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Adolescence is a Sensitive Period for Housing Mobility to Influence Risky Behaviors: An Experimental Design

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Abstract

Purpose—Test whether neighborhood mobility effects on adolescent risky behaviors varies at different developmental ages and gender.

Methods—The Moving to Opportunity (MTO) study randomly assigned volunteer families (1994–1997) to receive a Section 8 voucher to move to lower poverty neighborhoods versus a public housing control group. We tested three-way treatment, gender, and age-at-randomization interactions using intent-to-treat linear regression predicting a risky behavior index (RBI; measured in 2002, N = 2,829), defined as the fraction of 10 behaviors the youth reported (six measuring risky substance use [RSU], four measuring risky sexual behavior), and the RSU and risky sexual behavior subscales.

Results—The treatment main effect on RBI was nonsignificant for girls (B = −.01, 95% confidence interval −.024 to .014) and harmful for boys (B = .03, 95% confidence interval .009 to .059; treatment-gender interaction $p = .01$). The treatment, gender, and age interaction was significant for RBI ($p = .02$) and RSU ($p \leq .001$). Treatment boys 10 years or older at randomization were more likely ($p < .05$) than controls to exhibit RBI and RSU, whereas there was no effect of treatment for boys <10 years. There were no treatment control differences by age for girls' RBI, but girls 9+ years were less likely than girls ≤8 years to exhibit RSU ($p < .05$).

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Authors' contribution: Dr. Schmidt conceptualized and designed the study, executed all analyses and drafted the manuscript. Dr. Glymour edited the manuscript and advised on the interpretation of findings. Dr. Osypuk helped conceptualize and design the study, drafted the manuscript, and advised on the interpretation of findings. All authors have approved the final manuscript as submitted. The authors presented preliminary results from this manuscript at the Society for Epidemiologic Research (SER) June 2016 meeting.

Supplementary Data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jadohealth.2016.10.022.

Conclusions—Moving families of boys aged 10 years or older with rental vouchers may have adverse consequences on risky behaviors but may be beneficial for girls' substance use. Developmental windows are different by gender for the effects of improving neighborhood contexts on adolescent risky behavior.

Keywords

Risky behaviors; Sensitive periods; Adolescent behavior; Randomized controlled trial; Housing; Public housing; Adolescence

Adolescent risky behaviors, including substance use and risky sexual behavior (RSB), are significant public health concerns [1,2]. These behaviors co-occur during adolescence [3,4] and have both short- and long-term detrimental consequences for social and health outcomes [5]. Developmental theories suggest that antisocial behaviors may escalate over time and persist into adulthood [6], therefore, identifying the early causes is critical. Neighborhood context is one such early cause and is associated with a wide range of health and social outcomes, including risky behaviors [7,8].

However, most prior research does not consider how the developmental timing of exposures, particularly during childhood, can modify exposure impacts on health and health behaviors (i.e., critical or sensitive periods) [9]. Housing mobility may be most impactful during adolescence, in particular, since it is a period marked by dramatic biological, psychological, and social changes shaping risk and protective factors for health [9].

Moving is a stressor for children [10–12], but the effects of mobility may differ by gender [13]. For example, boys moving to more advantaged neighborhoods may fall in with riskier peer groups in their new neighborhoods, increasing their vulnerability to housing mobility [14]. In contrast, girls from high-disorder neighborhoods (i.e., disadvantaged neighborhoods) may be three times more likely than those from low-disorder neighborhoods to report sexual victimization [15]. For girls, the benefit of escaping this stressor may outweigh the trauma of moving [16].

The Moving to Opportunity (MTO) Demonstration Project is the only large-scale experiment based on extant US affordable housing policy [17] to examine the health effects of moving to more affluent neighborhoods. Leveraging this policy-relevant experimental design, the gold standard for causal inference [17,18], we examine how housing mobility affects adolescent risky behaviors. Specifically, we test whether the child's age at random assignment and gender modify treatment effects, to identify developmental periods when housing mobility is more influential for health.

Methods

The US Department of Housing and Urban Development sponsored MTO, a randomized controlled trial in 5 US cities (Baltimore, Boston, Chicago, Los Angeles, and New York) [19]. Eligible volunteer families were low income, had children younger than 18 years, qualified for rental assistance, and lived in distressed public housing in poor neighborhoods [19]. Volunteers were selected from waiting lists, and, once eligibility was confirmed,

completed enrollment agreements, informed consent forms, and the baseline survey [19]. MTO is not a medical intervention and was not registered as a clinical trial. University of Minnesota's Institutional Review Board approved this research.

