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Are public housing projects good for kids after all?

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Keywords: *public housing, neighborhoods, public schools, student outcomes*

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1. Introduction

Is public housing bad for children? Despite the best intentions, the benefits of public housing – such as improved affordability, better housing units, or greater residential stability – may be outweighed by detrimental effects of high-poverty neighborhoods, low-quality schools, neighborhood crime, or other (dis)amenities. Whether the net effect is positive or negative is theoretically ambiguous and likely to depend on the characteristics of the housing and its associated schools and neighborhood and their quality compared to origin neighborhoods. While the limited previous literature is discouraging, much of this work exploits *exits* from relatively undesirable public housing – comparing outcomes of children who left to those who remained (Katz et al., 2001; Jacob, 2004; Sanbonmatsu et al., 2006; Ludwig et al., 2013; Chetty et al., 2016; Chyn, 2018). Two notable exceptions, Weinhardt (2014) and Carlson et al. (2019), focus on *entries* into oversubscribed social housing in England and public housing in Wisconsin, respectively. While both studies report mostly null effects, limitations in sample size or variation in the public housing stock may have masked positive (or negative) effects under some circumstances. Further, they do not control for the independent effects of residential and school mobility.

In this paper, we draw on detailed individual-level longitudinal data on public school students in New York City (NYC) to examine the effects of *entries* into public housing, including some projects located in gentrifying neighborhoods. Exploiting plausibly random variation in the precise timing of entry into public housing, we estimate credibly causal effects of public housing on academic and weight outcomes using both difference-in-differences and event study designs. We exploit heterogeneity across the neighborhoods surrounding the 147 public housing developments and myriad origin residences and leverage data on public schools to explore the extent to which neighborhoods and schools shape the effects of public housing.

More specifically, we use administrative student-level data from the NYC Department of Education on NYC public school students, in grades 3-8, between academic years 2009 and 2017. We focus on 35,456 observations and 7,832 students who enter public housing in grades 5, 6, or 7 and thus have at least one year of standardized test scores both before and after moving into public housing. We use an expanded sample for attendance and weight analyses, adding students in grades K-2 and 9-12. We begin with a difference-in-differences identification strategy, using parsimonious models that link test scores and attendance to public housing residency and student fixed effects. We control for residential and school moves, estimate separate effects for the first post-move year and subsequent years, and explore heterogeneity across neighborhood types (both origin and destination), race/ethnicity, and gender. We further explore school characteristics of students moving into and out of different neighborhoods to understand the role of public schools. We investigate the empirical support for our identification assumption of plausibly random variation in the precise timing of student entry; we explore sociodemographic predictors of timing of entry and find little evidence that student characteristics are significant predictors of the grade of entry. Event study analyses also reveal little evidence of significant pre-trends.

To preview the results, we find that moving into public housing has positive and statistically significant effects on student outcomes, most prominently after the initial adjustment year. Small changes in test scores in year one are followed by larger improvements in subsequent years – both reading and math scores increase by roughly 0.1 standard deviations (sd). Event studies show smaller immediate changes in test scores post-move with steady improvement over time. As for heterogeneity, we find positive effects for all subgroups with larger effects for girls than boys (0.15 vs. 0.06) and for Asians and Whites (0.31 and 0.18 respectively) than Hispanics or Blacks (0.10 and 0.08 respectively). We find no significant effects for attendance or weight outcomes overall, but reductions in probability of being obese and overweight for boys.

Further, our results reveal the importance of neighborhoods – we see larger effects among students moving into higher-income neighborhoods (up to 0.13 increase) than those moving into lower-income neighborhoods (roughly 0.09 increase) after the first year in public housing. We also find improvement in attendance rate and reduction in chronic absenteeism for students moving into higher-income neighborhoods. Results suggest school matters, as moving out of low-income neighborhoods or into high-income neighborhoods is associated with attending better schools – with lower shares of economically disadvantaged schoolmates (that is, the share of students eligible for free and reduced-price lunch) and higher average test scores.

Taken together, our results suggest that differences in the neighborhood and school contexts of public housing studied in previous research underlie the differences in results. Put simply, the null effects in previous studies may reflect the poor quality of the schools or neighborhoods associated with public housing, while our positive effects may be driven by improvements in schools and neighborhoods. Bottom line, our results refute the popular belief that public housing *per se* is bad for kids and call for future work probing the circumstances under which public housing works to improve academic outcomes for low-income students.

2. Background and literature review

2.1. The promises and the problems of public housing

Public housing was the federal government's first major housing assistance program for low-income households. The Housing Act of 1937 established local housing authorities to develop public housing projects with the goal of providing "decent, safe, and sanitary dwelling for families of low-income" (p.888). While federally funded, public housing projects are administered, managed, and operated by local public housing authorities. Some examples of local housing authorities include Chicago Housing Authority and NYC Housing Authority (NYCHA). There are approximately 3,300 public housing authorities nationwide that serve around 1.2 million households living in public housing projects (HUD, 2020). Each public housing authority sets the eligibility criteria for public housing based on household income and has its own waiting list (if any) and tenant selection and assignment process. Households living in public housing typically pay 30 percent of their adjusted household income towards rent, which is in most cases well below the market rate.

Despite the best intentions to provide subsidized housing units for needy families, public housing has long been criticized for its creation of "concentration of poverty" (Massey & Kanaiaupuni, 1993). Public housing projects, typically consisting of one or more concentrated blocks of high-rise apartment buildings, were often sited in neighborhoods occupied by poor, minority residents (Von Hoffman, 1996; Schill & Wachter, 1995). Public housing tenants also come from low-income and minority households because of the program's eligibility criteria, bringing in a large number of poor, minority families to the neighborhood. Critics blamed the design of public housing projects created isolated geographic areas that are disproportionately poor and racially Black. For example, out of 33 projects constructed in Chicago between 1950 and 1970, all but one project was built in neighborhoods that were at least 85 percent Black (Hirsch, 1983).

Concerns about the concentration of poverty in and around public housing motivated federal housing policies to shift towards alternative housing assistance programs (Collinson et al., 2015). In the landmark case of Gautreaux in 1976, the Supreme Court ruled that the Chicago Housing Authority and the U.S. Department of Housing and Urban Development (HUD) discriminated against Black tenants by concentrating them in large-scale projects located in poor, Black neighborhoods. In 1992, Congress passed a new public housing funding program, HOPE VI, to replace public housing projects in distressed neighborhoods across the nation with privately-owned, mixed-income projects (Schwartz, 2014). Tenants living in public housing buildings subject to demolition were given vouchers to move out of public housing and into other rental units in the private market. The housing choice voucher program was first created in 1974 as an alternative to the project-based approach of public housing and allowed tenants to find rental units in the private housing market. These alternative programs were often viewed by policymakers as the preferred form of housing assistance as the means to alleviate the concerns around the concentration of poverty, compared to public housing that limits the choice of residential locations to poor neighborhoods.[1]

However, not all eligible households can receive housing choice vouchers.[2] Waiting lists for vouchers are long; the average waiting time for vouchers easily exceeds a year, with substantially longer waits of up to multiple years in large cities (Maney & Crowley, 2000). Even after many months on the waiting list, households are not guaranteed to successfully find housing in the private market. Low-income households – most likely under time and resource constraints – typically have 60 days to find adequate housing units that meet the federal housing quality standards and are also below the rent limits. Although prohibited by law in many states and municipalities to discriminate against the source of income to pay rent, landlords may also decline to accept vouchers (Galvez, 2011). Low-income households and minorities, in particular, may further face discrimination by landlords in the private housing market (President's Commission on Housing, 1982; Freeman, 2012; Tighe et al., 2017). As a result, a substantial number of voucher recipients fail every year to successfully utilize their housing vouchers or find housing in neighborhoods not different from where they used to live.

Public housing, therefore, remains an important stream of housing assistance for low-income families that may face multiple barriers in obtaining and utilizing housing vouchers. As

[1] As another alternative, the government subsidized private developers to ensure low- and moderate-income households could afford units in private projects. Low-Income Household Tax Credit (LIHTC) program is the most popular form of privately-owned, mixed-income projects. State allocating agencies would award tax credits to developers if at least 20 percent of their tenants have incomes below 50 percent of the area median income (AMI) or at least 40 percent have incomes below 60 percent of AMI.
[2] In the case of mixed-income projects, it is mostly moderate-income households that occupy the projects, often not affordable for low-income households without other forms of subsidy (Desai et al., 2010; O'Regan & Horn, 2013).

of 2020, public housing serves more than 2 million residents and 1 million households in need of housing assistance across the nation (HUD, 2020). The all-too-common long waiting lists for most public housing authorities attest the demand remains high. Furthermore, while previous studies and popular press often focus on the negative effects of poor neighborhoods surrounding public housing, there is limited causal evidence that public housing of this negative impact on children. It is crucial to understand the effects of living in public housing and the mechanisms through which it may further help or harm the residents and their children in need of housing assistance.

2.2. How might public housing affect student outcomes?

We identify four key channels through which public housing may affect student outcomes. First, moving into public housing may have *income effects*. Subsidized rents for public housing units, which are well below the market price, may effectively reduce rent burdens and increase disposable income. Public housing tenants typically pay 30 percent of their adjusted income towards rent, with some variation by local housing authorities (HUD, 2020).[3] Increased income is likely to improve children's academic outcomes, especially for low-income households. Previous studies suggest families in affordable housing are more likely to increase their expenditure on necessities and enrichment of their children yet experience reduced parental stress, which are all associated with improvements in children's cognitive skills, physical, social, and emotional health (Harkness & Newman, 2005; Newman & Holupka, 2016).

