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# Gender and Crime Victimization Modify Neighborhood Effects on Adolescent Mental Health

**WHAT'S KNOWN ON THIS SUBJECT:** Adolescents living in lower-poverty neighborhoods have better mental health than youth in high-poverty contexts, but it is unclear if associations are causal. Furthermore, it is unknown why some youth benefit more than others from moving to more advantaged neighborhoods.

**WHAT THIS STUDY ADDS:** Using an experimental study that randomly assigned families to receive vouchers to move to lower-poverty neighborhoods, we found that recent violent crime victimization adversely modified the mental health effects of moving to better neighborhoods.

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## abstract

**OBJECTIVE:** Leverage an experimental study to determine whether gender or recent crime victimization modify the mental health effects of moving to low-poverty neighborhoods.

**METHODS:** The Moving to Opportunity (MTO) study randomized low-income families in public housing to an intervention arm receiving vouchers to subsidize rental housing in lower-poverty neighborhoods or to controls receiving no voucher. We examined 3 outcomes 4 to 7 years after randomization, among youth aged 5 to 16 years at baseline ($n = 2829$): lifetime major depressive disorder (MDD), psychological distress (K6), and Behavior Problems Index (BPI). Treatment effect modification by gender and family's baseline report of recent violent crime victimization was tested via interactions in covariate-adjusted intent-to-treat and instrumental variable adherence-adjusted regression models.

**RESULTS:** Gender and crime victimization significantly modified treatment effects on distress and BPI ($P < .10$). Female adolescents in families without crime victimization benefited from MTO treatment, for all outcomes (Distress B = −0.19, $P = .008$; BPI B = −0.13, $P = .06$; MDD B = −0.036, $P = .03$). Male adolescents in intervention families experiencing crime victimization had worse distress (B = 0.24, $P = .004$), more behavior problems (B = 0.30, $P < .001$), and nonsignificantly higher MDD (B = 0.022, $P = .16$) versus controls. Other subgroups experienced no effect of MTO treatment. Instrumental variable estimates were similar but larger.

**CONCLUSIONS:** Girls from families experiencing recent violent crime victimization were significantly less likely to achieve mental health benefits, and boys were harmed, by MTO, suggesting need for cross-sectoral program supports to offset multiple stressors. *Pediatrics* 2012;130:472–481

Adolescents living in disadvantaged contexts, including neighborhood poverty, exhibit elevated emotional distress.[1,2] This association is hypothesized to be due to the higher prevalence of stressors and fewer stress-buffering resources in low-income neighborhoods.[1] However, the majority of neighborhood mental health studies are observational and therefore may be biased by unmeasured confounding.[3,4] Experimental designs alleviate these serious internal validity threats.[5] Moving to Opportunity (MTO) is the only study to date that has randomly assigned individuals to move to different neighborhood contexts, offering a robust test of whether changes in neighborhood and housing conditions cause mental health.

Not all youth respond uniformly to similar contexts.[6] For example, previous analyses of MTO showed mental health benefits for girls but either nonsignificant or null effects for boys.[7–9] These findings highlight the potential for subgroups to experience substantially divergent outcomes as a result of the same intervention. One possible source of heterogeneity is youth vulnerability. Many interventions provide the greatest benefit to individuals who are already relatively advantaged, with respect to health or social conditions. Children under stress before an intervention may not benefit to the same extent as more advantaged children; fully capitalizing on an intervention may require resources depleted in highly stressed or vulnerable youth.[10,11] Highly stressed or traumatized children may have difficulty transitioning to new communities (eg, feeling alienated, unable to establish social networks),[12–14] so relocating may be a more important stressor for these children.[15–17]

One of the most powerful and common sources of stress for youth in low-income neighborhoods is exposure to violence,[18,19] which is associated with poorer mental health,[20] school dropout,

teen pregnancy, criminal involvement,[21] and fraternization with substance-using peers.[22] This suggests that youth exposed to violent victimization may be less able to benefit from moving out of disadvantaged neighborhoods because they are already at higher risk for poor outcomes, and the stress of violence exposure may be compounded by the stress of assimilating into a new neighborhood and social network.[12,13,15,17]

We hypothesize that the mental health of youth from families who have experienced recent violent crime victimization will not benefit from, and may even be harmed by, moving out of high-poverty, violent neighborhoods into better neighborhoods through a housing mobility intervention, unlike their counterparts from nonvictimized families. We aim in this study to (1) confirm previous differential gender effects of MTO by using improved measures of mental health outcomes and (2) test our novel hypothesis of effect modification by familial exposure to violent crime.

