The acute effect of local homicides on children's cognitive performance

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Edited* by Robert J. Sampson, Harvard University, Cambridge, MA, and approved May 17, 2010 (received for review January 21, 2010)

This study estimates the acute effect of exposure to a local homicide on the cognitive performance of children across a community. Data are from a sample of children age 5–17 y in the Project on Human Development in Chicago Neighborhoods. The effect of local homicides on vocabulary and reading assessments is identified by exploiting exogenous variation in the relative timing of homicides and interview assessments among children in the same neighborhood but assessed at different times. Among African-Americans, the strongest results show that exposure to a homicide in the block group that occurs less than a week before the assessment reduces performance on vocabulary and reading assessments by between ∼0.5 and ∼0.66 SD, respectively. Main results are replicated using a second independent dataset from Chicago. Findings suggest the need for broader recognition of the impact that extreme acts of violence have on children across a neighborhood, regardless of whether the violence is witnessed directly.

cognitive function | neighborhoods | violence | acute stress

Despite the national decline in homicides that has occurred since the mid-1990s, homicide remains among the leading causes of death among 15- to 24-y-olds nationally and is the top cause of death among African-Americans in this age range (1). These figures reflect the toll that homicide takes in terms of lives lost, but they may understate the total impact of extreme violence among children living in violent areas. Research examining direct exposure to serious violence among youth suggests possible effects on a range of developmental outcomes, although the estimates are subject to problems of selection bias (2–5). This study takes a broader view and examines the impact of extreme violence as felt across a community, regardless of whether the violence is witnessed directly. Specifically, the analysis estimates the acute effect of local homicides on children's cognitive performance, as measured by two assessments of vocabulary and reading skills.

Incidents of extreme violence may affect children's performance on cognitive assessments through various physiological, emotional, or social responses related to stress, fear, or trauma. Research has shown that youth directly or indirectly exposed to different forms of community violence show elevated rates of symptoms related to acute or posttraumatic stress disorder, including disrupted sleep, anxiety, reduced awareness, and difficulty with concentration, all of which may act as mechanisms leading to impaired performance on cognitive assessments (6–9). The broader literature on stress and cognitive function provides further support for the hypothesized relationship between exposure to environmental stress and cognitive performance (10–12). Findings from experimental studies of humans are nuanced, but one consistent result is that highly elevated levels of stress or stress hormones impair cognitive performance, particularly on tasks related to declarative memory (10, 11). The general finding linking experimentally induced stress with impaired cognitive performance is consistent with a large literature from animal models (10–13).

Extending the findings from these experimental studies to assess the impact of violent events in children's environments is challenging, however, because the experience of living near a homicide cannot be reproduced in an experimental setting, and homicides are not distributed randomly across neighborhoods in a city. Estimates of "homicide effects" will be biased if unobserved factors jointly predict selection into a violent environment and the outcome of interest. To address the problem of selection bias, a method is developed that exploits exogenous variation in the relative timing of homicides and interview assessments among children living within the same neighborhood.

Data on all reported homicides occurring in Chicago from 1994 through 2002 are merged with data from a survey of children and families in Chicago conducted over the same timeframe, the Project on Human Development in Chicago Neighborhoods (PHDCN) (http://www.icpsr.umich.edu/PHDCN) (14). Children in the PHDCN sample who were clustered within the same neighborhoods were assessed over an extended period covering several months or longer. Using neighborhood fixed effects specifications, the impact of a recent, local homicide is identified by comparing scores on cognitive assessments among children living within the same neighborhood who were assessed at different times: Some were assessed in the days following a local homicide, whereas others were assessed months later or earlier. The central assumption underlying the method is that, within a given neighborhood, the timing of homicides in relation to the timing of interview assessments produces exogenous variation in the recency of local homicides; this exogenous variation serves as the basis for causal inference.

Results

From 1994 through 2002, 6,041 homicides in Chicago were reported by the Chicago Police Department and successfully geocoded. Exposure to local homicides varies substantially by race/ethnicity. Among African-Americans in the PHDCN samples, 54 assessments were conducted within 4 d after a homicide in the census tract (2.1%), 92 were within 7 d (3.5%), 131 were within 10 d (5.0%), 170 were within 14 d (6.5%), and 325 were within 28 d (12.5%). Exposure to local homicides is much less common among Hispanics and is extremely rare among whites.