Second, moving into public housing may mean *improved housing*. That is, public housing may provide housing units of "decent, safe, and sanitary dwelling." Improved housing conditions may include more reliable heat, water, and other utilities, as well as more space and improved privacy. Early studies, including Currie and Yelowitz (2000), suggest that public housing units provide better housing conditions, as they should meet federal housing quality standards. Currie and Yelowitz (2000) use the sex composition of children as an instrument for the relationship between families' likelihood of living in public housing and their housing conditions. Families with two children of the opposite sex are eligible for an extra bedroom than those of the same sex and are thus more likely to apply for public housing. They find that public housing children are

[3] Voucher recipients typically pay 30 percent of their adjusted income towards rent but must pay any additional amount if rents are above the payment standard set by local public housing authorities. In case of privately-owned mixed-income projects, rents are often not affordable for low-income households without other forms of subsidy. Put differently, public housing may bring larger income effects than other housing assistance programs.

less likely to live in overcrowded units or high-density complexes and less likely to repeat grades. However, anecdotal evidence from the popular press suggests otherwise; dilapidated housing conditions of NYC public housing recently called attention from the popular press and nearly resulted in a federal takeover of NYCHA (Benfer, 2019; Weiser & Goodman, 2018). More generally, previous research suggest housing conditions are closely related to children's physical and psychological development and academic performance (Leventhal & Newman, 2010; Coley et al., 2013).

Third, public housing may improve *residential stability* over time. Unlike families in private rental housing, public housing tenants are at lower risk of eviction or rent hikes at lease renewal.[4] Students in public housing may be less likely to experience multiple moves to new schools and communities, which are shown to have disruptive effects on their academic performance (Newman & Harkness, 2002; Crowley, 2003; Cordes et al., 2016; Cordes et al., 2019). Improved residential stability provided by public housing may therefore have positive academic impacts on students.

Finally, there may be *neighborhood effects* if moving into public housing means *different neighborhoods* – either or worse better than the alternative (or counterfactual) neighborhood. A broad literature documents the importance of neighborhood resources on children's development and academic outcomes (Leventhal & Newman, 2010; Chetty et al., 2016; Schwartz et al., 2017). While early descriptive studies show kids in public housing live in worse neighborhoods than those of welfare households living elsewhere (Newman and Schnare, 1997), more recent studies on NYC public housing – the setting of this study – suggest substantial variation in public housing neighborhoods. Han et al. (2020) document substantial variation in the micro-neighborhood food environment among students living in NYC public housing, which has consequences for childhood obesity. Dastrup and Ellen (2016) also find that most NYC public housing, originally built decades ago in low-income areas, is now surrounded by relatively in high-income neighborhoods, and Schwartz et al. (2010) do not find NYC public school students living in public housing attend worse schools than otherwise similar peers living elsewhere.

2.3. Quasi-experimental evidence on the impacts of public housing exits and entries

Existing research identifying the causal effect of public housing is limited. Most of these prior studies leverage exogenous exits from public housing programs driven by the building

[4] This includes housing voucher recipients who would need to find housing in the private market.

demolition or policy shifts towards the housing choice voucher program. The earliest studies include research on the Gautreaux mobility program, in which selected households living in Chicago Housing Authority's inner-city projects received housing vouchers to move to suburban neighborhoods as part of the Gautreaux litigation in 1976. The demand for the program exceeded its supply, and program participation was primarily determined by whether the applicant's telephone call went through on the registration day. Leveraging this variation, Rosenbaum and Popkin (1991) and Rosenbaum (1995) find improved academic performance among children who moved out of public housing located in extremely distressed inner-city neighborhoods and into private housing (using vouchers) in predominantly White, suburban communities.

Jacob (2004) exploits the exogenous timing of the demolition of public housing buildings in Chicago to examine the effect of public housing exits. He finds no significant differences in the test scores between children who move out earlier and those that stay in public housing. Jacob (2004) suggests that the null effects may be due to students moving to neighborhoods and schools that closely resemble the public housing neighborhoods they had left. Chyn (2018), however, examines the longer-run impacts and finds that three years after demolition, displaced households live in lower-poverty neighborhoods with lower crime rates, which leads to improved employment and wage outcomes.

The reported gains from the Gautreaux relocation program and lasting concerns about the concentrated poverty motivated the Moving to Opportunity (MTO) experiment in 1992. The purpose of MTO, the largest randomized controlled experiment on housing mobility, was to test whether providing housing vouchers would improve the life trajectories of the poorest families in public housing (Orr et al., 2003). Households with children living in public housing in census tracts with a poverty rate of at least 40 percent were eligible to participate in the experiment. The experimental group was randomly chosen to receive vouchers and mobility counseling, along with a requirement to move out of public housing and into low-poverty neighborhoods while the control group received no vouchers but could continue to live in public housing. Results are disappointing. A series of studies find no evidence of test score gains (or any effects on physical health, including incidences of childhood obesity); however, depending on the subgroup, some find evidence of mental health gains and reduction in risky behaviors for girls (but not boys) and longer-term positive effects on college attendance and earnings for children who moved at younger ages (Katz et al., 2001; Sanbonmatsu et al., 2006; Kling et al., 2007; Ludwig et al., 2013; Chetty et al., 2016).

To be clear, all of these studies focused on families leaving public housing in very poor, troubled neighborhoods. Whether results generalize to public housing in better neighborhoods – perhaps with better schools – is unclear, and the estimated results are most likely underestimated in previous studies.

Two recent quasi-experimental studies exploit exogenous timing of entry to public housing, yet they find mostly null effects of public housing on student outcomes. Weinhardt (2014) exploits plausibly random timing of entry into social housing *neighborhoods* in England.[5] His identification relies on the long waiting lists that give tenants little control over the precise timing they move into social housing neighborhoods. He compares two key stage exam test scores of early movers who in between the two exams and late movers or "future recipients" who move in after the two exams. He finds that earlier movers into social housing neighborhoods do not experience any detrimental effects on their test scores compared to later movers. Carlson et al. (2020) also examine the impact of entry into public housing in Wisconsin, comparing test scores for 841 students who enter public housing to 604 future recipients (and other welfare recipients). They find that some evidence that public housing leads to declines in math scores but null effects on reading scores.

While these recent studies represent important contributions, empirical limitations may have obscured any positive impact of public housing residency. First, neither accounts for the potentially disruptive effects of residential and/or school mobility, as distinct from moving into public housing *per se.* Thus, their estimates of impacts immediately post move may well be moderated by short term adjustment costs. Second, neither of the studies has sufficient sample size or variation to explore heterogeneity across student subgroups and/or neighborhoods. Carlson et al. (2020) have a small public housing sample and do not explore any variation within public housing sample in terms of demographic subgroups and neighborhoods.[6] A large majority

[5] Weinhardt (2014) is unable to precisely identify housing subsidy recipients, but instead identifies households moving into high-density social housing neighborhoods based upon the percentage of households that rent from the council (local authority), a registered social landlord or housing association and calculates the percentage of households living in social housing.

[6] Carlson et al. (2020) do not specify the racial composition of their sample of students living in public housing, but their overall housing assistance sample (in public housing and on housing choice vouchers) are 40 percent Black and 44 percent White. They find that housing assistance (for the overall sample) benefits black students, while they find null results for whites. They find no meaningful differences between girls and boys.

of the students in the Weinhardt (2014) sample were White (more than 80 percent), while public housing residents in the US include large populations of Blacks, Hispanics and Asians. The significant discrimination in housing markets suggests impacts may vary across racial/ethnic groups. As the neighborhood effects literature find differential effects by gender, we may find further differences in the impact of public housing residency across other student demographic subgroups.

In this paper, we build upon these two papers and exploit plausibly random variation in the timing of student entry to NYC public housing created by its application process and the waiting list. We use data on individual-level test scores following students up to four years after they move into public housing and attendance and weight outcomes for up to eight years. The rich longitudinal dataset, which includes indicators of school attended, allows us to parse the potentially disruptive effects of residential and school mobility followed by entry to public housing. In addition to exploring heterogeneity by racial/ethnic subgroups and gender, we capture the differences in neighborhoods surrounding public housing projects, including their school peer characteristics, to probe potential mechanisms. Leveraging variation in student and neighborhood characteristics and controlling for residential and school moves may help reconcile findings from previous research.

3. NYC public housing and the waiting list

NYCHA – the setting of our study – is the nation's largest public housing system. As of 2020, the NYC public housing system contains 169,820 households in 2,252 buildings and 139 projects dispersed across the city's five boroughs (NYCHA, 2020).[7] Roughly over 400,000 residents occupy NYC public housing, of which approximately 26 percent are under age 18. Large projects located in different parts of the city are likely to provide diverse living and learning environments for children living in NYC public housing. Dastrup and Ellen (2016) document that 54 public housing projects in NYC were surrounded by high-income neighborhoods, while 49 projects were in low-income neighborhoods in 2010. They find other neighborhood amenities, including public school quality, are correlated with neighborhood income, which may explain the finding in Schwartz et al. (2010) that public school students in

[7] The five boroughs include Manhattan, Bronx, Brooklyn, Queens, and Staten Island. The maximum rent for NYC public housing is 30 percent of the household's income, with HUD subsidizing the remainder of the rent. The average NYCHA public housing family's annual income is $25,502. The average monthly rent is $548, which is way below the market rate.

NYCHA buildings do not systematically attend worse public schools than otherwise similar peers living elsewhere in the city.