## METHODS

The MTO for Fair Housing Demonstration Project was a randomized controlled trial sponsored by the US Department of Housing and Urban Development[23] in 5 sites (1994–1998): Boston, Baltimore, Chicago, Los Angeles, and New York. Eligible low-income families had children aged <18, qualified for rental assistance, and lived in public housing or project-based assisted housing in areas with high concentrations of poverty.[24] Applicants were drawn from waiting lists, signed enrollment agreements and informed consent, completed the Baseline Survey, and were evaluated for eligibility[25] by public housing authorities. Five thousand three hundred one families volunteered, and 4610 families were eligible and randomized[8] (Fig 1). MTO was not registered in Consolidated Standards of Reporting

Trials (CONSORT) because it was not a medical intervention.

### Treatment Assignment

Special software randomly assigned MTO families to 1 of 3 conditions. The "regular Section 8" treatment group was offered Section 8 housing vouchers to subsidize a private market rental apartment in any neighborhood. The "low-poverty-neighborhood" treatment group was also offered Section 8 housing vouchers, but they were redeemable only in low-poverty neighborhoods (where <10% of Census Tract households were impoverished). Families in this group were offered housing counseling services to aid relocation. The third group was an untreated control group, who received no additional assistance but could remain in public housing.[25]

### Assessment

Surveys at baseline (1994–1998) and the interim follow-up (2001–2002) were conducted in person via computer-assisted personal interviewing technology with household heads and their children.[8,25] Youth were interviewed in teen centers to improve privacy.[24] We focus on adolescents (n = 3537 aged 12–19 as of May 31, 2001) randomized through December 31, 1997 in the MTO Tier 1 Restricted Access Data; the effective response was 89.3%.[8] Adults provided informed written consent for themselves and their children.[8,24,25] Northeastern University's Institutional Review Board approved this study.

### *Measures*

Past-month nonspecific psychological distress was measured by the K6 scale,[26] with 5-item Likert frequency response options for 6 items: depressed; nervous; restless or fidgety; hopeless; everything was an effort; worthless. We scored the K6 with 2-parameter binary item response theory (IRT) methods to obtain
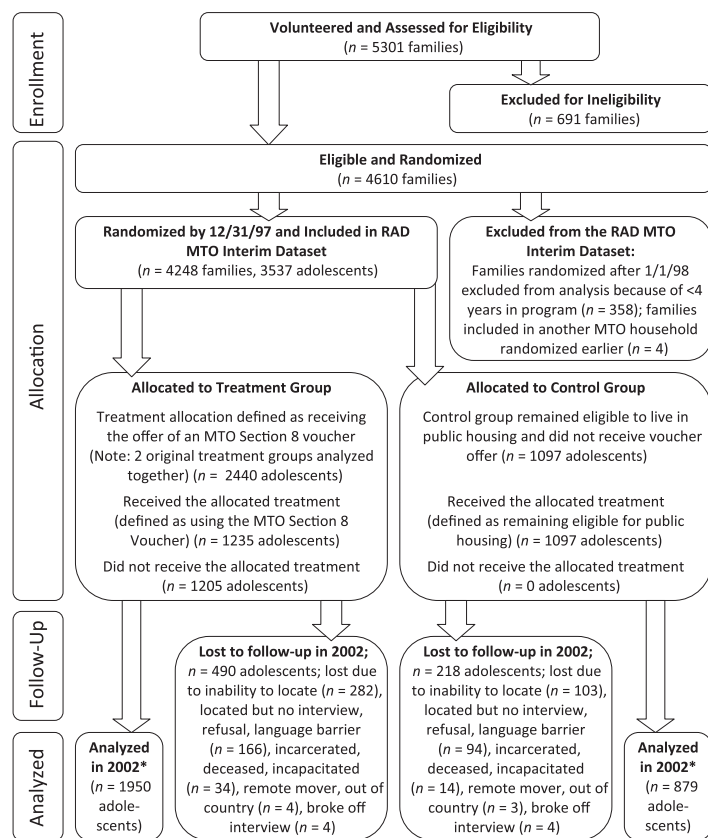
**FIGURE 1**
MTO youth enrollment, treatment allocation, and attrition. * 2002 Interim Survey yielded 89% effective response rate (RR) with a 2-stage follow-up sampling strategy, calculated as RR = MRR + SRR * (1 − MRR), where MRR = response rate for main sample (respondents initially responding to 2002 survey interview request) and SRR = response rate for subsample (a second attempt to find every 3 in 10 hard-to-reach families initially nonresponsive in 2002[8]; see p. A-8 of MTO Interim Evaluation [Orr et al, 2003].[8]).