The effect of a local homicide is estimated separately for African-Americans and Hispanics so that all comparisons are made within race/ethnic groups; whites and members of other race and ethnic groups are excluded because results for these groups would be based on only a handful of individuals in the sample who contribute to the estimate.[†] Estimates represent the effect of a local (within the neighborhood) homicide occurring within different time intervals preceding the assessment, including tract by survey wave fixed effects, and controlling for calendar year and month of year (analysis details are given in *Materials and Methods*).

Author contributions: P.S. designed research, performed research, analyzed data, and wrote the paper.

The author declares no conflict of interest.

*This Direct Submission article had a prearranged editor.

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This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1000690107/-/DCSupplemental.

[†]Gender and age group interactions also were tested, although no clear pattern of interactions was present.

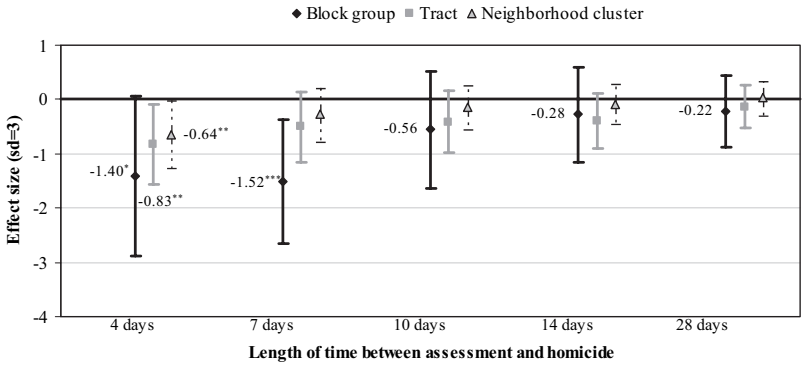

Fig. 1. Effect on WISC-R scores of a recent homicide occurring within the block group, census tract, or neighborhood cluster, respectively, among African-Americans in the PHDCN. Coefficient values are shown for all block group estimates and for significant estimates at all levels. Sample sizes: Block group estimates are based on 2,294 assessments among 1,082 respondents; census tract estimates are based on 2,381 assessments among 1,106 respondents; and neighborhood cluster estimates are based on 2,393 assessments among 1,111 respondents. *$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.

Neighborhoods are operationalized using three successively larger nested boundaries: block groups, census tracts, and neighborhood clusters (15, 16). (Definitions of each geographic boundary are given in *SI Appendix*.)

Two assessments are available in the PHDCN to measure vocabulary and reading skills; both assessments have been validated and used extensively in previous research using the PHDCN to capture key verbal/language skills important for social interaction and academic achievement (17–19). The first assessment is a vocabulary subtest from the Wechsler Intelligence Scale for Children-Revised (WISC-R) in which scores are normed to reflect performance relative to a national sample of children of the same age, with the normalized scale designed to have a mean of 10 and SD of 3 (20). The second assessment is a letter and word reading subtest from the Wide Range Achievement Test (WRAT3). Scores again are normed to reflect performance relative to a national sample of children of the same age; the normalized scale is designed to have a mean of 100 and SD of 15 (21). The assessments capture dimensions of cognitive skill that are strongly predictive of later educational attainment, labor market success, health, and criminal behavior (22–26).

Figs. 1 and 2 show a series of point estimates representing the effect of exposure to a homicide within African-American children's neighborhoods, using three successively larger geographic levels of analysis: block groups, census tracts, and neighborhood clusters. Estimates for Hispanics are null in almost every specification and thus are not shown but are available in *SI Appendix*. From left to right, the figures show the effect of a homicide that occurred within 4 d, 7 d, 10 d, 14 d, and 28 d before the cognitive assessment.

Fig. 1 displays results using the WISC-R vocabulary score as the dependent variable, and Fig. 2 displays results using the WRAT3 reading score as the dependent variable. From Fig. 1, exposure to a homicide in the block group that occurred within 4 d before the assessment reduces African-Americans' WISC-R scores by 1.40 points ($P < 0.10$), an effect that is marginally significant at conventional levels. The estimated effect of exposure to a homicide within a week before the assessment is more precise and indicates that a homicide in the child's block group within a week before the WISC-R assessment reduces a child's score by 1.52 points, slightly more than 0.5 SD ($P < 0.01$). Estimated effects of exposure to homicides in the block group occurring more than a week before the assessment are nonsignificant. The effects of exposure to a homicide in the child's census tract or neighborhood cluster that occurred within 4 d before the assessment are negative and statistically significant, but each estimate is substantially smaller in magnitude than the effect of a homicide occurring in the block group. As the duration of time between the homicide and the assessment increases, the estimated effects of homicides in the census tract and the neighborhood cluster are weak and nonsignificant.