Treatment group assignment

Specialized software randomly assigned eligible volunteer families (N = 4,610) from 1994 to 1998 to: (1) a "low-poverty" group offered a rental voucher subsidizing rent in neighborhoods with <10% of the population in poverty, paired with housing relocation counseling; (2) a "Section 8" group offered a regular Section 8 voucher redeemable in any neighborhood; or (3) a control group that could remain in public housing [19]. Both voucher groups had 90 days to use the voucher, after which it expired.

Assessment

We used data from the baseline (1994–1998) and interim surveys (2001–2002; 4–7 years later), conducted via in-person interviews with household heads and their children [20]. We do not use final survey data (2008–2010; 10–15 years later) because children in the pre-to late-adolescent period at study randomization (1994–1997) would be in early adulthood at the final survey, and our outcomes would not be developmentally appropriate. Most of the 5-to 16-year olds at baseline were not interviewed at the final survey. This same sample was aged 12–19 years at interim, making the interim survey the appropriate target period for our study. Up to two randomly selected children per family were interviewed. We focus on adolescents aged 12–19 years by May 31, 2001 (n = 2,829 of 3,537 youth eligible, 89.3% response rate) [20].

Measures

Our outcome, the risky behavior index (RBI), is the fraction of 10 items (0 = no, 1 = yes) youth self-report relating to risky substance use (RSU) and RSB, including: past 30-day alcohol use, cigarette use, marijuana use, binge drinking, alcohol and (separately) marijuana use before or during school or work, no condom use during last sexual intercourse, no contraceptive use during last intercourse, early sexual initiation (before age 15), and 2 or more sexual partners in the past year (Cronbach's $\alpha = .75$, mean [SD] = .13 [.18]). The RBI focuses on more recent, and a wider range of, behavior than original work documenting gender effects of MTO on a four-item scale measuring lifetime alcohol, cigarette, and marijuana use, and sexual intercourse ever [20]. Analyses using the original scale were substantively similar. We also examined the RSU ($\alpha = .74$, mean [SD] = .08 [.17]) and RSB ($\alpha = .64$, mean [SD] = .20 [.27]) subscales.

Randomly assigned treatment consisted of two treatment arms (low poverty and Section 8) and the control group. Both treatment groups experienced improved neighborhood poverty compared with controls (Appendix Table 1), and homogeneous ($p < .05$) treatment effects on all outcomes, therefore, we combined the two treatment arms. Analyses retaining the three treatment groups show identical patterns, with slightly larger effects for the low-poverty group. MTO families could move without a treatment voucher, which occurred throughout follow-up, sometimes more than once, so the exposure here is the initial housing voucher

offer. The effect modifier is age at randomization (range: 5–16 years, mean = 10 years), which we model linearly. Sensitivity analyses confirmed linearity.

Analytic approach

We estimated intention-to-treat (ITT) analyses, preserving the strength of the experimental design, to assess the average effect of being randomly offered a housing voucher compared with controls. We estimated linear regression models in Stata 13, adjusted for site and household clustering, and weighted for changing random assignment ratios and attrition [21]. Missing data on the outcomes were minimal (range: 1%–4%), so we estimated complete case analyses.

We tested three-way treatment-gender-age interactions to preserve power and accommodate well-documented gender modification [20–23]. We output age-specific treatment control differences using postestimation commands and calculated effect sizes [24] and number needed to harm/treat (NNH/NNT) [25], to quantify the magnitude of our effects (Appendix Table 2). We graphed the treatment control differences by age at randomization and gender, with 95% confidence intervals (CIs). Since these outcomes are more likely to manifest among older youth, we estimated sensitivity analyses by (1) adjusting for interim survey age and (2) restricting the sample to older children (15- to 19-year-olds) to confirm the robustness of our findings.

Since only half of the treatment group moved using a treatment voucher (take up) [20], we estimated instrumental variable (IV) treatment-on-treated (TOT) analyses to assess the average effect of actually moving with the offered voucher [17]. If families with boys or older adolescents are more or less likely to take up the voucher, then ITT estimates would capture this differential selection. TOT analyses isolate the effect of moving that is entirely caused by treatment assignment, effectively removing differential selection from the estimates. If TOT and ITT analyses converge, this rules out selective take-up by adolescent age or gender as an explanation for any observed effect modification of treatment. In the first-stage TOT models, we predicted treatment take-up from randomized MTO treatment and covariates to obtain the probability of voucher take up for the whole sample (no controls could take up a voucher by design). In the second stage, we used the probability of take up as a predictor to estimate the effect of moving with the voucher. IV methods estimate the unbiased effect of moving [21,26] and readily accommodate effect modification [22,23,27].

Results

Baseline variables were mostly balanced across treatment groups (Table 1), but youth behavior problems and problems requiring special medicine or equipment were more prevalent in the treatment group. Adjusting for these two imbalanced covariates did not affect our results.