distress factor scores with a standard normal distribution.[26] (Cronbach $\alpha$ = .80, mean [SD] = −0.0395 [1.123]). (Each unit change in the IRT-scaled K6 corresponds to approximately an SD; regression coefficients are interpreted approximately as proportions of an SD in effect size). IRT scoring is recommended because items with stronger relationships to the underlying distress construct are weighted heavier, increasing reliability and precision over simple summed scores.[26,27]

Behavior problems were measured by 11 self-reported items adapted from the Behavior Problems Index (BPI)[28] assessing primarily externalizing behaviors. Responses for items such as "I lie or cheat" and "I have a hot temper" range from 0 (not true) to 2 (often true). We used 2-parameter binary IRT methods to obtain BPI factor scores ($\alpha$ = .80, mean [SD] = −0.0250 [1.086]).

Lifetime *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* major depressive disorder (MDD) was adapted from the National Comorbidity Survey Replication–Adolescent Supplement, implemented by trained lay interviewers. This measure displays good concordance with *Diagnostic and Statistical Manual* diagnoses[29]; the algorithm to derive lifetime MDD is in Supplemental Information 1 (mean [SD] = 0.0458 [0.2538]). Although temporal ordering of treatment and lifetime MDD is not established in these analyses, given that this sample was young at baseline (before typical age of MDD onset[30]) and randomized to

treatment, we feel confident that group differences in 2002 MDD can be attributed to incident differences since baseline.

Randomly assigned treatment of an offer of a housing voucher (versus not) was indicated with 1 binary variable: treatment versus control group. Although MTO contained 2 experimental treatment groups, effects on mental health were similar for both groups (versus controls), and formal statistical tests for each outcome could not reject ($P$ < .05) effect homogeneity. We therefore combined experimental groups to improve statistical power. Results retaining the original 3 treatment groups are presented in Supplemental Figs 3–5. (Mean neighborhood poverty immediately after relocation for low-poverty and Section 8 treatment groups were 7.9% and 27.1%, respectively, compared with baseline control mean of 50.5%, indicating that experimental movers did move to substantially lower-poverty neighborhoods; 1990 census data).

Treatment adherence was defined as using the rental subsidy voucher offered to lease an apartment within 90 days (after which the voucher offer expired).[7,8] By definition, the experimental voucher was unavailable to the control group so control subjects were fully compliant. Approximately half of families randomly assigned to the experimental treatment of a voucher offer took up the offer and moved by using the voucher.

Victimization was based on household head report that a household member had been victimized by violent crime within 6 months before baseline.

*Covariates*

To improve efficiency, we adjusted for site, gender, and other prerandomization characteristics enumerated in Table 1. Covariate adjustment had little effect on results.

**TABLE 1** MTO Youth, Baseline Variables, Overall and by Treatment Group

| Construct | Variable | Treatment Group | | | |
| --- | --- | --- | --- | --- | --- |
| | | Overall | Treatment Group | Control | $P^a$ |
| Total in interim survey in 2002 | N | 2829 | 1950 | 879 | |
| Baseline mean poverty rate | Percent poverty rate in the 1990 census tract | 49.8 | 49.5 | 50.5 | |
| Family characteristics | | | | | |
| Victimization | Percent with household member victimized by crime during past 6 mo | 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 people | 45.0 | 44.8 | 45.4 | |
| Youth characteristics | | | | | |
| Age, y | | 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 y | 16.6 | 16.7 | 16.3 | |
| | Special school, class, or help for behavioral or emotional problems in past 2 y | 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 y | 26.3 | 26.7 | 25.4 | |
| 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 AFDC (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 | |
| | GED | 16.7 | 16.1 | 17.9 | |
| | In school | 13.9 | 14.4 | 12.6 | |
| Neighborhood/mobility variables, % | Lived in neighborhood ≥5 y | 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. The following baseline variables were used as covariates in regression analyses: site; youth gender, race, giftedness, and schoolwork or behavior problems; household head marital status, employment, education, tenure in neighborhood, relationships with baseline neighbors, presence of family/friends in baseline neighborhood, and previous application for Section 8. Missing baseline covariate data were imputed to site-specific means (<5 missing)[8] or modeled with missing indicators (7 missing for youth giftedness and household head education). AFDC, Aid to Families With Dependent Children; GED, general equivalency diploma.

a $P$ value from test of treatment group differences calculated from Wald $\chi^2$ 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.