Results shown in Fig. 2 indicate that living in a block group where a homicide occurred within 4 d before the assessment reduces African-Americans' scores on the WRAT3 by 9.72 points ($P < 0.10$), an effect size that is substantively large (0.65 SD) but only marginally significant because of imprecision in the estimate. The estimated effect of exposure to a homicide in the block group within a week before the assessment also is substantively large but

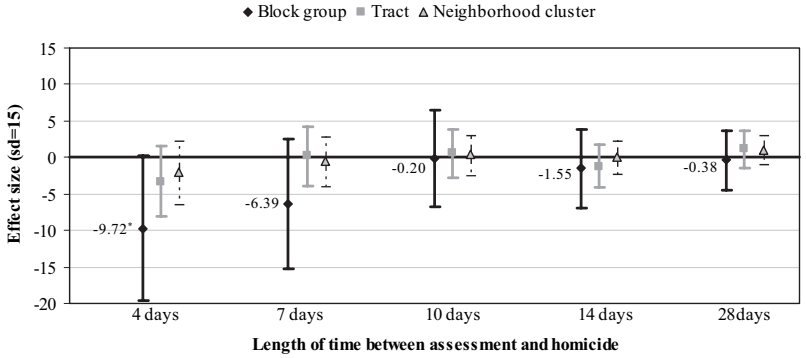

Fig. 2. Effect on WRAT3 scores of a recent homicide occurring within the block group, census tract, or neighborhood cluster, respectively, among African-Americans in the PHDCN2. Coefficient values are shown for all block group estimates and for significant estimates at all levels. Sample sizes: Block group estimates are based on 2,296 assessments among 1,075 respondents; census tract estimates are based on 2,381 assessments among 1,099 respondents; and neighborhood cluster estimates are based on 2,392 assessments among 1,104 respondents. *$P < 0.10$.

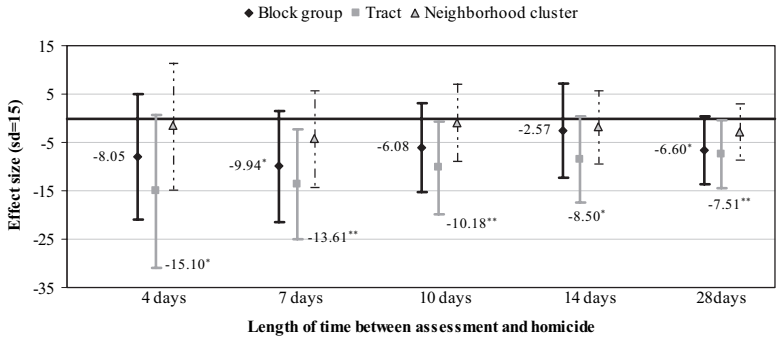

Fig. 3. Effect on Woodcock-Johnson letter-word scores of a recent homicide occurring within the block group, census tract, or neighborhood cluster, respectively, among African-Americans in the Three City Study Chicago sample. Coefficient values are shown for all block group estimates and for significant estimates at all levels. Sample sizes: Block group estimates are based on 342 assessments among 177 respondents; census tract and neighborhood cluster estimates are based on 348 assessments among 180 respondents. *$P < 0.10$; **$P < 0.05$.

is estimated imprecisely and is not significant. As the time window between the homicide and the assessment extends beyond a week, the effect size again becomes smaller, a pattern that is present for both assessments and at all levels of analysis. Homicides occurring in the child's census tract or neighborhood cluster have nonsignificant effects on WRAT3 scores regardless of the duration of time between the homicide and the assessment.

Alternative estimates based on kernel-weighted local linear regressions suggest a temporal pattern to the results in which the effect of local homicides is most severe in the period immediately following the homicide and diminishes in a linear manner as the period between the homicide and the assessment widens. Roughly 9 d after the homicide the effect size approaches zero and fluctuates around zero thereafter. (Details are given in *SI Appendix*.)