Like most public housing authorities in major cities, NYCHA is oversubscribed and has its own tenant selection and assignment process, creating extensive uncertainty in the precise timing that eligible households can apply and receive an offer for public housing. First, NYC residents have little control over the *timing of their application*, because NYCHA closes its waiting list for public housing from time to time to control the volume of the applications it receives. When applications for public housing open, eligible households that apply are placed on the waiting list based on their family size, income, needs (e.g., emergencies), and date of application. Second, applicants have limited control over the *timing of receiving offers* due to the long waiting list. As of 2020, 176,646 families are on the waiting list for NYC public housing (NYCHA, 2020). In the past five years, the average time between "date entered waiting list" and "admission date" for NYC public housing has been more than 38 months (HUD, 2019).[8] Third, applicants are unlikely to manipulate their *timing of entry* through waiting and rejecting offers. When applicants reach the top of the waiting list, they must select one preferred project within 30 days, conditional on containing an anticipated vacancy. NYCHA randomly assigns applicants to vacant units in the selected project. Applicants can reject the initial offer and can receive up to two offers, but their application will be closed if they fail to accept or reject the offers within 60 days (NYCHA, 2020).[9] Previous research suggests few households reject the initial offer for housing assistance programs with long waiting lists, as it may entail a substantial wait for and uncertainty regarding the availability of another unit (Coley et al., 1997; Rosenbaum, 1995; DeLuca & Rosenbaum, 2003). NYCHA closing its waiting list from time to time may further reduce households' likelihood of rejecting offers, as it would increase their uncertainty around the chance to create new applications to get back on the waiting list.

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[8] Note that this average waiting time does not include the time spent on the waiting list for households that have not received the offer yet (or those that withdraw from the list) and may underestimate the average waiting time to receive a public housing offer.

[9] In exceptional cases, "emergency" applicants – such as households with children that are homeless, victims of domestic violence, or intimidated witnesses – may be prioritized in the tenant selection process. The timing of entry to public housing for these emergency applicants will be also be affected by the limited availability, list closures, etc. that create randomness in the timing of entry. Emergency applicants are only allowed to select a preferred borough rather than a particular project but are also allowed to reject the initial offer. The application will be closed if they reject the second offer.

We exploit the resulting exogenous variation in the timing of household entry to NYC public housing to examine the causal impact of public housing residency on student outcomes. We explore the empirical support for the proposition that the timing and the grade in which students enter public housing are uncorrelated with pre-determined student characteristics in the following sections.

4. Data, measures, and sample

We use individual-level longitudinal data from the NYC Department of Education on NYC public school students, grades 3-8, in academic years (AY) 2009-2017. These data include scores on state tests in English Language Arts and mathematics standardized by grade (*z-ELA* and *z-Math* respectively), attendance, height and weight measures (from an annual FitnessGram®), student residential and school location, and sociodemographic variables, such as gender, race/ethnicity, grade, educational program participation (e.g., students with disability and English language learners), and economically disadvantaged students.[10] In addition to the attendance rate, *Attendance*, we construct an indicator for chronic absenteeism, *ChrncAbsent*, which identifies students absent for ten or more days in an academic year. We calculate body mass index (BMI) using student height and weight and follow Centers for Disease Control and Prevention guidelines in constructing an indicator for obesity, *Obese,* if BMI is at or above the 95th percentile for their age and sex and overweight, *Overweight*, if BMI is at or above the 85th percentile. Two indicator variable captures school and residential mobility: *NewSchool* equals 1 in time t if a student attends a different school in t than t-1 and *NewAddress* equals 1 in time t if student address differs between t and t-1. We also link our student-level data to longitudinal school-level data on enrollment, standardized test scores, and demographic characteristics, such as percentage Black, Hispanic, Asian, White, eligible for free or reduced-price lunch from the New York State Annual School Report and the School Report Card.

Critically, we identify students living in NYCHA housing using student residential location and address data for NYCHA buildings. Specifically, an indicator for public housing residency, *PH*, equals 1 if student i lives in public housing in t or any previous period – that is, *PH* is 1 in the first year a student lives in public housing and all following years.[11] We also create

[10] Economically disadvantaged students are defined by whether they were ever eligible for free or reduced-price lunch (household incomes below 185 percent of the federal poverty level) in AY 2001-2017.

[11] We adopt this "intent-to-treat" definition because household decisions to exit public housing are likely endogenous. Thus, our impact estimates include the effects in all years post moving into public housing.

an indicator *EntryPH,* which equals 1 in the first year a student lives in public housing, and *PostPH,* which equals 1 in all subsequent years. In this way, we parse the immediate effects of moving into public housing – which may include potential disruptive effects of school and residential mobility – from effects in subsequent years. Similarly, we create a set of pre- and post-public housing year indicators for our event study specifications.

We identify two neighborhood types surrounding the public housing projects. Following Dastrup and Ellen (2016) classification of NYC public housing neighborhoods, we define "high-opportunity" projects as those surrounded by census block groups with average median household incomes at or above the city median in 2010 and "low-opportunity" projects if below the median. We assign time-invariant indicator variables for students who move into high-opportunity projects (*HighOpp*) and for students who move into low-opportunity neighborhoods (*LowOpp*). We construct similar indicators based on student "origin" neighborhoods – that is, their residential neighborhoods in time t-1 when they moved into public housing in time t. *HighOrigin* equals 1 for students if their census block group of the origin residence is surrounded by census block groups with average median household incomes at or above the city median, and *LowOrigin* equals 1 for other students.

Since our identification strategy relies upon comparing student outcomes before and after entering public housing, we focus on three cohorts of students that enter public housing in grades 5, 6, or 7 and have at least one year of standardized test scores before and after entering public housing. We call these cohorts G5, G6, and G7, respectively (to be concrete, G5 are students who enter public housing in grade 5). These include 7,832 students with 35,456 pre- and post-public housing observations in grades 3-8. Our extended sample for attendance and weight analyses include 40,086 pre- and post-public housing observations of students in grades K-12.

Table 1 provides summary statistics of our analytic sample by public housing entry cohort in AY 2009, a "pre-treatment" year for all of the students (none live in public housing yet), by construction. As shown, our three entry cohorts are quite similar in baseline characteristics. All cohorts are slightly overrepresented by female students (52 to 55 percent female) and approximately 40 percent are Black and 50 percent Hispanic, with 8 to 9 percent being Asian and 2 percent White. Virtually all are economically disadvantaged (rounded up to 100 percent) with standardized test scores below NYC average in both reading (ranging between -0.31 and -0.28) and math (between -0.33 and -0.27). The earlier cohort has higher shares of chronically absent students (58 percent vs. 52 to 54 percent) but have approximately the same attendance rate as other cohorts (91 and 92 percent). Roughly one quarter are obese, and 43 percent are overweight across all cohorts. Time-invariant indicators for neighborhood characteristics before and after moving into public housing show that around 47 to 48 percent of these students eventually move into high-opportunity projects and 21 to 22 percent come from high-income neighborhoods prior to entering public housing. Overall, student characteristics appear to differ little across entry cohorts prior to entering public housing, and the shares of students that move into high-opportunity projects are strikingly similar across cohorts.

5. Empirical strategy

5.1. Regression models

The centerpiece of our empirical work is a regression model linking student academic outcomes to *PH*, our public housing indicator, along with a set of time-varying student characteristics and student fixed effects to capture any unobserved time-invariant differences between students:

$$Y_{it} = \beta_0 + \beta_1 PH_{it} + \gamma X_{it} + \delta_i + \tau_t + \varepsilon_{it} \quad (1)$$

where Y_{it} is the standardized test scores and attendance outcomes for student i in grade t, including *zELA*, *zMath*, *Attendance*, and *ChrnAbsent*. X_{it} is a vector of other time-varying student characteristics, including disability status and English language learner status. Student and grade fixed effects are δ_i and τ_t, respectively. Our coefficient of interest is β_1, which captures the impact of living in public housing. In this formulation, β_1 will warrant a causal interpretation if the precise timing of entry public housing is random. We provide empirical evidence in support of this below.

We parse the first year and subsequent effects with the following:

$$Y_{it} = \beta_0 + \beta_1 EntryPH_{it} + \beta_2 PostPH_{it} + \gamma X_{it} + \delta_i + \tau_t + \varepsilon_{it} \quad (2)$$

where β_1 captures the first-year effect of living in public housing– including any disruptive effects of residential and school moves – and β_2 captures the effect of living in public housing in subsequent years. Alternative specifications add controls for *NewSchool* and *NewAddress* to isolate the disruptive effects of school and residential mobility from the effect of living in public housing after an adjustment period.

We investigate the potential mechanisms underlying the effect of public housing in two ways, first, by exploring heterogeneity in impacts by neighborhood income and student demographic characteristics and, second, by exploring intermediary variables, such as school peer characteristics. To do so, we introduce a series of interaction terms between public housing variables and neighborhood (or demographic) indicators to estimate separate coefficients for those moving into low- and high-opportunity neighborhoods, for those moving out of low- and high-origin neighborhoods, and for different demographic subgroups (by gender, race/ethnicity). For instance, we estimate separate coefficients for high- and low-opportunity destination neighborhoods with the following:

$$Y_{it} = \beta_0 + \beta_{l1}\, \mathit{LowOpp} \times \mathit{EntryPH}_{it} + \beta_{l2}\, \mathit{LowOpp} \times \mathit{PostPH}_{it} + \beta_{h1}\, \mathit{HighOpp} \times \mathit{EntryPH}_{it} + \beta_{h2}\, \mathit{HighOpp} \times \mathit{PostPH}_{it} + \gamma X_{it} + \delta_i + \tau_t + \varepsilon_{it} \quad (3)$$

where other models would substitute *LowOpp* and *HighOpp* with a set of indicators for origin neighborhoods (*LowOrigin* and *HighOrigin*), for gender (*Female* and *Male*), and for race/ethnicity (*Asian*, *Black*, *Hispanic*, and *White*) to be interacted with the indicators for public housing residency (*EntryPH* and *PostPH*).