Effect modification by gender

Outcome descriptives are presented by gender, for the total sample and by treatment group (Table 2). Gender modified the treatment effect on the RBI (interaction $p = .01$) and RSU (interaction $p < .001$; Table 3). Gender did not modify the treatment effect on RSB (Table 3);

the gender-pooled main effect of MTO on RSB was marginally statistically significant and harmful (Beta(standard error) = .024(.013), $p = .07$, 95% CI: −.002 to .05).

MTO had harmful effects on boys' RBI and RSU. MTO had nonsignificant effects on girls' RBI but had significant beneficial effects on girls' RSU. IV analyses adjusting for voucher take up demonstrated similar patterns, with estimates about twice as large as ITT.

Risky behavior index

The three-way treatment, gender, and age at randomization interaction was significant for RBI (interaction $p = .02$). For RBI (Figure 1A), boys experienced harmful treatment effects compared with controls beginning at age 10 (when the 95% CI no longer contained 0), with larger adverse effects at every additional year of age. For example, the adverse effect for boys receiving a voucher at age 15 was .41 SD higher compared with controls (a moderate effect), with an NNH of −2.5 (Appendix Table 2); this means that if 100 boys aged 15 years were assigned MTO treatment, 40 would report higher levels of risky behaviors than control group boys of the same age. In contrast, the adverse effect for boys receiving a voucher at age 10 was only .14 SD higher (a small effect), with an NNH of −20, meaning that if 100 boys aged 10 years were assigned MTO treatment, only five would report higher levels of risky behaviors than control group boys of the same age. MTO treatment did not affect girls' RBI (Figure 1A).

Risky substance use

The three-way interaction was also significant for RSU (interaction $p = .01$) (Figure 1C), which, for boys, demonstrated similar patterns and a similar magnitude of effects as the RBI. Harmful effects emerged for boys as early as age 9, with the most harm (i.e., the biggest treatment control difference) concentrated among the oldest boys at randomization. In contrast, effects were beneficial for girls' RSU when age at randomization was 9 years or older and increased with age, although the 95% CI widens as age increases. Specifically, the treatment effect for girls receiving a voucher at age 15 was .25 SD lower compared with controls (a small effect), with an NNT of 8.3 (Appendix Table 2); this means that if 100 girls aged 15 years were assigned MTO treatment, 12 would report lower levels of risky behaviors than control group girls of the same age. In contrast, the effect of receiving a voucher at age 10 was only .13 SD lower (a small effect), with an NNH of 25, meaning that if 100 girls aged 10 years were assigned MTO treatment, only four would report lower levels of risky behaviors than control group girls of the same age. IV patterns were similar to ITT but larger for both RBI and RSU (Figure 1B,D, respectively), with IV effect sizes in the moderate to large range for boys, and in the small to moderate range for girls (Appendix Table 2).

Risky sexual behavior

Gender and age did not modify the marginally statistically significant treatment effects on RSB (interaction $p = .27$; Appendix Figure 1), but there was a marginally statistically significant two-way treatment age interaction (interaction $p = .09$). ITT models demonstrated harmful effects of MTO on RSB for youth who were aged 11 to 16 years at

randomization, with effects increasingly harmful at older ages (Figure 2A), and IV patterns that were similar but larger (Figure 2B).

Discussion

In this randomized trial of rental housing subsidy vouchers for low-income families, we found that children's age at randomization and gender modified MTO treatment effects on risky behaviors.

Effect modification among boys

For boys, the age modification resulted in harmful treatment effects for all three outcomes. Prior literature has documented this trend in other outcomes [20–23], as well as the differential effects by age on physical health [28] and income [29]. Additional research has documented that the adverse effects for boys were concentrated in families with baseline health vulnerabilities and violent victimization [22,23]. Yet until this study, no literature has documented that the harmful effects of housing mobility for boys' risky behaviors are concentrated among those aged 10 years or older when they moved.

Effects ranged from moderate to large for boys aged 15 years, and small to moderate for boys aged 10 for RBI and RSU, but were small for RSB. Consistent with the literature, adolescence is a sensitive period [9], and for boys, the trauma of moving [10] may explain their worse outcomes compared with controls. Housing mobility also may disconnect boys from social networks, leaving them vulnerable to falling in with riskier peer groups in their new neighborhoods [14]. Indeed, recent research suggests that youth without dense, secure social networks in their neighborhoods (i.e., strong econetworks) are at a higher risk for health risk behaviors [30]. This remains an important avenue to investigate.

Effect modification among girls

For girls, the findings are more complex with different patterns emerging for substance use and sexual risk behaviors. Receiving MTO treatment at older ages was increasingly beneficial for girls' RSU, compared with controls, with small to moderate effects. However, MTO was increasingly harmful for girls' RSB at older ages (like boys), although effects were small. Overall RBI is nonsignificant, given opposite subscale patterns.