Although the analytic approach is designed to be robust to selection bias by making comparisons within neighborhoods, the assumption of exogenous variation in the recency of local homicides could be violated if there is systematic heterogeneity among African-American children living within the same neighborhood who were assessed at different times. Additional analysis presented in *SI Appendix* assesses whether there are observable differences in caregiver or child characteristics among children living in the same neighborhood who were or were not exposed to local homicides in the period before the assessment. Results reveal no systematic heterogeneity in any key caregiver characteristics or in children's self-reported violent activity or school performance/engagement.

Results presented to this point are based on a relatively small number of children who were assessed within a short period following a local homicide in their neighborhood; with this limitation in mind, replications of the analysis are essential before drawing strong conclusions. This section describes results from a replication using data from the Chicago sample of the Three City Study of Welfare, Children and Families (http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/04701) (27, 28), a longitudinal study of low-income families living in three cities (Boston, Chicago, and San Antonio) that began in 1997. The Three City Study includes an independent sample from the same city as the PHDCN sample—Chicago—and the timing of the survey overlaps with the timing of the PHDCN, reducing the possibility that period effects may obscure comparisons of results from the two surveys. The Three City Study conducted assessments of cognitive skills based on a letter-word identification subtest and an applied problems subtest from the Woodcock-Johnson Psycho-Educational Battery-Revised (29). The availability of both assessments allows for a test of whether the pattern of results is unique to verbal/reading skills or to specific features of the WISC-R or WRAT3 assessments used in the PHDCN. The primary drawback of the Three City Study Chicago sample is the small sample size and, as a result, the imprecision of estimates. Results displayed below are based on 180 African-Americans in the sample.

Figs. 3 and 4 display results from specifications that replicate those presented in Figs. 1 and 2, using the Woodcock-Johnson assessments as dependent variables and the Three City Study Chicago sample. The two measures of cognitive skills are regressed on an indicator for whether the child was assessed within a given time frame relative to a local homicide in the census tract of residence, including neighborhood fixed effects and calendar year and month of year fixed effects.[‡] Separate models are estimated for African-Americans and Hispanics, and whites and members of other race/ethnic groups are excluded. Similar to the PHDCN, estimated effects are null for Hispanics and are not shown in the figures.

Results for African-Americans displayed in Figs. 3 and 4 replicate the pattern of strong negative effects of local homicides occurring in close proximity to the assessment, although estimates are imprecise and the patterns are not identical to those found in the PHDCN. Fig. 3 indicates that exposure to a homicide in the child's block group has negative effects on letter-word scores, although the confidence intervals are wide, and only the effect of a homicide occurring within a week before the assessment is marginally significant.[§] Estimated effects of homicides within the census tract are much stronger. Exposure to a homicide in the child's census tract within 4 d before the assessment reduces scores on the letter-word subtest by 15.10 points, or 1 full SD ($P < 0.10$), and exposure to a homicide within a week before the assessment reduces scores by 13.61 points ($P < 0.05$). As the window of time between the homicide and the assessment expands beyond a week, the effect sizes are smaller but remain significant at conventional levels.

Fig. 4 shows negative, nonsignificant effects of homicides occurring within the block group on applied problems scores. At the level of the census tract, exposure to a local homicide occurring within 4 d before the applied problems subtest reduces

[‡]To maximize precision of the estimates, neighborhood fixed effects are used instead of neighborhood by survey wave fixed effects, which are used in the analysis based on the PHDCN. Identification in the neighborhood fixed effects approach is based on variation in exposure to local homicides among children living within the same neighborhood (block group, census tract, or neighborhood cluster), regardless of the survey wave in which the interview was conducted. Allowing for comparisons across survey waves improves the precision of estimates and is less problematic in the Three City Study because the first and second waves of the survey were conducted over a very short time span, ranging only from 1999 to 2001. Results are substantively the same using neighborhood by survey wave fixed effects. Additional details of the analysis and the Three City Study dataset are available in *SI Appendix*.

[§]The anomalous positive effect on applied problem scores of homicides within the block group occurring within 14 d before the assessment (Fig. 4) is driven by two outlying cases who scored roughly 4 SD above the mean on the applied problems subtest and were assessed 14 d after a local homicide in the block group. When these two cases are removed from the sample, the pattern of results resembles that found for other specifications.