* $P < .05$.

## Analytic Approach

We estimated additive effects of treatment assignment by regressing outcomes (K6, BPI, and MDD) on randomly assigned treatment group with covariate-adjusted linear regression, per intent-to-treat (ITT) principles.[31] Covariate adjustment was not necessary for internal validity given randomization; however, adjustment often improves efficiency without compromising type 1 error rate.[32,33] We first estimated adjusted models for treatment effects averaged over all youth and next assessed modification of treatment effects on mental health by gender with gender-by-treatment interactions (given previous evidence of gender effect modification[7,8]). We then assessed whether family violent crime victimization modified treatment effects by using treatment-by-victimization interactions, retaining the gender-treatment interactions. Effect modification is summarized graphically, displaying average treatment effects on mental health (experimental minus control means), for each gender-victimization subgroup. Negative values for treatment coefficients indicate beneficial effects of treatment.

When ITT effect modification tests were statistically significant, we also calculated adherence-adjusted effect estimates based on instrumental variable (IV) analysis, estimated with 2-stage least squares regression. We estimated IV effects because ITT effect estimates are probably attenuated compared with effects of using the voucher to move, given that many families randomized to receive vouchers did not use them. Direct comparisons of movers to nonmovers would potentially be biased. IV analyses are appropriate to correct for differential adherence in randomized controlled trials and avoid biases associated with directly comparing compliers to noncompliers.[34,35] Under the main assumption that treatment assignment can only affect mental health indirectly, via use of the voucher to move, treatment assignment is a valid IV to estimate the effects of using the vouchers to move out of public housing on mental health. The IV approach also reveals whether patterns of ITT treatment effect heterogeneity could be attributable to lower adherence rates among previously victimized families.[36] In MTO, IV effect estimates are typically interpreted as the effect of using the voucher among individuals who did in fact use it.[7,37]

All analyses accounted for household clustering, with weights accounting for random assignment ratio changes and attrition.[7] We report robust SEs. We imputed row-column values for missing outcome values (<1% for distress and BPI and 4% for lifetime MDD). We used M-Plus 6.11 for IRT analyses and Stata 11.0 (Stata Corp, College Station, TX) for all other analyses.

## RESULTS

Table 1 presents sample descriptives. ITT estimates of overall marginal effects of treatment were null for psychological distress (B = 0.015, 95% confidence interval [CI]: −0.075 to 0.105, $P$ = .75), null for lifetime MDD (B = −0.008, 95% CI: −0.027 to 0.012, $P$ = .44), and null for BPI (B = 0.066, 95% CI: −0.022 to 0.153, $P$ = .141; results not shown). These average effects masked qualitative effect modification by gender (Table 2), significant for all 3 outcomes. Randomization to the MTO intervention significantly benefitted girls' psychological distress and MDD but significantly harmed boys' psychological distress and BPI.

Table 3 displays IV adherence-adjusted treatment effects by gender; patterns

**TABLE 2** MTO ITT Treatment Effects at Interim (4- to 7-Year) Follow-up on Mental Health Among Adolescents, Effect Modification by Gender