MTO improved a range of mental health outcomes for treatment girls compared with controls [20–23], and there was evidence of harmful effects on physical health [28] and beneficial effects on income [29] at certain ages. A key reason for the benefits to girls identified from MTO qualitative work may be the reduced sexual victimization risk girls experienced in lower poverty compared with high-poverty neighborhoods [16]. Girls 11–17 years old (vs. younger) have a higher risk for sexual violence [31], thus arguably have more to gain from moving. To the extent that girls resort to destructive coping mechanisms, like substance use, to deal with sexual trauma [32], removing this threat may explain reduced substance use among treatment group girls.

The harmful MTO effects for girls in terms of higher sexual risk suggests that girls' risk of sexual violence [16] is unrelated to consensual sexual behavior, and an entirely different

mechanism is at work. For example, girls who moved to new neighborhoods may have encountered peer rejection or peer pressure and engaged in riskier sex [33] as a means of gaining acceptance.

Implications and limitations

Conceivably, the effects of age at randomization may be conflated with the outcomes. In other words, we may have found effects concentrated among older children because children younger at randomization were simply not old enough to engage in risky behaviors; children randomized at age 5 would be 12 at the interim survey, whereas children randomized at age 12 could be 16 to 19. We explored this with two sensitivity analyses. First, we adjusted all models for interim survey age. Second, we reestimated all models among children aged 15 to 19 years at interim (8–16 at randomization). Both analyses replicated the patterns of our results.

These results suggest that the effects of housing mobility are contingent upon characteristics of the child and family and are consistent with other work demonstrating that only girls from families with no baseline health vulnerabilities or violent victimization experienced better mental health, whereas only boys from families with baseline health vulnerabilities or violent victimization experienced worse mental health [22,23]. Moreover, children younger than 13 years at randomization were the only group to exhibit income gains over controls, after reaching young adulthood [29]. Our work, and others, not only supports the existence of sensitive periods but also highlights how sensitive periods may differ by outcome.

One implication is that boys, particularly when moved during adolescence, may require additional supports to succeed. The housing choice voucher (HCV) program (formerly Section 8) is the largest federal affordable housing program in the United States [34]. Although housing mobility programs are beginning to supplement HCV with additional services [35], their scope remains small. Our study adds to growing evidence that policies outside the health sector, such as MTO, influence the health of children and families [36], and that these programs may improve health of low-income families by improving the social determinants of health and health disparities.

It is important to note that we cannot disentangle the bundled effects of neighborhoods and housing mobility. Consistent with prior work [22,23,27], we found no differences between the two voucher groups, therefore housing mobility, and/or changes in neighborhood poverty (either to moderate or low poverty), may drive effects. Housing mobility is a negative stressor for children, which aligns with our findings for boys and for girls' RSB [10,11]. However, our findings for girls' RSU suggest that all moves may not be equal and are consistent with limited evidence that higher quality moves may offset adverse effects of housing mobility for some children [37]. Notably, the homogenous effects for the two voucher groups on health may suggest housing mobility as more important for adolescents, whereas adults may be more impacted by neighborhood environment [21,38] and less impacted by residential mobility [11]. This is important to explore given the higher frequency with which low-income households move [39].

Although the MTO interim data are now 15 years old, the benefits of using these rigorous experimental data outweigh the limitations. First, we would not be able to test our hypotheses focused on adolescence with the final data, given that children in the targeted baseline age range would be too old. Second, since Section 8/HCVs remain the predominant federal affordable housing policy [34], and this unique experiment is not likely to be replicated, we still have much to learn from this program. MTO participants comprised a disadvantaged, urban, minority sample, potentially limiting generalizability. However, as the target of federal subsidized housing programs, this is a policy-relevant population.

The effects of moving children to lower poverty neighborhoods depends on gender and the child's age, with later moves harmful for boys' substance use and for both genders' sexual risk behaviors, but beneficial for girls' substance use. Our findings highlight the potentially large effect that a major family transition, such as moving, can have on children's behavioral health. Children who move during this developmental stage may require additional social supports to offset the potentially adverse impacts of housing mobility on health. Better understanding what shapes children's response to moves is important to inform the policies and programs that improve health of low-income families.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. CDC. Annual smoking-attributable mortality, years of potential life lost, and productivity losses-United States, 1997–2001. MMWR. 2005; 54:625–8. [PubMed: 15988406]
2. Hawkins JD, Catalano RF, Miller JY. Risk and protective factors for alcohol and other drug problems in adolescence and early adulthood: Implications for substance abuse prevention. Psychol Bull. 1992; 112:64–105. [PubMed: 1529040]
3. Jessor, R., Jessor, S. Problem behavior and psychosocial development. New York, NY: Academic Press, Inc; 1977.
4. Ketterlinus R, Lamb M, Nitz K, Elster A. Adolescent nonsexual and sexual-related problem behaviors. J Adolesc Res. 1992; 7:431–56.
5. Kessler RC, Avenevoli S, Ries Merikangas K. Mood disorders in children and adolescents: An epidemiologic perspective. Biol Psychiatry. 2001; 49:1002–14. [PubMed: 11430842]
6. Moffitt TE. Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. Psychol Rev. 1993; 100:674–701. [PubMed: 8255953]
7. Leventhal T, Brooks-Gunn J. The neighborhoods they live in: The effects of neighborhood residence on child and adolescent outcomes. Psychol Bull. 2000; 126:309–37. [PubMed: 10748645]
8. Browning CR, Leventhal T, Brooks-Gunn J. Neighborhood context and racial differences in early adolescent sexual activity. Demography. 2004; 41:697–720. [PubMed: 15622950]
9. Kuh D, Ben-Shlomo Y, Lynch J, et al. Glossary: Life course epidemiology. J Epidemiol Community Health. 2003; 57:778–83. [PubMed: 14573579]