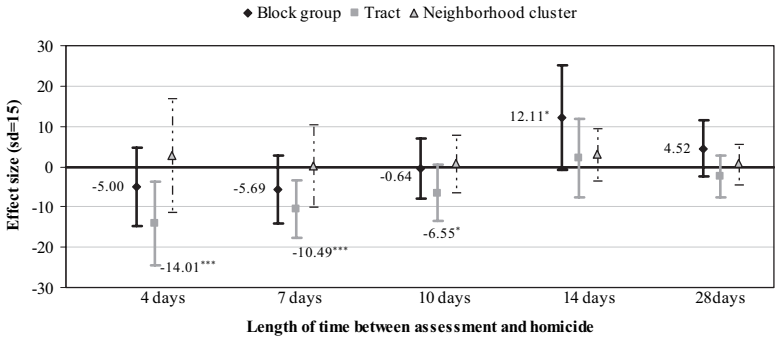

Fig. 4. Effect on Woodcock-Johnson Applied Problems scores of a recent homicide occurring within the block group, census tract, or neighborhood cluster, respectively, among African-Americans in the Three City Study Chicago sample. Coefficient values are shown for all block group estimates and for significant estimates at all levels. Sample sizes: Block group estimates are based on 341 assessments among 176 respondents; census tract and neighborhood cluster estimates are based on 347 assessments among 179 respondents. $^{**}P < 0.05$; $^{*}P < 0.10$; $^{***}P < 0.01$.

applied problems scores by 14.10 points ($P < 0.01$), and the effect size remains large and statistically significant for homicides occurring in the census tract within 10 d before the assessment.

Although estimates based on the Three City Study Chicago sample are less precise than estimates based on the PHDCN, results from kernel-weighted local linear regressions reproduce the temporal pattern found in the PHDCN (*SI Appendix*). At each level of analysis, the effect of local homicides is most severe when the homicide occurred in close proximity to the assessment, and the effect declines in a linear pattern as the time between the homicide and the assessment widens.

Discussion

Evidence from two independent samples of children in Chicago shows that exposure to a local homicide within a short period preceding a cognitive assessment reduces performance substantially, a finding that is present among African-Americans but not Hispanics. The magnitude of the effect varies depending on the sample, the assessment, the proximity of the homicide to the child's residence, and the length of time that passes between the homicide and the assessment. In the PHDCN, exposure to a homicide within the block group that occurs within a week before the WISC-R vocabulary assessment reduces scores by roughly 0.5 SD, and exposure to a homicide within the block group that occurs within 4 d before the assessment reduces WRAT3 reading scores by 0.66 SD. In the Three City Study Chicago sample, exposure to a homicide within the census tract that occurs within a week before the assessment reduces Woodcock-Johnson letter-word scores and applied problems scores by 0.66 to 1 SD, although these estimates have wide confidence intervals.

In each case, the estimated effects of recent local homicides are substantial, suggesting that local homicides have a nontrivial acute effect on African-American children's performance on cognitive tests that fades as the window of time between the homicide and the assessment widens. In the PHDCN sample, the effect of a homicide appears strongest when the homicide occurs close to the child's home, within the block group of residence, and is smaller for homicides that occur within the census tract or the neighborhood cluster. In the Three City Study, the geographic pattern is less clear because the estimates at the block group level are extremely imprecise; the strongest effects are found at the census tract level, and there are no effects at the level of the neighborhood cluster.

Collectively, the results provide evidence that local violence weighs on the minds of children as they approach cognitive assessments, but the mechanisms producing lower levels of cognitive performance are not testable with the available data. The pattern of findings is consistent with the literature on acute stress disorder, which is defined as a response to a threatening event that induces fear, helplessness, or horror. Among other symptoms are reduced awareness and difficulties with concentration for a period lasting at least 2 d and up to 1 mo after the stressor (30–34). Although this definition aligns fairly closely with the patterns presented, the absence of effects for Hispanics complicates any simple interpretation of the likely mechanisms. It is not clear, for instance, why local homicides would generate acute stress among African-Americans and not among Hispanics. One possible explanation is that homicides may be less salient or less threatening in the lives of Hispanics because the victims of homicides are frequently African-American.[¶] By contrast, homicide victims in African-Americans' neighborhoods are almost always of the same race. Unfortunately the data do not have sufficient power to detect interactions by race/ethnicity of victim, and the racial/ethnic difference in the effect of local homicides remains an unexplained finding that warrants additional research.