We then probe the intermediary factors driving the differences in the effect of public housing between high- and low-opportunity neighborhoods (and high- and low-income origin neighborhoods) by exploring the effects on school characteristics:

$$School_{it} = \beta_0 + \beta_{l1}\, \mathit{LowOpp} \times \mathit{EntryPH}_{it} + \beta_{l2}\, \mathit{LowOpp} \times \mathit{PostPH}_{it} + \beta_{h1}\, \mathit{HighOpp} \times \mathit{EntryPH}_{it} + \beta_{h2}\, \mathit{HighOpp} \times \mathit{PostPH}_{it} + \gamma X_{it} + \delta_i + \tau_t + \varepsilon_{it} \quad (4)$$

where $School_{it}$ is a set of school-level characteristics including enrollment, share of economically disadvantaged peers, and average z-scores of math and reading exams that student i attends in grade t. Again, we substitute *LowOpp* and *HighOpp* with a set of indicators for origin neighborhoods, gender, and race/ethnicity.

Finally, we conduct a series of robustness checks. We examine whether our results are robust to limiting our sample to students who do not exit public housing during our study period.

We explore heterogeneity by entry cohort (G5, G6, and G7) to examine alternative specifications of our difference-in-differences approach. We use an extended sample of students in grades K-12 for attendance outcomes to examine whether the longer-term results are robust to our baseline results focusing on students in grades 3-8. We also examine other non-academic student outcomes, including student obesity outcomes, that we have data for students in grades K-12.

5.2. Timing of moving into public housing: testing key assumptions

As described earlier, the key to a causal interpretation of our impact estimates is that the precise timing of entering public housing is effectively random – specifically, that the "assignment" of entry into public housing in grade 5 rather than grade 6 or 7 is effectively random – and unrelated to outcomes or salient student characteristics. Although a formal test of this hypothesis is not possible – since salient characteristics may be unobservable – the similarity of the mean characteristics of cohorts, shown in Table 1, bolsters our confidence in this assumption. We probe the empirical support for this claim further in two ways. First, we estimate a linear probability model linking an indicator for "early mover" (G5 rather than G6 or G7) or "late mover" (in G7 rather than G5 or G6) to student baseline characteristics including demographics and test scores in AY 2009.[12] This way, we shed light on the extent to which baseline characteristics predict the timing of entry. As shown in Table 2, all coefficients are statistically insignificant with one exception of being black in column 2. However, all measures of academic performance prior to public housing entry, including standardized test scores and attendance outcomes, do not predict entry cohort.

Second, we explore the trajectory of student outcomes prior to entry into public housing using an event study specification of our baseline model. We use event study analyses to gain insight into whether outcomes were improving (or falling) in the pre-period – suggesting a trend that might have continued after entry. As shown in Figures 1a and 1b, test scores in previous years (pre 2 and pre 3-) are statistically indistinguishable from the reference year's test score (pre 1 or the year prior to entering public housing or pre 1) – with an exception for *zMath* in pre 2, for which we cannot reject the null hypothesis that all pre-public housing test scores are

[12] Borough fixed effects are included in the model to reflect the NYC public housing assignment process, in which households are required to indicate preferred borough on their application to be placed on the waiting list (see Section 3). Results in Table 2 are robust to the alternative model that does not include borough fixed effects. Main regression models do not include borough fixed effects, because student fixed effects are likely to absorb borough fixed effects unless students move across boroughs. We, instead, stratify our sample by borough and re-estimate our baseline model as a robustness check.

distinguishable from zero in a joint F-test at the 0.1 level. On the contrary, reading and math scores gradually increase after public housing residency and are statistically distinguishable from the reference year (see post 2 and post 3+). To summarize, event study analyses show no statistically significant pre-trends, again, suggesting a causal interpretation of our impact estimates is warranted.

6. Results

6.1. Moving into public housing improves student academic outcomes

As shown in Table 3, estimates from our parsimonious model suggest living in public housing increases reading and math scores by 0.03 to 0.04 sd, respectively. Adding controls for residential and school mobility increases the estimated effects to 0.06 and 0.07 and yields negative coefficients for *NewSchool* and *NewAddress* (-0.03 and -0.02, respectively). Thus, the naïve estimates in the parsimonious model may reflect, in part, the academic adjustment costs of residential and school mobility. As for attendance, naïve estimates suggest a deleterious effect of public housing – attendance falls by 0.6 percentage points (pp) and chronic absenteeism increases by 2.7 pp. However, controlling for school and residential mobility suggests no effect of moving into public housing, per se, although moving to a new school or new address has a negative effect.

To probe the timing of these effects, we estimate separate effects for the first year and the subsequent years. As shown in Table 4, we see positive test score effects in the first year of 0.04 (*zELA*) and 0.05 (*zMath*), followed by larger effects of 0.10 (*zELA*) and 0.11 (*zMath*) in later years. In this formulation, we see no separate negative effect of residential mobility, although the negative effect of school mobility remains. While there is no statistically significant effect of public housing per se on attendance outcomes, the effects of residential and school mobility remain negative and statistically significant.

Overall, our results in Tables 3 and 4 suggest that moving into public housing yields considerable improvements in student test scores with larger positive effects in later years and does not harm, if not benefit, attendance outcomes conditional on residential and school mobility.

6.2. Are effects larger for public housing in better neighborhoods?

Results in Table 5 show that neighborhoods matter. For test score outcomes, public housing has similarly positive effects in the initial year of around 0.04 for reading and slightly larger improvement in math for students moving into high-opportunity projects (0.06) than those in low-opportunity projects (0.04). The differences in test score improvements become larger in later years between students moving into different public housing neighborhoods, where students in high-opportunity projects improve reading and math scores by 0.11 and 0.13 and other students in low-opportunity projects improve by 0.09 and 0.10. These are all statistically meaningful differences at the 0.1 level. We also find statistically significant improvement in attendance rates by 0.4 pp and reduction in incidence of chronic absenteeism by 2.1 pp for students who move into high-opportunity projects after the initial year in public housing. We see no statistically significant changes in attendance outcomes for students who move into low-opportunity projects, yet the directions of the coefficients still remain positive for attendance rates and negative for chronic absenteeism. These results suggest that the positive impact of moving into public housing on test scores persists regardless of neighborhood, but improvements in neighborhood quality may enhance the positive impacts and also improve student attendance outcomes.

As for heterogeneity by origin neighborhood, we find less pronounced differences in the impact of moving into public housing. In Table 6, in the initial year in public housing, we find that the improvements in reading (0.04) and math (0.05) scores are substantially similar and statistically indistinguishable between students from different origin neighborhoods. However, in later years, students moving from lower-income neighborhoods experience larger increases in reading scores than students moving from higher-income neighborhoods (0.10 vs. 0.08). Yet again, improvements in math scores are not statistically different between students from lower-income and higher-income neighborhoods in later years (0.11). For attendance outcomes, we find students from higher-income neighborhoods are likely to experience larger and statistically significant improvement in attendance rates (by 0.06 pp) and reduction in chronic absenteeism (by 2.9 pp). Students from lower-income neighborhoods do not experience any statistically significant changes in attendance outcomes after moving into public housing.[13] While we find generally positive impact of moving into public housing regardless of neighborhood quality, the magnitude of the effects may depend upon the extent to which moving into public housing delivers a better or worse neighborhood.

[13] In future work, we plan to explore heterogeneity by changes in neighborhood median income or by whether students move to a better public housing neighborhood compared to their neighborhood of origin residence.

6.3 Heterogeneity by demographic subgroups

We explore heterogeneity in impact by other student demographic characteristics. In Table 7, we find the positive effects on test scores are primarily driven by female students. The estimated increase in test scores range up to 0.15 sd for female students in their later years in public housing. Male students do not experience statistically significant increases in reading scores in their first year in public housing; however, both their reading and math scores appear to improve after the initial year (by 0.04 and 0.06, respectively). For attendance outcomes, in Table 7 columns 3 and 4, we find the estimated impacts of moving into public housing are not statistically significant for both boys and girls.

In Table 8, we find that Asian and White students experience larger increases in test scores following entry to public housing – ranging up to 0.31 increase for Asians and 0.18 increase for Whites. While our analytic sample includes diverse demographic groups of students, note that 8 percent are Asian and 2 percent are White; the largest positive effects are represented by small shares of Asian and White students. However, we still find meaningful improvements in test scores among Hispanic (up to 0.10) and Black students (up to 0.08) after they move into public housing. For attendance outcomes, we find generally positive impact except for White students.

6.4. Probing mechanisms: Moving to better schools

We examine whether the differences in the estimated impact by public housing neighborhoods are attributable to the quality of public schools that students attend. In Table 9, we find that school peer characteristics change in different directions depending on the surrounding neighborhood. Students who move into low-opportunity projects attend schools with lower school-level standardized test scores than their previous school (around 0.02 to 0.03 sd reduction for both reading and math), but students who move into high-opportunity projects attend schools with higher standardized test scores (between 0.02 and 0.03 increase). Regarding the share of economically disadvantaged peers, although the magnitudes are small (of roughly 1.4 pp differences), we also find that changes are in different directions by the type of public housing neighborhood, where students moving to high-opportunity neighborhoods experience a reduction in the share of poor peers at school. School-level enrollment reduce for students in both types of neighborhoods.