| | Psychological Distress | | | | | Behavior Problems | | | | | Lifetime MDD | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | β | SE | Lower CI[a] | Upper CI[a] | $P$ | β | SE | Lower CI[a] | Upper CI[a] | $P$ | β | SE | Lower CI[a] | Upper CI[a] | $P$ |
| Regression coefficients | | | | | | | | | | | | | | | |
| Treatment | −0.123 | 0.061 | −0.244 | −0.003 | * | −0.035 | 0.060 | −0.153 | 0.083 | | −0.032 | 0.016 | −0.064 | −0.000 | * |
| Male | −0.411 | 0.070 | −0.547 | −0.274 | *** | −0.063 | 0.068 | −0.195 | 0.070 | | −0.074 | 0.016 | −0.106 | −0.042 | *** |
| Treatment by male interaction | 0.274 | 0.086 | 0.104 | 0.443 | ** | 0.199 | 0.082 | 0.037 | 0.360 | * | 0.049 | 0.020 | 0.011 | 0.087 | * |
| Calculated treatment effects | | | | | | | | | | | | | | | |
| Girls | −0.123 | 0.061 | −0.244 | −0.003 | * | −0.035 | 0.060 | −0.153 | 0.083 | | −0.032 | 0.016 | −0.064 | −0.000 | * |
| Boys | 0.150 | 0.064 | 0.024 | 0.276 | * | 0.164 | 0.060 | 0.046 | 0.282 | ** | 0.017 | 0.011 | −0.005 | 0.038 | |

Treatment variable indicates assignment to active treatment group receiving a housing subsidy offer, compared with controls (omitted). Regression models adjusted for site; race; household head marital status, employment, education, lived in neighborhood for 5 y or more, chats with neighbor at least once a week, no family in neighborhood, no friends in neighborhood, very likely to tell neighbor if he or she saw neighbor's child getting into trouble, and has applied for Section 8 before; child is gifted; child had problems with schoolwork or behavior; plus male, treatment, and treatment by male interaction. Models adjusted for family-level clustering, output with robust SEs, and weighted. IRT methods were used to derive psychological distress and behavior problems.

[a] CI = 95% CI for the mean.
*** $P$ < .001;
** $P$ < .01;
* $P$ < .05;
# $P$ < .10.

are similar to ITT estimates but approximately twice as large.

Confirming our novel hypothesis, victimization adversely modified effects of the MTO intervention assignment on the K6 and BPI; youth in victimized families had worse average treatment effects than their counterparts from families who had not experienced victimization, overall and within gender group (Fig 2). For all 3 outcomes, girls from nonvictimized families were the only subgroup to significantly benefit from the intervention. Boys in victimized families were the only subgroup significantly harmed by the intervention (Fig 2 A and B).

Psychological distress illustrates these patterns. The modest average beneficial ITT effect of treatment of girls (Table 2, B = −0.123, P = .044) masked larger benefits for girls from nonvictimized families (B = −0.192, 95% CI: −0.334 to −0.050, P = .008, ie, a 0.17 SD decrease in distress [Cohen's D = −0.192/1.123[38]]) and an effect close to zero for girls from victimized families (B = −0.027, 95% CI: −0.187 to 0.133, P = .74; Fig 2A). Furthermore, the overall harmful ITT effect among boys (B = 0.150, P = .020)

reflected substantial harm among boys from victimized families (B = 0.243, 95% CI: 0.076 to 0.410, P = .004) and null effects among boys from nonvictimized families (B = 0.078, 95% CI: −0.068 to 0.224, P = .29). Patterns for BPI (Fig 2A) and MDD (Fig 2B) were strikingly similar to those for distress. Effects were marginally stronger for (and concentrated in) the low-poverty versus Section 8 treatment group for distress and BPI (Supplemental Figs 3 and 4).

Victimization-treatment interaction coefficients were at least marginally significant for distress and BPI, indicating adverse heterogeneity of treatment effects by baseline victimization (respectively, B = 0.165, 95% CI: −0.017 to 0.347, P = .076 and B = 0.235, 95% CI: 0.059 to 0.410, P = .009). There was an adverse, but nonsignificant, effect modification of treatment by victimization for MDD.

Adherence-adjusted IV estimates also indicate significant treatment benefits on distress and BPI for girls from nonvictimized families, harmful effects among boys from victimized families, and null effects for the other 2 groups (Fig 2C). Similar to ITT effects, IV results for MDD were null. IV effect estimates

of using a voucher to move were twice as large as ITT estimates, as expected given 51% treatment adherence.

## DISCUSSION

We found differential intervention effects on distress, behavior problems, and MDD 4 to 7 years after adolescents moved out of public housing into lower-poverty neighborhoods in the MTO experiment. Female adolescents experienced beneficial mental health effects of the MTO treatment, but male adolescents experienced harmful effects. Moreover, for both girls and boys, effects of the MTO treatment were worse for youth from families in which someone was a victim of violent crime before randomization. The MTO IV effect sizes ranged from a harmful 0.42 to 0.53 SDs for boys and from a beneficial 0.23 to 0.32 SDs for girls for the dimensional outcomes. These are moderate effect sizes[38]; indeed, the beneficial effect for girls' distress is nearly that obtained from psychotherapy treatment in youth[39] (especially notable because psychotherapy is administered to clinical populations, yet we see similar effect sizes here in a nonclinical sample).

