during housing market crises. Finally, the incidences of child maltreatment, residential mobility and lead poisoning all had negative effects on KRA-L scores, 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 bad housing conditions were accounted for, African American children scored slightly higher than white children. 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 lived with extended family and had better access to services and supports that were not measured in this study.

We also evaluated the impact of housing and neighborhood conditions on several known risk factors for poor school readiness scores 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 bad 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). We also found that living in housing that was of low market value or in a neighborhood of concentrated disadvantage lowered mobility rates. Affordable rents tend to be found in buildings with low market value in disadvantaged neighborhoods. Given that most of the families in our study population were low income but living 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 market distress, 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 the neighborhood and housing context that have measureable impacts on kindergarten readiness scores and other early childhood risk factors that are important to child development. 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 provide average predicted test scores for various levels of housing and neighborhood distress with all other variables held constant at their mean. We present these estimates in Figure 4 (on the next page), for children with and without lead poisoning. Children with elevated blood lead levels score lower on KRA-L than other children within each level of housing and neighborhood disadvantage. But we have already seen that children living with in poor housing and neighborhood conditions are almost twice as likely to have elevated lead levels. As can also be seen in Figure 4, in the points designated by an asterisk (*), children with the highest exposure to

bad 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 KRA-L scores for this poor population at varying levels of housing distress.

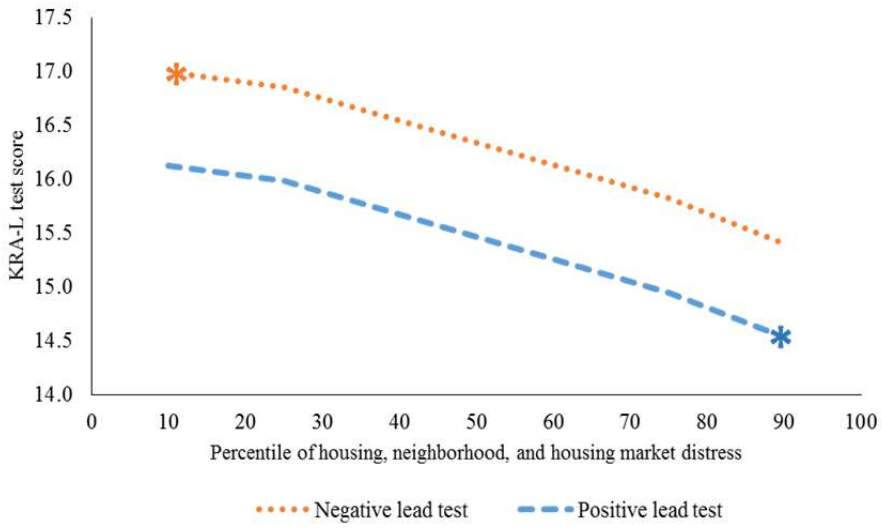

Figure 4. Average predicted test scores for levels of housing and neighborhood distress.

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. Moreover, our trajectories inform us that only a minority of children change the quality of their housing and neighborhoods over time. 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 entire student body in this district qualifies for free and reduced price lunch and the housing and neighborhoods occupied by the most advantaged students' families are relatively affordable compared to the region.

Limitations

This study has several limitations. 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 relied on administrative records data. This 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. Conditions such as plumbing problems, internal leaks, paint and plaster deterioration, and electrical problems, which can be highly stressful and detrimental to child health, would only be indirectly reflected in property records data, potentially with a considerable lag. We believe that our markers of housing market events, such as foreclosure and tax delinquency, are probably picking up some unmeasured deterioration in housing quality that happens quickly when houses go vacant, especially in weak market areas.

Third, several of our key outcome variables have limitations. The KRA-L test is a measure of kindergarten readiness related to literacy skills. There are other aspects of 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. Moreover, 15 percent of children in the study did not have any lead test results in the data. Finally, our measure of child maltreatment is based on cases that are reported to the authorities and screened-in for investigation. 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 threats. The ideal would have been to randomly assign families to the full range of housing and neighborhood conditions available to this population and then observe the effects on outcomes. However, even with initial random assignment, subsequent moves would introduce selection 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 conditions.[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.