While moving into public housing consistently have positive impacts on student academic performance regardless of their surrounding neighborhoods, students in higher-income neighborhoods may benefit more in the transition partly due to the changes in school peer characteristics and the resulting learning environment.

Similarly, we examine the changes in school peer characteristics for students moving out of low-income versus high-income neighborhoods in Table 10. We find that students from lower-income neighborhoods are likely to move to schools with higher average reading scores of around 0.02 after their initial year in public housing, but we find no statistically significant changes in school-level math scores. On the contrary, we find reductions in both school-level reading and math scores for students moving from higher-income neighborhoods (around 0.04 to 0.05). These changes in peer test scores may explain the larger positive gains in reading scores for students moving from lower-income neighborhoods yet statistically indistinguishable gains in math scores found in Table 6. We also find that students moving from lower-income neighborhoods are likely to attend schools with lower shares of economically disadvantaged peers (by 0.6 pp), while students moving from higher-income neighborhoods experience increase in the share of economically disadvantaged peers of around 2 pp after moving into public housing. Unlike students moving from lower-income neighborhoods, those from higher-income neighborhoods do not attend smaller schools than before.

We further explore whether school characteristics vary by student demographic subgroups and find meaningful differences. In Table 11, we find that female and male student experience different changes in school characteristics after they move into public housing. Female students attend schools with higher standardized test scores for both reading and math by 0.02 after the initial year they move into public housing, while male students attend schools with lower scores by 0.02 in the initial year and around 0.01 for reading to 0.02 for math in later years. These changes in school peer characteristics may explain larger improvements in test scores and attendance outcomes among female students found in Table 7. In Table 12, we find that Asian students experience the most dramatic changes in peer characteristics after moving into public housing; they attend schools with peer test scores that are around 0.05 higher in the initial year and 0.14 higher for reading and 0.11 for math in later years than their pre-treatment years. On the contrary, Hispanic and Black students experience a drop in school-level standardized test scores by around 0.01 to 0.03 in the initial year but the changes become statistically insignificant in later years. These may explain positive yet smaller improvements in student test scores for Hispanic and Black students found in Table 8. Students of different demographic subgroups may leverage changes in housing and neighborhood in disparate ways, including the choice of public schools to attend. Our results suggest that the resulting characteristics of public schools attended by demographic subgroups may be driving the differences in the magnitude of our estimated impact of moving into public housing.

6.4. Robustness checks and other outcomes

We conduct a series of robustness checks and find that the results are not sensitive to alternative samples and specifications. First, results are robust to measuring the outcomes excluding public housing exiters in Table A.1. Our intent-to-treat approach in identifying public housing residency considers students who exit public housing after their first year to still be "treated" by public housing. We exclude students who ever leave public housing from our sample and still find consistently positive and statistically significant impacts of public housing residency on student academic performance.

Second, we examine whether the effects are different by entry cohort – G5 (Figures A.1a and A.1b), G6 (Figures A.2a and A.2b), and G7 (Figures A.3a and A.3b). Event study results suggest that if we stratify our analytic sample by students who enter public housing in the same grade, we still identify no significant pre-trends in their standardized test scores for both reading and math. We also examine statistically significant and steady improvements in student test scores across all cohorts. These results suggest that our study results are not sensitive to alternative difference-in-differences estimations.

Finally, we extend our sample of students to all K-12 students who entered public housing in grades 5, 6, or 7 to examine the longer-term impact on student attendance and weight outcomes. Similar to our results for students in grades 3-8, we find that public housing residency has no significant impacts on student attendance outcomes (see Table A.2). We also examine student weight outcomes and find no significant changes in their likelihood of being obese or overweight. Examining heterogeneity in weight outcomes by sex, we find some evidence of statistically significant reductions in the probability of being obese and overweight for boys after their initial year in public housing (see Table A.3).

7. Conclusion and discussion

Our study provides credibly causal evidence that public housing residency improves academic outcomes for NYC public school students. In a study observing students a similar setting in NYC but in *voucher households,* students were found to perform 0.05 sd better, on average, in both reading and math scores after receiving vouchers (Schwartz et al., 2019). We find comparable improvements of around 0.03 to 0.04 sd in student reading and math scores after moving into public housing. After the initial year in public housing, the year in which students make residential moves, by definition, and are highly likely to make school moves, we find student performance in reading and math exams increases by 0.09 and 0.11 sd. Our results suggest steady improvements over time, with little evidence of significant pre-trends in test scores. Stalled academic performance on the first year of entry may reflect potentially disruptive effects of residential and school moves in addition to any benefits of public housing. Residential and school mobility may play a key role in reconciling previous evidence on the null effects of moving into public housing from Weinhardt (2014) and Carlson et al. (2020), as they do not parse out the effects of disruptive moves from the impact of entering to public housing.

Moreover, our results highlight the importance of context. Our data include diverse public housing projects, and we find statistically significant and meaningful differences in impacts in different types of public housing neighborhoods. We find the strongest treatment effects of around 0.11 and 0.13 sd increase in reading and math scores for students who move into public housing sited in neighborhoods with higher average household incomes. These results are not only statistically significant but also substantively important. These results particularly reconcile findings from previous studies on the Gautreaux relocation program, mass public housing demolitions in Chicago, and the MTO experiment that focus on exits from extremely distressed public housing neighborhoods. Public housing, when supported by sufficient neighborhood resources, may have substantial positive impacts on student academic performance, given its income effects and potential improvements in housing conditions and residential stability. However, note that we find positive effects of public housing persist regardless of neighborhoods.

Our data also include a diverse set of student bodies that may provide more nuanced evidence on the impact of public housing by student demographic subgroups. We find larger improvement in test scores for girls (0.15 sd) than boys (0.06 sd). These results are similar to the findings from the MTO studies that girls benefit more from transitions to low-poverty neighborhoods relative to boys. For reference, Weinhardt (2014) and Carlson et al. (2020) do not find any statistically meaningful differences between girls and boys. We also explore heterogeneity by racial and ethnic groups and find that public housing residency has positive impacts not only on Black and White students but also on Hispanic and Asian children, who are little represented in previous literature. Previous studies on public housing mostly focus in geographic areas with less diverse body of students. For example, public housing kids in Chicago included in Jacob (2004) and Chyn (2018) are around 96 percent and 98 percent Black, and the sample of students in England's social housing neighborhoods from Weinhardt (2014) is roughly 84 percent White. As an exception, the sample of students on housing assistance in Wisconsin from Carlson et al. (2020) is 40 percent Black and 44 percent White; however, they do not specify the demographic breakdown between students on housing choice vouchers and in public housing and – due to the small public housing sample – are unable to explore heterogeneity by race. Our sample of NYC public housing children are 41 percent Black and 49 percent Hispanic, the remaining being 8 percent Asian and 2 percent White.

In summary, our results provide compelling evidence that public housing, unlike popular beliefs, may improve educational outcomes for low-income students. Public housing serves as an important source of housing assistance, especially for a particularly disadvantaged subset of populations that may face multiple barriers in utilizing alternative housing programs. Our study suggests that moving into public housing may provide low-income children with living environments beneficial to their academic outcomes when given the time to offset the disruption in the initial adjustment period. The potential positive effects of living in public housing are larger for projects located in high-opportunity neighborhoods. Future research includes understanding the role of differences in housing quality across public housing units to further understand what we can improve the current public housing system.

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Table 1. Baseline variable means by grade of entry to public housing, AY 2009.

	Entered public housing in:		
	Grade 5 “G5” (1)	Grade 6 “G6” (2)	Grade 7 “G7” (3)
Student characteristics			
Female	0.55	0.52	0.54
Asian	0.08	0.09	0.08
Black	0.42	0.43	0.38
Hispanic	0.48	0.46	0.52
White	0.02	0.02	0.02
Economically disadvantaged	1.00	1.00	1.00
Student with disabilities	0.14	0.13	0.12
English language learner	0.18	0.17	0.19
Grade	3.57	4.36	4.89
Student outcomes			
zELA	-0.28	-0.28	-0.31
zMath	-0.27	-0.33	-0.32
Attendance	0.91	0.92	0.92
ChrnAbsent	0.58	0.52	0.54
Obese	0.27	0.25	0.23
Overweight	0.43	0.43	0.43
Neighborhood characteristics			
HighOrigin	0.21	0.22	0.21
HighOpp	0.47	0.48	0.47
N	1,048	1,179	1,443

Notes: By construction, all observations in AY 2009 for this study’s analytic sample are pre-public housing observations.

Table 2. Probability of moving into public housing in earlier and later grades, AY 2009.

	G5 "early mover" (1)	G7 "late mover" (2)
Female	0.013 (0.014)	0.011 (0.014)
Asian	0.006 (0.027)	-0.033 (0.028)
Black	0.024 (0.015)	-0.036** (0.016)
White	-0.071 (0.051)	0.027 (0.053)
Economically disadvantaged	0.030 (0.104)	-0.163 (0.109)
Student with disabilities	0.019 (0.021)	-0.035 (0.022)
English language learner	-0.004 (0.019)	0.031 (0.020)
zELA	0.008 (0.010)	-0.011 (0.010)
zMath	0.004 (0.009)	0.005 (0.010)
Attendance	-0.021 (0.132)	0.196 (0.137)
ChrnAbsent	0.035 (0.029)	-0.006 (0.020)
Obese	0.025 (0.021)	-0.003 (0.022)
Overweight	0.002 (0.018)	-0.015 (0.019)
Grade FX	Y	Y
P-value for joint F-test	0.110	0.021
R2	0.298	0.349
N students (obs)	3,670	3,670

Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
Hispanic is the reference category for race/ethnicity.