**TABLE 3** MTO IV Adherence-Adjusted Treatment Effects at Interim (4- to 7-Year) Follow-up on Mental Health Among Adolescents, Effect Modification by Gender

|  | Psychological Distress | | | | | Behavior Problems | | | | | Lifetime MDD | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | $\beta$ | SE | Lower CI[a] | Upper CI[a] | P | $\beta$ | SE | Lower CI[a] | Upper CI[a] | P | $\beta$ | SE | Lower CI[a] | Upper CI[a] | P |
| Regression coefficients |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Treatment | −0.237 | 0.117 | −0.467 | −0.007 | * | −0.068 | 0.115 | −0.293 | 0.157 |  | −0.062 | 0.031 | −0.123 | −0.001 | * |
| Male | −0.409 | 0.069 | −0.544 | −0.274 | *** | −0.061 | 0.067 | −0.192 | 0.070 |  | −0.074 | 0.016 | −0.106 | −0.043 | *** |
| Treatment by male interaction | 0.547 | 0.173 | 0.209 | 0.886 | ** | 0.405 | 0.165 | 0.082 | 0.728 | * | 0.097 | 0.039 | 0.021 | 0.172 | * |
| Calculated treatment effects |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Girls | −0.237 | 0.117 | −0.467 | −0.007 | * | −0.068 | 0.115 | −0.293 | 0.157 |  | −0.062 | 0.031 | −0.123 | −0.001 | * |
| Boys | 0.310 | 0.132 | 0.052 | 0.569 | * | 0.337 | 0.125 | 0.093 | 0.581 | ** | 0.035 | 0.023 | −0.009 | 0.079 |  |

Second-stage IV results presented here. The treatment variable represents treatment adherence, that is, whether the family used the housing subsidy to move. Two-staged least squares regression models adjusted for site; race; household head marital status, employment, education, lived in neighborhood for 5 y or more, chats with neighbor at least once a week, no family in neighborhood, no friends in neighborhood, very likely to tell neighbor if he or she saw neighbor's child getting into trouble, and has applied for Section 8 before; child is gifted; child had problems with schoolwork or behavior; plus male, treatment, and treatment by male interaction. Models adjusted for family-level clustering, output with robust SEs, and weighted. IRT methods were used to derive psychological distress and behavior problems. To assess robustness to misspecification of pre-randomization covariates in linear regression for binary outcome MDD, we implemented a version of G-estimation[64] which does not rely on correct specification of the outcome from linear regression but relies only on randomization of the instrument. Results were almost identical (available on request), so we present results from conventional IV analysis.