Conclusions

This study demonstrates that housing quality and market distress can be important factors in understanding the ecological context for early educational success. The first several years of life are particularly crucial for human development (Heckman, 2006) so it is essential to deepen our understanding of the particular aspects of the residential milieu that may be important. 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. By looking at a continuous record of neighborhood and housing exposure, month-by-month during the pre-school years, this study addresses a need that has been identified in the literature for studies that adopt a longitudinal and developmental framework (Sampson et al., 2008; Wodtke et al., 2011).

Numerous studies have suggested the deleterious effects of neighborhood socio-economic disadvantage on early development, but this research shows that the state of repair of families' housing units within neighborhoods are a proximal influence that further contributes to kindergarten readiness. We also demonstrate that housing market forces play a role in

exacerbating housing problems and their effects on children, and that there are spillover effects of housing disinvestment in the immediate area to children in nearby properties. 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.

An additional conclusion of this study is that IDSs that incorporate detailed information on children and on the conditions of the properties that they live in can be useful for research at a population scale. An advantage of such studies is that they enable longitudinal analysis at relatively low cost and provide a continuous capture of housing information. They also provide a platform for local action to address concerns raised by the studies. For example, the problematic properties and exposures identified in the research can be monitored in the population using the same IDS. Practical solutions can be pilot tested and rigorously evaluated against events and outcomes captured in the IDS, thereby going further to cement the connection between research findings and their strategic application.

IMPLICATIONS FOR PRACTICE AND POLICY

This study focused on the nexus between housing circumstances, early childhood development, and kindergarten readiness. A major contribution is the articulation of the magnitude and existing patterns of housing problems among young children as it relates to their school readiness. Housing and neighborhood quality are inextricably linked through market dynamics, public and private investment decisions and residential selection, arguably structured along race and class lines. These forces have resulted in profound place-based patterns of inequality, such as those seen in big city school systems where many children enter kindergarten at an educational disadvantage. Yet across housing niches, properties vary in quality and distress and these housing experiences affect children's health and development as well.

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.

The research identifies key intervening events, which play a part in the process and could be the target of prevention. Residential instability, child maltreatment and elevated lead levels are exacerbated by housing problems and undermine early educational success. Since the early childhood period is the locus of the intervening events in question, 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 care providers could also play a role. For example, Simpson and Fowler (1994) showed children who move frequently have a number of poorer outcomes including academic performance, so they urge pediatricians to pay special attention to these children. Child welfare agencies also need to carefully evaluate the housing problems facing families that come to their attention and expand their partnerships with housing agencies to prevent housing instability and exposure of young children to deleterious conditions.

The practical application of the proposed study extends to how school districts prepare for students who are entering their system. For school systems that have large numbers of disadvantaged students, this type of housing information could be useful in educational planning for children coming into kindergarten. Though districts often have clear strategies for dealing with homeless children and families, they have less systematic approaches to addressing the needs of children with vulnerable housing experiences.

The study suggests that place-based initiatives need to pay more attention to the value of reliable, high quality, housing experiences for early childhood well-being and early educational outcomes. There is a need for closer coordination between agencies engaged in housing development and those serving families with young children. This could translate into practical implications regarding the site selection and marketing of new housing developments with greater connection to existing early childhood services and primary school catchment areas. Moreover, planners and implementers of place-based initiatives can be alerted to the importance of addressing housing instability and distressed properties in their neighborhoods.

Another practical outcome of this study is a demonstration of the contribution that IDSs, which cross silos of housing, human services and education, can make to serving populations in a region. Because IDSs rely on the linkage and aggregation of data collected for other purposes, they have the potential to provide information for data-driven initiatives at a lower cost than relying on original data collection. A growing number of practitioners are interested in the promise of integrated data as evidenced by the work of the Actionable Intelligence for Social Policy network and this study provides an example of what can be learned from these systems when they incorporate detailed housing information.