Table 3. Parsimonious regression results for student outcomes, AY 2009-17.

Dependent variable:	zELA (1)	(2)	zMath (3)	(4)	Attendance (5)	(6)	ChrnAbsent (7)	(8)
PH	0.028***	0.060***	0.041***	0.070***	-0.006***	0.002	0.027***	-0.007
	(0.010)	(0.013)	(0.011)	(0.013)	(0.001)	(0.002)	(0.007)	(0.009)
NewSchool		-0.033***		-0.031***		-0.007***		0.019***
		(0.009)		(0.009)		(0.001)		(0.006)
NewAddress		-0.023***		-0.021***		-0.006***		0.030***
		(0.008)		(0.008)		(0.001)		(0.006)
Student FX & Grade FX	Y	Y	Y	Y	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y	Y	Y	Y	Y
R2	0.727	0.727	0.745	0.745	0.695	0.697	0.627	0.628
N obs	35,456	35,456	35,456	35,456	35,456	35,456	35,456	35,456

Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

Table 4. Baseline regression results for student outcomes, AY 2009-17.

Dependent variable:	zELA (1)	zMath (2)	Attendance (3)	ChrnAbsent (4)
EntryPH	0.041***	0.049***	0.001	-0.004
	(0.013)	(0.014)	(0.002)	(0.009)
PostPH	0.097***	0.110***	0.002	-0.013
	(0.015)	(0.016)	(0.002)	(0.011)
NewSchool	-0.034***	-0.033***	-0.007***	0.020***
	(0.009)	(0.009)	(0.001)	(0.006)
NewAddress	0.002	0.006	-0.005***	0.026***
	(0.010)	(0.010)	(0.001)	(0.007)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.727	0.745	0.697	0.628
N obs	35,456	35,456	35,456	35,456

Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1). EntryPH and PostPH are statistically different at the 0.01 level for columns 1 and 2.

Table 5. Regression results for student outcomes by public housing neighborhood, AY 2009-17.

Dependent variable:	zELA (1)	zMath (2)	Attendance (3)	ChrnAbsent (4)
EntryPH x LowOpp	0.041***	0.040**	0.002	-0.004
	(0.015)	(0.016)	(0.002)	(0.011)
PostPH x LowOpp	0.088***	0.095***	0.001	-0.005
	(0.016)	(0.018)	(0.002)	(0.012)
EntryPH x HighOpp	0.041***	0.061***	0.001	-0.004
	(0.015)	(0.016)	(0.002)	(0.011)
PostPH x HighOpp	0.108***	0.126***	0.004**	-0.021*
	(0.017)	(0.018)	(0.002)	(0.012)
NewSchool	-0.034***	-0.033***	-0.007***	0.020***
	(0.009)	(0.009)	(0.001)	(0.006)
NewAddress	0.001	0.005	-0.005***	0.026***
	(0.010)	(0.010)	(0.001)	(0.007)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.727	0.745	0.697	0.628
N obs	35,456	35,456	35,456	35,456

Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
PostPH x HighOpp and PostPH x LowOpp are statistically different at the 0.1 level for columns 1-4.

Table 6. Regression results for student outcomes by origin neighborhood, AY 2009-17

Dependent variable:	zELA (1)	zMath (2)	Attendance (3)	ChrnAbsent (4)
EntryPH x LowOrigin	0.041***	0.049***	0.001	-0.003
	(0.014)	(0.015)	(0.002)	(0.010)
PostPH x LowOrigin	0.103***	0.111***	0.002	-0.008
	(0.016)	(0.017)	(0.002)	(0.011)
EntryPH x HighOrigin	0.036**	0.051***	0.002	-0.007
	(0.018)	(0.018)	(0.002)	(0.014)
PostPH x HighOrigin	0.076***	0.106***	0.006**	-0.029**
	(0.019)	(0.020)	(0.002)	(0.014)
NewSchool	-0.035***	-0.033***	-0.007***	0.019***
	(0.009)	(0.009)	(0.001)	(0.006)
NewAddress	0.002	0.006	-0.005***	0.026***
	(0.010)	(0.010)	(0.001)	(0.007)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.727	0.745	0.697	0.628
N obs	35,456	35,456	35,456	35,456

Note: Robust standard errors are shown in parentheses (*** $p<0.01$, ** $p<0.05$, * $p<0.1$).
PostPH x HighOrigin and PostPH x LowOrigin are statistically different at the 0.1 level for columns 1, 3, and 4.

Table 7. Regression results for test scores by sex, AY 2009-17.

Dependent variable:	zELA (1)	zMath (2)	Attendance (3)	ChrnAbsent (4)
EntryPH x Female	0.067***	0.067***	0.001	-0.005
	(0.015)	(0.015)	(0.002)	(0.010)
PostPH x Female	0.148***	0.153***	0.002	-0.007
	(0.016)	(0.018)	(0.002)	(0.012)
EntryPH x Male	0.012	0.030*	0.001	-0.002
	(0.015)	(0.016)	(0.002)	(0.011)
PostPH x Male	0.043**	0.064***	0.003	-0.019
	(0.017)	(0.018)	(0.002)	(0.012)
NewSchool	-0.036***	-0.034***	-0.007***	0.020***
	(0.009)	(0.009)	(0.001)	(0.006)
NewAddress	0.002	0.006	-0.005***	0.026***
	(0.010)	(0.010)	(0.001)	(0.007)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.728	0.745	0.697	0.628
N obs	35,456	35,456	35,456	35,456

Note: Robust standard errors are shown in parentheses (*** $p<0.01$, ** $p<0.05$, * $p<0.1$).
PostPH x Female and PostPH x Male are statistically different at the 0.01 level for columns 1 and 2.

Table 8. Regression results for test scores by race, AY 2009-17.

Dependent variable:	zELA	zMath	Attendance	ChrnAbsent
	(1)	(2)	(3)	(4)
EntryPH x Hispanic	0.039**	0.040**	0.001	-0.003
	(0.015)	(0.016)	(0.002)	(0.011)
PostPH x Hispanic	0.091***	0.095***	0.002	-0.001
	(0.017)	(0.018)	(0.002)	(0.012)
EntryPH x Black	0.018	0.033**	-0.000	-0.004
	(0.015)	(0.016)	(0.002)	(0.011)
PostPH x Black	0.063***	0.084***	0.002	-0.030**
	(0.017)	(0.019)	(0.002)	(0.012)
EntryPH x Asian	0.189***	0.172***	0.005**	0.003
	(0.033)	(0.026)	(0.002)	(0.014)
PostPH x Asian	0.297***	0.316***	0.010***	-0.012
	(0.029)	(0.029)	(0.002)	(0.014)
EntryPH x White	0.011	0.126***	0.006	0.001
	(0.045)	(0.046)	(0.004)	(0.034)
PostPH x White	0.162***	0.178***	-0.005	0.073**
	(0.044)	(0.044)	(0.005)	(0.033)
NewSchool	-0.033***	-0.032***	-0.007***	0.020***
	(0.009)	(0.009)	(0.001)	(0.006)
NewAddress	0.000	0.005	-0.005***	0.025***
	(0.010)	(0.010)	(0.001)	(0.007)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.727	0.745	0.697	0.628
N obs	36,560	36,560	36,560	36,560

Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 9. Regression results for school characteristics by destination neighborhood, AY 2009-17.

Dependent variable:	Enrollment	% ED	zELA	zMath
	(1)	(2)	(3)	(4)
EntryPH x LowOpp	-52.646***	0.888***	-0.025***	-0.029***
	(6.255)	(0.256)	(0.006)	(0.006)
PostPH x LowOpp	-57.918***	0.736**	-0.016**	-0.019**
	(8.572)	(0.341)	(0.008)	(0.009)
EntryPH x HighOpp	-45.621***	-0.264	0.003	-0.004
	(6.758)	(0.276)	(0.006)	(0.007)
PostPH x HighOpp	-43.123***	-0.787**	0.029***	0.022**
	(8.867)	(0.358)	(0.008)	(0.009)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.616	0.615	0.701	0.718
N obs	35,456	35,456	35,456	35,456

Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 10. Regression results for school characteristics by origin neighborhood, AY 2009-17.

Dependent variable:	Enrollment	% ED	zELA	zMath
	(1)	(2)	(3)	(4)
EntryPH x LowOrigin	-63.106***	-0.084	-0.003	-0.009
	(5.672)	(0.229)	(0.005)	(0.006)
PostPH x LowOrigin	-69.437***	-0.629*	0.017**	0.013
	(8.149)	(0.324)	(0.007)	(0.008)
EntryPH x HighOrigin	-3.295	1.849***	-0.044***	-0.046***
	(9.060)	(0.386)	(0.008)	(0.009)
PostPH x HighOrigin	13.213	2.248***	-0.035***	-0.043***
	(10.625)	(0.446)	(0.010)	(0.011)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.618	0.616	0.701	0.718
N obs	35,456	35,456	35,456	35,456

Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 11. Regression results for school characteristics by sex, AY 2009-17.