[a] CI = 95 CI for the mean

*** P < .001;
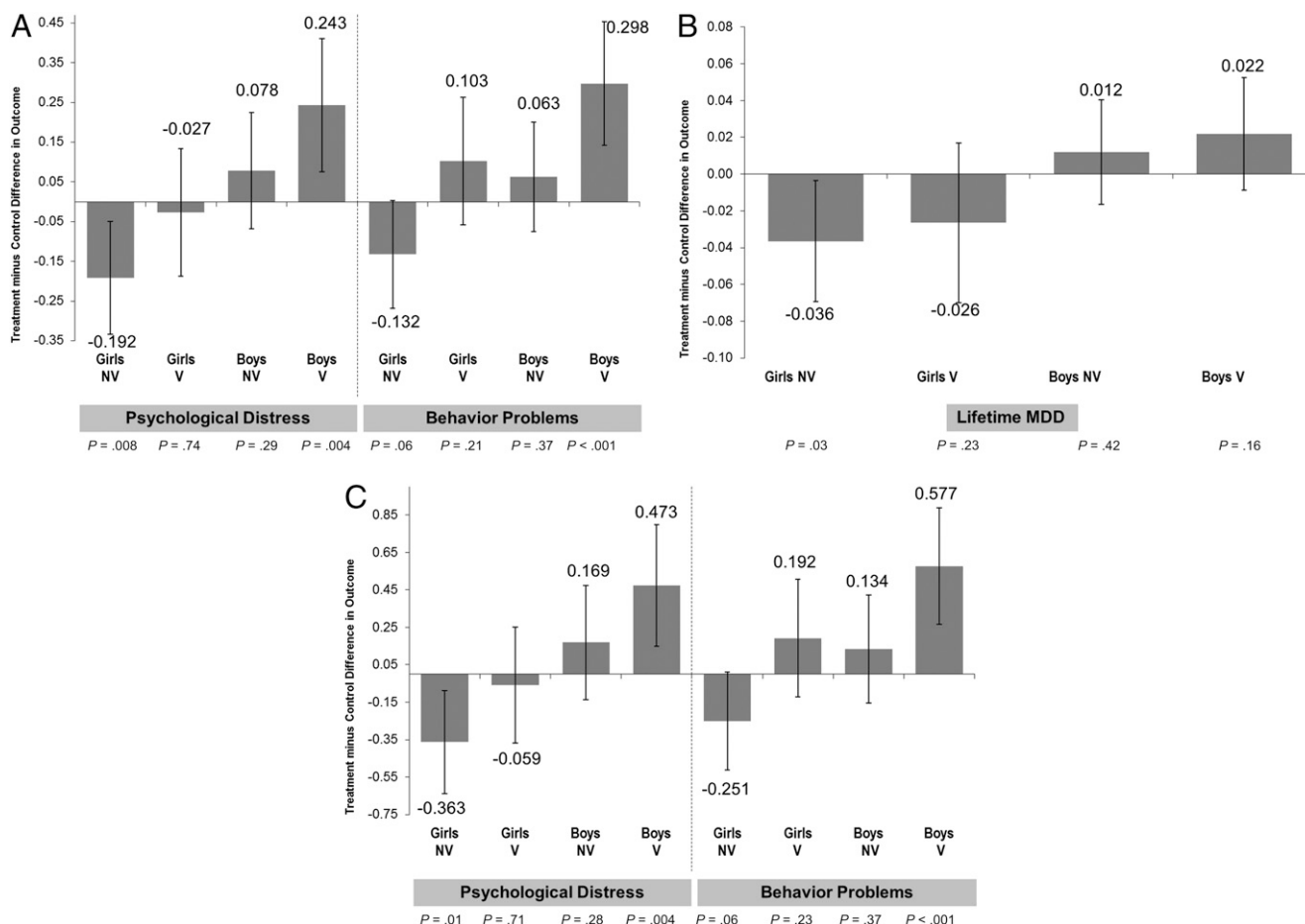
** P < .01;

* P < .05;

# P < .10.

**FIGURE 2**

MTO treatment effects on mean difference in adolescent mental health 4–7 years after baseline, modified by gender and recent violent crime victimization. A, The linear regression ITT estimates for adolescent distress and behavior outcomes. B, Linear regression ITT estimates for lifetime MDD. C, Adherence-adjusted estimates of treatment effects from second-stage IV analysis for distress and behavior problems. Treatment-victimization interaction results for ITT: A, Distress: B (SE) = 0.165 (0.093), *P* = .076; Behavior Problems: B (SE) = 0.235 (0.089), *P* = .009; B, MDD: B (SE) = 0.010 (0.020), *P* = .626. C, For IV: Distress: B (SE) = 0.304 (0.183), *P* = .096; for Behavior Problems: B (SE) = 0.443 (0.178), *P* = .013. *P* values reported beneath each bar near figure bottom test each subgroup effect against a null hypothesis of zero. Models adjusted for covariates listed in Table 2, plus treatment-baseline victimization interaction. See Supplemental Information 1 for definition of lifetime MDD. NV, nonvictimized; V, victimized.

Few previous publications evaluate health effects of MTO at 4 to 7 years' follow-up.[7,8,40,41] Previous research reported adverse effects of MTO on overall youth self-rated health and asthma; beneficial effects of MTO on distress, lifetime MDD, and smoking for adolescent girls; and, for boys, null associations with mental health outcomes and, unexpectedly, adverse behavioral outcomes.[7,8,41] The Department of Housing and Urban Development recently released outcomes for a younger cohort of children, 12 years after baseline, showing similar gender patterns.[42] Statistical tests of gender interactions were not reported however, so no formal replication is available.