10. Leventhal T, Newman S. Housing and child development. Child Youth Serv Rev. 2010; 32:1165–74.
11. Jelleyman T, Spencer N. Residential mobility in childhood and health outcomes: A systematic review. J Epidemiol Community Health. 2008; 62:584–92. [PubMed: 18559440]
12. Mok PL, Webb RT, Appleby L, Pederson CB. Full spectrum of mental disorders linked with childhood residential mobility. J Psychiatr Res. 2016; 78:57–64. [PubMed: 27074536]
13. Pearlin LI. The sociological study of stress. J Health Soc Behav. 1989; 30:241–56. [PubMed: 2674272]
14. Clampet-Lundquist S, Edin K, Kling JR, Duncan GJ. Moving teenagers out of high-risk neighborhoods: How girls fare better than boys. Am J Sociol. 2011; 116:1154–89. [PubMed: 21648249]
15. Turner HA, Shattuck A, Hamby S, Finkelhor D. Community disorder, victimization exposure, and mental health in a National Sample of Youth. J Health Soc Behav. 2013; 54:258–75. [PubMed: 23525045]
16. Popkin, SJ., Leventhal, T., Weismann, G. Girls in the 'Hood: The Importance of Feeling Safe. Washington, DC: The Urban Institute; 2008.
17. Ludwig J, Liebman JB, Kling JR, et al. What can we learn about neighborhood effects from the moving to opportunity experiment? Am J Sociol. 2008; 114:144–88.
18. Sobel ME. What do randomized studies of housing mobility demonstrate? causal inference in the face of interference. J Am Stat Assoc. 2006; 101:1398–407.
19. Goering, J., Kraft, J., Feins, J., et al. Moving to opportunity for fair housing demonstration program: Current status and initial findings. Washington, DC: US Department of Housing & Urban Development, Office of Policy Development and Research; 1999.
20. Orr, L., Feins, JD., Jacob, R., et al. Moving to opportunity for fair housing demonstration program: Interim impacts evaluation. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research; 2003.
21. Kling JR, Liebman JB, Katz LF. Experimental analysis of neighborhood effects. Econometrica. 2007; 75:83–119.
22. Osypuk TL, Schmidt NM, Bates LM, et al. Gender and crime victimization modify neighborhood effects on adolescent mental health. Pediatrics. 2012; 130:472–81. [PubMed: 22908105]
23. Osypuk TL, Tchetgen Tchetgen EJ, Acevedo-Garcia D, et al. Differential mental health effects of neighborhood relocation among youth in vulnerable families. Arch Gen Psychiatry. 2012; 69:1284–94. [PubMed: 23045214]
24. Cohen, J. Statistical power analysis for the behavioral sciences. New York, NY: Academic Press; 1969.
25. Cook RT, Sackett DL. The number needed to treat: A clinically useful measure of treatment effect. BMJ. 1995; 310:452–4. [PubMed: 7873954]
26. Angrist JD, Imbens GW, Rubin DB. Identification of causal effects using instrumental variables. J Am Stat Assoc. 1996; 91:444–55.
27. Nguyen QC, Schmidt NM, Glymour MM, et al. Were the mental health benefits of a housing mobility intervention larger for adolescents in higher socioeconomic status families? Health Place. 2013; 23:79–88. [PubMed: 23792412]
28. Fortson JG, Sanbonmatsu L. Child health and neighborhood conditions: Results from a randomized housing voucher experiment. J Hum Resour. 2010; 45:840–64.
29. Chetty R, Hendren N, Katz L. The effects of exposure to better neighborhoods on children: New evidence from the Moving to Opportunity Experiment. American Economic Review. 2016; 106(4): 855–902.
30. Browning CR, Soller B, Jackson AL. Neighborhoods and adolescent health-risk behavior: An ecological network approach. Soc Sci Med. 2015; 125:163–72. [PubMed: 25011958]
31. Black, MC., Basile, KC., Breiding, MJ., et al. The national intimate partner and sexual violence survey: 2010 Summary report. Atlanta GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2011.