Dependent variable:	Enrollment (1)	% ED (2)	zELA (3)	zMath (4)
EntryPH x Female	-53.026***	0.072	-0.003	-0.011
	(6.489)	(0.265)	(0.006)	(0.007)
PostPH x Female	-61.732***	-0.044	0.023***	0.017**
	(8.710)	(0.348)	(0.008)	(0.009)
EntryPH x Male	-46.216***	0.648**	-0.021***	-0.025***
	(6.487)	(0.266)	(0.006)	(0.007)
PostPH x Male	-39.340***	0.078	-0.014*	-0.018**
	(8.709)	(0.349)	(0.008)	(0.009)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.617	0.615	0.701	0.718
N obs	35,456	35,456	35,456	35,456

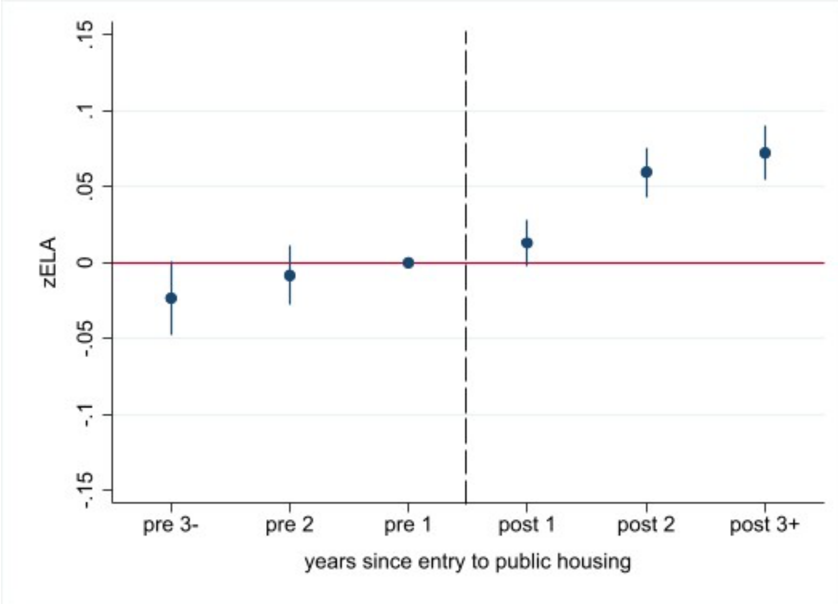
Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 12. Regression results for school characteristics by race/ethnicity, AY 2009-17.

Dependent variable:	Enrollment (1)	% ED (2)	zELA (3)	zMath (4)
EntryPH x Hispanic	-71.668***	0.356	-0.011*	-0.019***
	(6.613)	(0.266)	(0.006)	(0.007)
PostPH x Hispanic	-89.428***	0.463	-0.009	-0.014*
	(8.735)	(0.344)	(0.008)	(0.009)
EntryPH x Black	-35.863***	0.936***	-0.024***	-0.028***
	(6.602)	(0.274)	(0.006)	(0.007)
PostPH x Black	-36.020***	0.795**	-0.005	-0.005
	(8.808)	(0.356)	(0.008)	(0.009)
EntryPH x Asian	1.640	-3.275***	0.047***	0.047***
	(14.836)	(0.637)	(0.015)	(0.015)
PostPH x Asian	62.516***	-7.880***	0.141***	0.111***
	(15.328)	(0.638)	(0.016)	(0.016)
EntryPH x White	11.381	2.522**	-0.002	-0.022
	(31.122)	(1.144)	(0.024)	(0.027)
PostPH x White	107.635***	5.255***	0.029	0.039
	(31.133)	(1.173)	(0.025)	(0.027)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.620	0.620	0.702	0.719
N obs	35,456	35,456	35,456	35,456

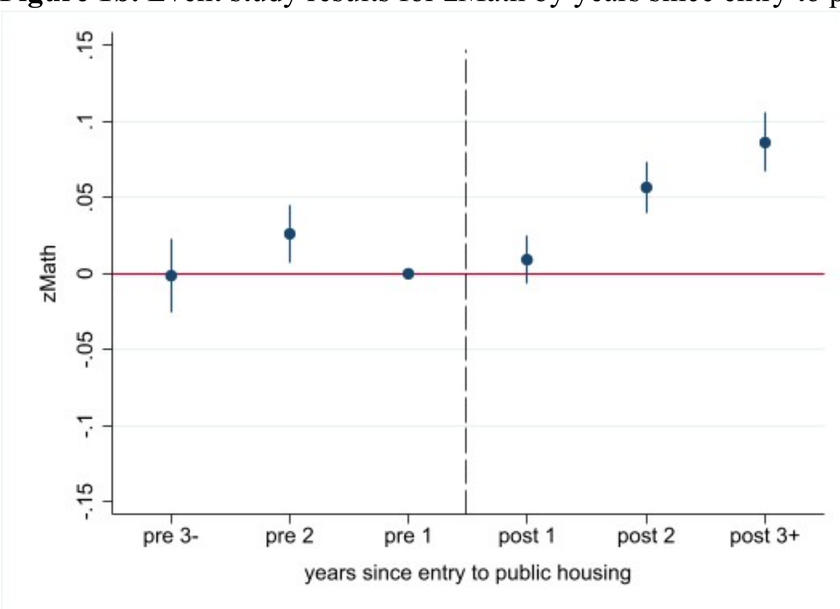
Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Figure 1a. Event study results for zELA by years since entry to public housing, AY 2009-17.



Notes: N=36,560. Reference year is the year prior to entry (pre 1). Student fixed effects are included in the models.

Figure 1b. Event study results for zMath by years since entry to public housing, AY 2009-17.



Notes: N=36,560. Reference year is the year prior to entry (pre 1). Student fixed effects are included in the models.

Appendix

Table A.1. Regression results for student outcomes without exiters, AY 2009-17.

Dependent variable:	zELA (1)	zMath (2)	Attendance (3)	ChrnAbsent (4)
EntryPH	0.041***	0.049***	0.001	-0.004
	(0.013)	(0.014)	(0.002)	(0.009)
PostPH	0.097***	0.110***	0.002	-0.013
	(0.015)	(0.016)	(0.002)	(0.011)
NewSchool	-0.034***	-0.033***	-0.007***	0.020***
	(0.009)	(0.009)	(0.001)	(0.006)
NewAddress	0.002	0.006	-0.005***	0.026***
	(0.010)	(0.010)	(0.001)	(0.007)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.727	0.727	0.745	0.745
N obs	29,453	29,453	29,453	29,453

Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1). EntryPH and PostPH are statistically different at the 0.01 level for columns 1 and 2.

Table A.2. Regression results for student outcomes, grades K-12, AY 2009-17.

Dependent variable:	Attendance (1)	ChrnAbsent (2)	Obese (3)	Overweight (4)
EntryPH	0.001	-0.001	-0.001	-0.004
	(0.001)	(0.009)	(0.007)	(0.008)
PostPH	0.002	-0.005	-0.007	-0.004
	(0.002)	(0.011)	(0.008)	(0.009)
NewSchool	-0.005***	0.027***	-0.008*	-0.003
	(0.001)	(0.007)	(0.005)	(0.006)
NewAddress	-0.004***	0.014	-0.004	0.007
	(0.001)	(0.006)	(0.004)	(0.005)
Student FX & Grade FX	Y	Y	Y	Y
Time-varying characteristics	Y	Y	Y	Y
R2	0.670	0.600	0.734	0.726
N obs	38,812	38,812	38,812	38,812

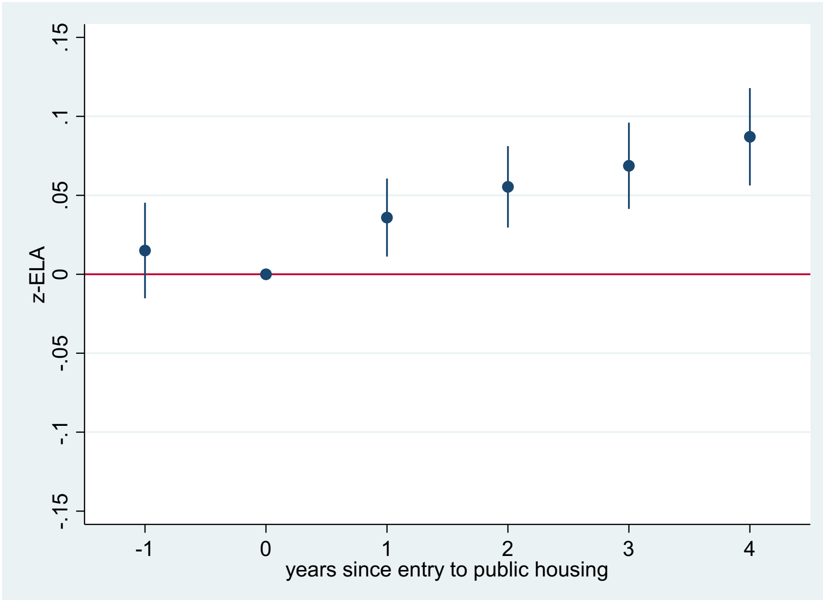
Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table A.3. Regression results for weight outcomes by sex, grades K-12, AY 2009-17.