This study has implications for several specific areas of policy debate. First, many cities are still struggling to deal with distressed properties in neighborhoods that were hard hit by the foreclosure crisis. However, the current debates about deployment of resources for blight removal and revitalization focus mainly on how they can be used to achieve market stabilization. Evidence that foreclosed, vacant and abandoned properties have negative effects on young children adds an additional urgency to that debate. Additionally, this study underlines the importance for young children of programs that provide funding for addressing vacant, foreclosed and dilapidated housing. Reductions in these programs in recent years have limited cities' abilities to carry out code enforcement, remediation, demolition and sustainable re-use of vacant land, all of which may be important to improve the experiences of children in hard hit areas.

Second, the study also has implications for significant policy areas in regard to early childhood. Many states and locales are making increased investments in universal high quality preschool programs. This study suggests that such programs give special attention to children that are negatively affected by housing and neighborhood problems, including those experiencing housing instability, lead poisoning and child maltreatment. Without compensatory educational interventions, these children are unlikely to be kindergarten ready when they enter elementary school. Future study will be able to link information about the role that housing plays in children's exposure to early learning environments of varying levels of quality to their subsequent school readiness and school performance outcomes. Findings from such an approach will be able to inform policy discussion about which children are not adequately served in these

universal approaches and how to best leverage strategic investments in the early childhood system to produce the largest benefits.

Third, kindergarten readiness sets the stage for early learning and literacy (Kurdek & Sinclair, 2001) and a number of states and initiatives are focused on efforts to address third grade reading proficiency as a standard and expectation. This study demonstrates that housing and neighborhood conditions are important contributors to school readiness and the related third grade policy goal. Federal policy has made strides to ensure educational access and resources for homeless children (particularly through the McKinney-Vento Homeless Assistance Act). However, a potentially large population of children is exposed to sub-standard housing conditions and housing instability leaving them less able to arrive at school ready to learn and succeed once there. This study could help inform a policy dialogue about how to best ensure that these children have protections and resources similar to those for homeless children.

The forth policy area of relevance relates to place-based initiatives such as the federal Promise and Choice Neighborhoods programs and national foundation initiatives such as Annie E. Casey Foundation's Family-Centered Community Change model. These approaches use neighborhood and housing as a focal point for strengthening the cradle to career pipeline for children. A defining element of such work is achieving an integrated view of services and supports for families with young children, with stable housing and communities as a necessary base. The present study will inform such work by identifying housing quality as a key element of success and pointing to the policy levers that could produce the most return in the targeting of these initiatives.

Finally, federal policy has played an important role in requiring state longitudinal student record systems to track children from kindergarten through college and career. However, there are only beginning efforts to incorporate health and social service records into these systems and virtually no capacity to factor in local housing and property records on an ongoing basis. Yet this study demonstrates the important contributions that local housing and neighborhood conditions make to children's early school success. There is tremendous value to be gained from linking records across agencies and jurisdictions and enabling information to be visualized and applied down to the level of communities and neighborhoods. The findings of this study can be used to advocate that government-supported longitudinal data systems be expanded to include housing

and neighborhood data. As big data begins to take center stage, those advocating data driven policy must be able to view housing within the same data context as family and child well-being so as to concretely appreciate how housing matters at the local, state and national level.

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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Appendix 1. Principal Component Analysis (PCA): Loading for First Component

Year	2000	2007	2008	2009
N of census tract	501	501	447	447
Individual poverty (%)	0.913	0.882	0.884	0.899
Household with public Assistance (%)	0.865	0.719	0.789	0.773
Female-headed family with own children (%)	0.901	0.816	0.862	0.878
Unemployment (%)	0.878	0.694	0.858	0.852
African-American (%)	0.785	0.790	0.804	0.809
Under age 18 (%)	0.610	0.495	0.572	0.539
Total variance explained by (%)	69.2	55.2	64.3	64.1

Note. Unit of analysis: Census tract, Area: Cuyahoga County, OH.
Sources: Census 2000 (SF3), ACS 2009 5-yr estimates, ACS 2010 5-yr estimates, and ACS 2011 5-yr estimates.
The neighborhood distress rank for other years was obtained by linear interpolation of the years given in the table.