32. Miranda R, Meyerson LA, Long PJ, et al. Sexual assault and alcohol use: Exploring the self-medication hypothesis. Violence Vict. 2002; 17:205–17. [PubMed: 12033555]

33. Crockett LJ, Raffaelli M, Shen Y-L. Linking self-regulation and risk proneness to risky sexual behavior: Pathways through peer pressure and early substance use. J Res Adolesc. 2006; 16:503–25.

34. Kruckenberg, K. Poverty & Race Research Action Council. Poverty & Race Research Action Council Policy Brief. Washington DC: Poverty & Race Research Action Council; 2011. Two Simple changes to improve health outcomes in the section 8 voucher program. Available at: http://www.prrac.org/pdf/HQS-SEMAPhealthpolicybriefApril2011.pdf [Accessed November 4, 2016]

35. Scott, M., Cunningham, M., Biess, J., et al. Expanding choice: Practical strategies for building a successful housing mobiity program. Washington, DC: The Urban Institute, Poverty & Race Research Action Council; 2013.

36. Osypuk TL, Joshi P, Geronimo K, Acevedo-Garcia D. Do social and economic policies influence health? a review. Curr Epidemiol Rep. 2014; 1:149–64. [PubMed: 25984439]

37. Hango D. The long-term effect of childhood residential mobility on educational attainment. Sociological Q. 2006; 47:631–64.

38. Ludwig J, Sanbonmatsu L, Gennetian L, et al. Neighborhoods, obesity, and diabetes - a randomized social experiment. N Engl J Med. 2011; 365:1509–19. [PubMed: 22010917]

39. Mateyka, P. Desire to move and residential mobility: 2010–2011. Washington, DC: US Census Bureau; 2015.

IMPLICATIONS AND CONTRIBUTION

Using an experimental design that manipulated family housing context, this study found that a child's gender and older age at random assignment modified effects of moving to more advantaged neighborhoods on adolescent risky behavior, suggesting developmental windows where changes in social determinants of health are more influential for adolescent health.

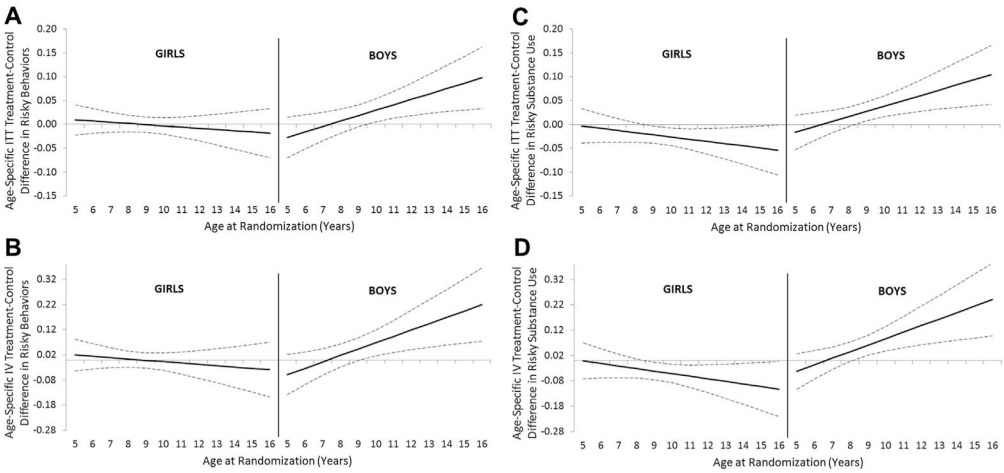

Figure 1.

MTO treatment effects on youth RBI and RSU subscale 4–7 years after randomization with 95% CI, modification by gender and age. (A) Age-specific ITT effect estimates for RBI; (B) age-specific IV adherence-adjusted effect estimates for RBI; (C) age-specific ITT effect estimates for RSU; (D) age-specific IV adherence-adjusted effect estimates for RSU. ITT results, (A) 3-way interaction effect B(SE) = .014(.006), p = .02, 95% CI: .003–.025; IV results, (B) 3-way interaction effect B(SE)= .031(.012), p = .01, 95% CI: .007–.054. ITT results, (C) 3-way interaction effect B(SE) = .016(.006), p = .01, 95% CI: .005–.027; IV results, (D) 3-way interaction effect B(SE) = .036(.012), p = .003, 95% CI: .012–.060. p values reported for each bar test each subgroup effect against a null hypothesis of zero. Models adjusted for site. The y-axis scale is larger in (B) and (D) because the IV effects are nearly twice as large as the ITT effects (A and C). CI = confidence interval; MTO = moving to opportunity; RBI = risky behavior index; RSU = risky substance use.