Dependent variable:	Obese (1)	Overweight (2)
EntryPH x Female	-0.001	0.001
	(0.007)	(0.009)
PostPH x Female	0.001	0.014
	(0.008)	(0.010)
EntryPH x Male	-0.000	-0.010
	(0.008)	(0.009)
PostPH x Male	-0.015*	-0.024**
	(0.005)	(0.010)
NewSchool	-0.008*	-0.002
	(0.005)	(0.006)
NewAddress	0.004	0.007
	(0.004)	(0.005)
Student FX & Grade FX	Y	Y
Time-varying characteristics	Y	Y
R2	0.726	0.726
N obs	38,812	38,812

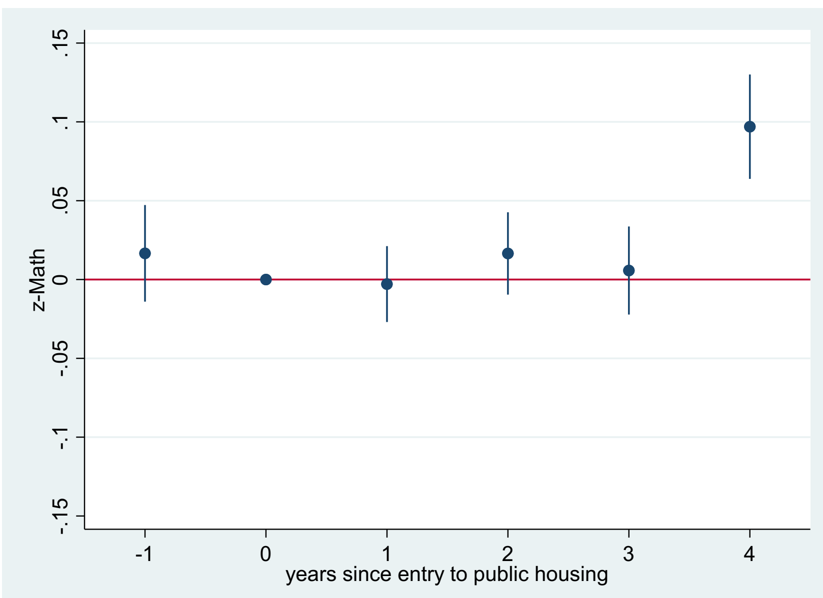
Note: Robust standard errors are shown in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
PostPH x Female and PostPH x Male are statistically different at the 0.01 level for columns 1 and 2.

Figure A.1a. Event study results for z-ELA by years since entry to public housing, *G5*.



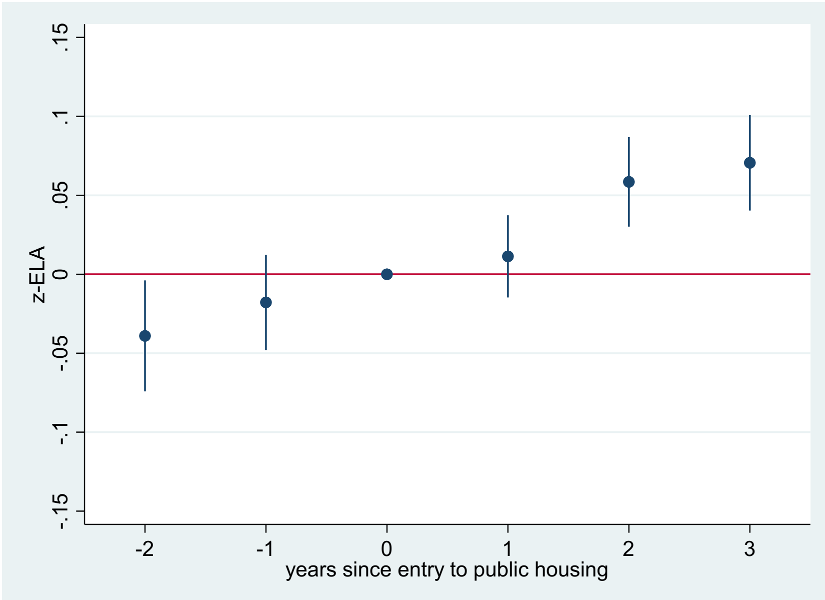
Notes: N=13,697; reference year is the year prior to entry (-1); student fixed effects are included in the model; joint F-test on pre-entry years in public housing p=0.330 and on post-entry years in public housing p=0.004.

Figure A.1b. Event study results for z-Math by years since entry to public housing, *G5*.



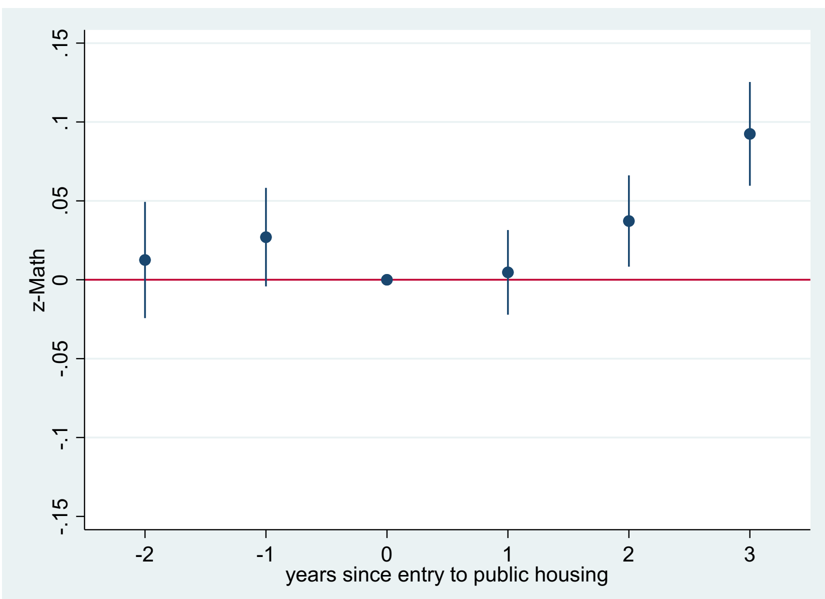
Notes: N=13,697; reference year is the year prior to entry (-1); student fixed effects are included in the model; joint F-test on pre-entry years in public housing p=0.288 and on post-entry years in public housing p=0.000.

Figure A.2a. Event study results for z-ELA by years since entry to public housing, *G6*.



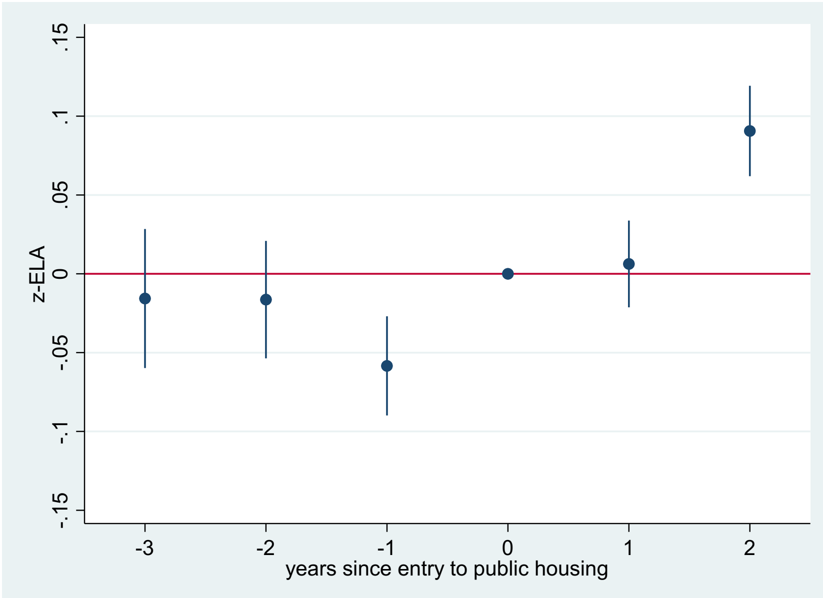
Notes: N=12,605; reference year is the year prior to entry (-1); student fixed effects are included in the model; joint F-test on pre-entry years in public housing p=0.243 and on post-entry years in public housing p=0.000.

Figure A.2b. Event study results for z-Math by years since entry to public housing, *G6*.



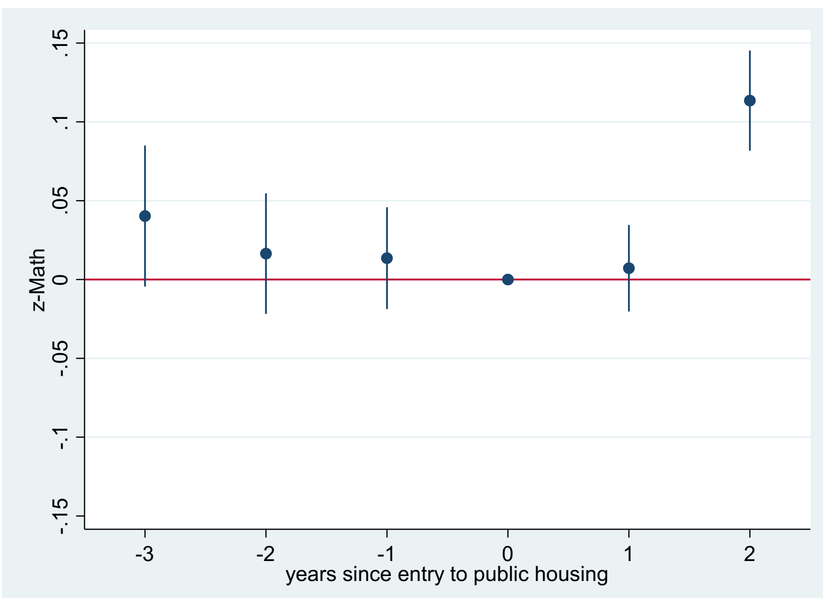
Notes: N=12,605; reference year is the year prior to entry (-1); student fixed effects are included in the model; joint F-test on pre-entry years in public housing p=0.450 and on post-entry years in public housing p=0.000.

Figure A.3a. Event study results for z-ELA by years since entry to public housing, *G7*.



Notes: N=10,258; reference year is the year prior to entry (-1); student fixed effects are included in the model; joint F-test on pre-entry years in public housing p=0.003 and on post-entry years in public housing p=0.000.

Figure A.3b. Event study results for z-Math by years since entry to public housing, *G7*.



Notes: N=10,258; reference year is the year prior to entry (-1); student fixed effects are included in the model; joint F-test on pre-entry years in public housing p=0.363 and on post-entry years in public housing p=0.000.