Appendix 2. Models of Housing and Neighborhood (HN) Exposure: Multinomial Logit Model

	Model 1A: Selection weights			Model 1B: Stabilizing factor		
	b	*se*		*b*	*se*	
Time invariant						
Low birth weight (Yes=1)	-0.022	0.063		-0.018	0.063	
Gender (Female=1)	0.013	0.040		0.019	0.040	
Race/ethnicity (Reference=Non-Hispanic Black)						
(White)	0.104	0.063	†	0.137	0.062	*
(Hispanic)	-0.014	0.091		-0.002	0.091	
(Other)	-0.139	0.232		-0.129	0.233	
English as a second language (Yes=1)	-0.065	0.108		-0.072	0.107	
Disability (Yes=1)	-0.056	0.067		-0.040	0.067	
Teen mother (Yes=1)	0.122	0.057	*	0.099	0.057	†
Mother has high school degree (Yes=1)	-0.137	0.044	**	-0.154	0.044	***
Child and calendar time						
Time						
3	-0.147	0.063	*	-0.213	0.062	***
4	-0.234	0.066	***	-0.346	0.063	***
5	-0.371	0.070	***	-0.528	0.063	***
6	-0.585	0.077	***	-0.796	0.066	***
Kindergarten entry year						
2009	-0.129	0.056	*	-0.131	0.056	*
2010	-0.120	0.056	*	-0.125	0.056	*
2011	-0.302	0.058	***	-0.304	0.058	***
Baseline treatment and time-dependent variables						
Poverty (Share of time below poverty line)	-0.020	0.084		0.019	0.060	
Neighborhood distress index interacted with housing quality						
0 (in good condition)	0.261	0.003	***	0.263	0.003	***
1 (in bad condition, not low value)	0.261	0.003	***	0.262	0.003	***
2 (in bad condition and low value)	0.258	0.003	***	0.260	0.003	***
Housing market distress event	0.164	0.053	**	0.160	0.048	***
Residential moves (Average per year)	0.023	0.036		0.099	0.058	†
Child neglect/abuse investigation	-0.050	0.075		-0.107	0.029	***
Time dependent at t-1						
Poverty (Share of time below poverty line)	-0.335	0.107	**			
Housing market distress events	0.038	0.052				
Residential moves (Average per year)	-0.118	0.018	***			
Child neglect/abuse investigation	-0.169	0.077	*			
Time dependent at t						
Poverty (Share of time below poverty line)	0.525	0.094	***			
Child neglect/abuse investigation	0.274	0.062	***			
Treatment at t-1						
Neighborhood distress index interacted with housing quality						
0 (in good condition)	-0.052	0.001	***	-0.051	0.001	***
1 (in bad condition, not low value)	-0.024	0.001	***	-0.024	0.001	***
2 (in bad condition and low value)	0.000	(omitted)		0.000	(omitted)	
Constant	-16.795	0.220	***	-16.778	0.219	***

Note. †*p*<.10, **p*<.05, ***p*< .01, ***p<.001. N (person-year)=67,590 (first imputation dataset). Parameter estimates presented are for the probability of being in the highest level of neighborhood and housing distress, relative to the least distressed level.

Appendix 3. Stabilized Treatment Weights

Weight	Mean	SD	Percentiles			
			1st	25th	75th	99th
Stabilized treatment weight (SW) for LEAD model	0.998	0.076	0.744	0.983	1.011	1.269
Stabilized treatment weight (SW) for KRA-L model	1.000	0.152	0.612	0.955	1.034	1.585

Note. N=13,681 for Lead model and N=13,689 for KRA-L model. Statistics shown for first imputation data set.

Appendix 3 shows descriptive statistics for the inverse probability of treatment weights used to estimate the lead and KRA-L models. These weights adjust for selection into different levels of neighborhood and housing distress across time. They are estimated via multinomial logit models detailed in the models section of the paper and presented in Appendix 2. A total of 77 children, less than 0.6% of the sample is dropped to avoid outliers with weights larger than 2.6.