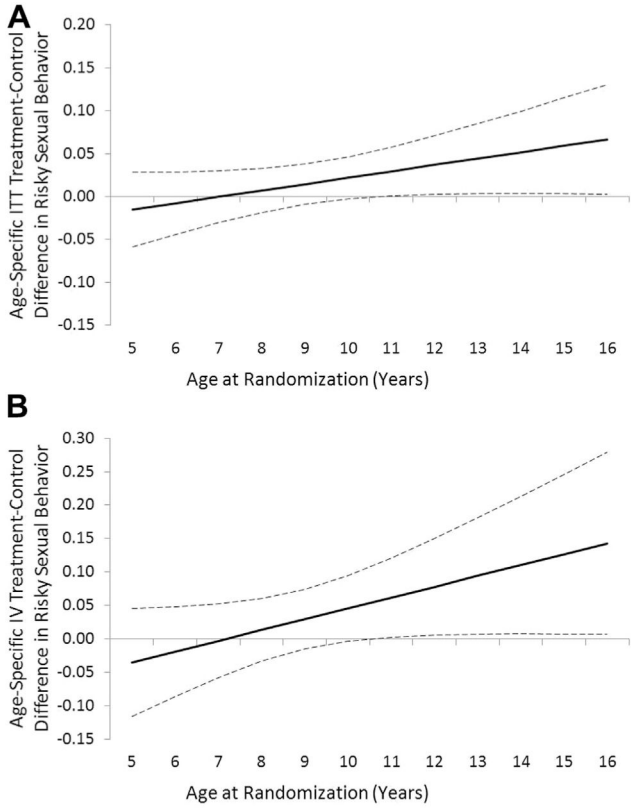

Figure 2.

MTO treatment effects on youth RSB 4–7 years after randomization with 95% CI, modification by age. (A) Age-specific ITT effect estimates; (B) age-specific IV adherence-adjusted effect estimates. ITT results, (A) 2-way interaction effect B(SE) = .007(.004), p = .09, 95% CI: −.001 to .016; IV results, (B) 2-way interaction effect B(SE) = .016(.009), p = .08, 95% CI: −002, .034. p values reported for each bar test each subgroup effect against a null hypothesis of zero. Models adjusted for site. The y-axis scale is larger in (B) because the IV effects are nearly twice as large as the ITT effects (A). CI = confidence interval; ITT = intention-to-treat; IV = instrumental variable; MTO = moving to opportunity; RSB = risky sexual behavior.

Table 1

Moving to opportunity youth, baseline variables, overall and by treatment group

Construct	Variable	Overall	Treatment	Controls	*p* value[a]
Total in Interim Survey in 2002	N	2,829	1,950	879	
Baseline mean poverty rate	Percent poverty rate in the 1990 census tract	49.8%	49.5%	50.5%	
Family characteristics					
Victimization	Household member victimized by crime during past 6 months	43.0%	43.8%	41.3%	
Site	Baltimore	15.5%	16.0%	14.2%	
	Boston	18.9%	18.1%	20.7%	
	Chicago	22.4%	23.3%	20.4%	
	Los Angeles	18.6%	17.5%	21.2%	
	New York	24.6%	25.1%	23.5%	
Household size	2 people	7.3%	6.9%	8.3%	
	3 people	22.3%	22.1%	22.9%	
	4 people	25.4%	26.2%	23.4%	
	5 or more people	45.0%	44.8%	45.4%	
Youth Characteristics					
Age (in years)		9.94	9.96	9.88	
Gender	Male	49.9%	49.5%	51.0%	
	Female	50.1%	50.5%	49.0%	
Race/ethnicity	African American	62.8%	63.2%	62.1%	
	Hispanic ethnicity, any race	30.0%	30.3%	29.5%	
	White	1.1%	1.0%	1.2%	
	Other race	2.2%	2.4%	1.9%	
	Missing race	3.8%	3.2%	5.3%	
Gifted	Special class for gifted students or did advanced work	15.4%	14.7%	16.8%	
Developmental Problems	Special school, class, or help for learning problem in past 2 years	16.6%	16.7%	16.3%	
	Special school, class, or help for behavioral or emotional problems in past 2 years	7.7%	8.7%	5.3%	*
	Problems that made it difficult to get to school and/or to play active games	6.5%	7.1%	5.0%	
	Problems that required special medicine and/or equipment	9.1%	10.0%	7.0%	*
	School asked to talk about problems child having with schoolwork or behavior in past 2 years	26.3%	26.7%	25.4%	