Our findings add to previous literature in 2 ways. We tested a specific explanation for treatment effect heterogeneity: vulnerability due to previous crime victimization. Furthermore, we operationalized health outcomes by using validated latent variable methods, improving precision in measuring distress, which substantively altered conclusions from previous work.[31] Specifically, we found that MTO significantly elevated distress for boys, in contrast to previous findings, which were null.[7,8]

The null effects we found for behavior problems among girls and MDD among boys may reflect gendered expression of mental health. Girls more commonly manifest distress as mood disorders/symptomatology, and boys more typically express externalizing disorders/symptomatology.[43,44] Our findings present consistent patterns; adolescent boys and youth from families with a history of violent crime victimization did not benefit from moves into lower-poverty neighborhoods and in some cases were harmed.

Qualitative evidence from MTO suggests that girls may have benefited because

they escaped neighborhood environments with pervasive sexual harassment and threats of sexual violence.[45] In contrast, adolescent boys may have had difficulty adjusting to changes in social networks and relationships in the new neighborhoods.[46] Boys in high-crime areas may cope by adhering to context-specific oppositional "street" cultures[47] that are less advantageous in lower-poverty neighborhoods. We did not test these potential explanations, although research on mechanisms is clearly needed. A child's age or developmental stage may also modify treatment,[39] but we did not test that hypothesis in this study, although other MTO analyses have.[39,48,49] This remains important to investigate.

Our findings suggest that gender is one of several social determinants that modifies children's capacity to benefit from new resources and neighborhood contexts, consistent with previous research on child development.[6] We found harm specific to 1 group: boys from families with a history of recent crime victimization. This adds to emerging evidence emphasizing that low-income children are often blocked from achieving healthy, successful adulthoods by an interlocking system of adversity in which individual and neighborhood socioeconomic disadvantage compromise health via multiple pathways.[6,50–52] Ameliorating these barriers requires meaningful intersectoral collaboration, in particular, coordinating housing and health services.

Housing Choice Vouchers (formerly known as Section 8), on which MTO was based, are central to US rental housing assistance policy.[53,54] Large-scale social interventions of this kind, therefore, should be designed and monitored with an eye to health impacts and the possibility of unintended negative consequences for vulnerable populations. Determining which children accrue health benefits and which are harmed may help enhance programs to improve outcomes for all children. Recently, innovative intersectoral programs (eg, medical legal partnerships,[55] volunteer programs such as Health Leads),[56] which integrate social services into health care settings, have demonstrated promise for improving health outcomes for low-income families. Social service delivery programs are also increasingly integrating health care; for example, HOPE VI, a major federal housing relocation program, requires tailored supportive services for its residents, including health care.[57,58]

An important question concerns whether the neighborhood context, and/or the move itself, influenced child mental health. Although there is some research on this question elsewhere,[15,16,59,60] MTO cannot tease these apart because of its bundled treatment. Our results documented marginally stronger treatment effects in the low-poverty group, rather than the section 8 group, providing 1 clue that the type of neighborhood to which families moved may have mattered more for adolescent mental health than the move itself. This important question for future research may implicate other potential interventions such as place-based neighborhood revitalization efforts to modify neighborhoods directly.[61]

MTO's original aims focused on economic self-sufficiency, not health,[62] so mental health was not assessed at baseline. Additional data would have improved statistical power and facilitated investigating differential treatment effects by baseline health. Although we had limited power given low prevalence of MDD, our consistent pattern of results was triangulated from different mental health outcomes, including diagnostic, symptomatology, internalizing, and externalizing measures, which may jointly better represent a broader universe of mental health outcomes. We operationalized violent crime victimization at the family level, assuming it affects the whole family,[63] because no individual-level variable was available. Lastly, these findings may not generalize to all adolescents because MTO families were exceptionally disadvantaged at baseline. Yet this population is of particular social relevance as the target of means-tested policies.

## CONCLUSIONS

The $70 million MTO demonstration program sought to assess the potential effects of moving low-income families from high- to low-poverty neighborhoods.[24] Its experimental design places MTO among the strongest existing studies of how changes in neighborhood context affect children's mental health. Our results show that the MTO program benefited a robust group of adolescent girls and harmed a particularly vulnerable group of adolescent boys. Incorporating additional services across sectors may be important for facilitating successful outcomes among all families receiving housing mobility assistance.

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