Construct	Variable	Overall	Treatment	Controls	*p* value[a]
Household Head Characteristics					
Family Structure	Never married	55.9%	55.2%	57.5%	
	Teen parent	25.9%	26.4%	25.0%	
Socioeconomic Status	Employed	25.8%	26.1%	25.3%	
	On Aid to Families with Dependent Children (welfare)	76.0%	75.5%	76.9%	
Education	Less than high school	47.1%	47.2%	46.7%	
	High school diploma	36.2%	36.6%	35.3%	
	General Education Development	16.7%	16.1%	17.9%	
	In school	13.9%	14.4%	12.6%	
Neighborhood/mobility variables	Lived in neighborhood 5 or more years	65.7%	65.8%	65.5%	
	No family living in neighborhood	64.1%	63.1%	66.3%	
	No friends living in neighborhood	37.3%	36.8%	38.5%	
	Had applied for section 8 voucher before	44.3%	43.6%	45.8%	
Neighbor relationships	Chats with neighbors at least once a week	51.9%	51.3%	53.2%	
	Respondent very likely to tell neighbor if saw neighbor's child getting into trouble	56.7%	56.8%	56.4%	

All variables range between 0 and 1 except baseline age (5–16) and mean poverty rate, so means represent proportions. Analysis weighted for varying treatment random assignment ratios across time and for attrition. All tests were adjusted for clustering at the family level. Regression analyses were adjusted for site.

$^{*}p < .05$.

[a] *p* value from test of treatment group differences calculated from Wald chi-square tests outputted from logistic regression for dichotomous baseline characteristics and multinomial logistic regression for categorical characteristics. F-tests were used with linear regression for continuous variables. The null hypothesis is that the treatment and control group proportions or means did not differ.

Table 2

MTO risky behavior outcomes at interim (2002) descriptive statistics, by gender and treatment group

Outcome	Girls			Boys		
	Overall, mean (SD)	Treatment group, mean (SD)	Controls, mean (SD)	Overall, mean (SD)	Treatment group, mean (SD)	Controls, mean (SD)
Risky behavior index (RBI)	.09 (.18)	.09 (.18)	.10 (.17)	.15 (.24)	.16 (.25)	.13 (.21)
Risky substance use (RSU)	.06 (.17)	.05 (.17)	.08 (.19)	.09 (.23)	.10 (.24)	.06 (.18)
Risky sexual behavior (RSB)	.15 (.29)	.16 (.30)	.13 (.26)	.25 (.36)	.26 (.37)	.23 (.34)

SD = standard deviation.

Table 3

MTO ITT and IV effects on risky behavior index and subscales at interim (2002) with 95% CI, effect modification by gender

	ITT models														
	Risky behavior index					**Risky substance use**					**Risky sexual behavior**				
	B	**SE**	**95% CI**		***p* value**	**B**	**SE**	**95% CI**		***p* value**	**B**	**SE**	**95% CI**		***p* value**
Regression coefficients															
MTO treatment	−.005	.010	−.024	.014		−.027	.010	−.046	−.008	**	.028	.016	−.002	.058	†
Male	.030	.012	.006	.053	*	−.019	.011	−.040	.003	†	.102	.019	.064	.140	***
MTO treatment male interaction	.039	.016	.008	.070	*	.067	.015	.039	.096	***	−.005	.026	−.055	.045	
Calculated treatment effects															
Girls	−.005	.010	−.024	.014		−.027	.010	−.046	−.008	**	.028	.016	−.002	.058	†
Boys	.034	.013	.009	.059	**	.041	.011	.019	.063	***	.023	.021	−.017	.063	
	IV models														
	Risky behavior index					Risky substance use					Risky sexual behavior				
	B	SE	95% CI		*p* value	B	SE	95% CI		*p* value	B	SE	95% CI		*p* value
Regression coefficients															
MTO treatment	−.010	.019	−.046	.027		−.052	.019	−.088	−.015	**	.053	.030	−.005	.111	†
Male	.030	.012	.006	.053	*	−.018	.011	−.040	.003	†	.102	.019	.064	.140	***
MTO treatment-male interaction	.079	.031	.018	.140	*	.135	.029	.077	.192	***	−.008	.050	−.107	.091	
Calculated treatment effects															
Girls	−.010	.019	−.046	.027		−.052	.019	−.088	−.015	**	.053	.030	−.005	.111	†
Boys	.069	.026	.019	.119	**	.083	.023	.038	.128	***	.045	.041	−.035	.125	

B = Beta; CI = confidence interval; ITT = intention-to-treat; IV = instrumental variable; MTO = moving to opportunity; SE = standard error.

Sample size ranges from 2,715 to 2,796 depending on missingness. Treatment groups modeled together because of treatment effect homogeneity. Models adjusted for site.

* $p < .05$,

** $p < .01$,

*** $p < .001$,

† $p < .10$.