With this caveat in mind, this study provides evidence for acute effects of community violence that is robust to selection bias, a central problem faced by the observational literature on exposure to violence and community disadvantage more broadly (35–39). The identification strategy developed here addresses the selection bias problem by exploiting variation in the recency of local homicides arising from the relative timing of interview assessments and local homicides among children in families that have selected the same neighborhood. Importantly, the method is designed to capture only the acute impact of homicides and by design does not provide any information on permanent impacts on cognitive development. Still, the analysis of acute effects may have implications for understanding long-range inequality if one considers the spatial concentration of homicides and the prevalence of violent events within specific communities. As an example, if the findings from this analysis are simplified and one assumes that homicides within the census tract impair cognitive functioning for roughly 1 wk, calculations based on the PHDCN sample indicate that about 15% of African-American sample members spend at least 1 mo out of a year functioning at a low level purely because of local homicides. According to the same calculations, African-American sample members living in the city's most violent neighborhoods spend at least one quarter of the year, or roughly 1 wk out of every month, functioning at a low level because of local homicides.

Thus, although the analysis is limited to the identification of acute effects, these calculations indicate that in the most violent communities youth frequently may navigate daily life within

[¶]Among Hispanics exposed to local homicides within the week before the assessment, 54% of homocied victims were Hispanic. Among African-Americans exposed to local homicides within the week before the assessment, 87% of homicide victims were African-American.

the school or home environment while functioning at less-than-optimal levels. An additional implication of the results is that the impact of violence is not limited to those victimized or those who directly witness an act of violence but is felt by children across a community who live in close proximity to extreme violent events. This finding has implications for efforts to mitigate the harmful consequences of exposure to violence. Whereas reviews of the literature have led to calls for interventions designed to provide treatment or counseling for children directly exposed to violence within the home, school, or neighborhood environment (4), the current findings suggest the need for a broader recognition of the impact that violence can have on children living in the area, regardless of whether they witness violence directly or are personally victimized.

Materials and Methods

The PHDCN is a longitudinal study of families with children that in three interview waves has collected extensive information on child development, including assessments of vocabulary/reading skills among adolescents. The sample is representative of families with children living in Chicago in 1995. Families were followed wherever they moved over a period ranging from late 1994 through 2002, and residential addresses were geocoded at all three interview waves, allowing researchers to link families to their residential location through restricted-use files. The second source of data is a geocoded file identifying the location where the homicide occurred and the date of every homicide reported by the Chicago Police Department from 1994 through 2002. Neighborhoods are operationalized using three successively larger nested boundaries: block groups, census tracts, and neighborhood clusters (definitions of each geographic boundary are provided in *SI Appendix*) (15, 16). Cognitive assessments in the PHDCN were given to children in age cohorts 6, 9, 12, and 15 y at waves 1 and 2 of the survey and to children in age cohorts 3, 6, 9, and 12 y at wave 3 of the survey. Sample members from age cohort 18 y of the PHDCN are excluded in all waves, and sample members from age cohort 15 y are excluded in wave 3 because they received a different assessment designed for adults. Children in the final sample range in age from 5 to 17 y.

By using the merged data file children's vocabulary and reading scores are regressed on an indicator for a recent homicide in the census tract, with tract by survey wave fixed effects,[‖] as in Eq. **1**:

$$\mathrm{Y_i} = \alpha + \beta(\mathrm{Homicide})_\mathrm{i} + \delta(\mathbf{Wave} \times \mathbf{Tract})_\mathrm{i} + \gamma(\mathbf{Year})_\mathrm{i} + \tau(\mathbf{Month})_\mathrm{i} + \varepsilon_\mathrm{i}, \quad [1]$$

where $\mathrm{Y_i}$ is child *i*'s score on one of two assessments of cognitive skills, *Wave* and *Tract* represent census tract by survey wave indicators, *Year* and *Month* represent calendar year and month of year indicators, and *Homicide* is an indicator taking on a value of unity if the child's assessment was conducted within a given period after a homicide in the census tract; β represents the effect of a local and recent homicide on the child's cognitive assessment score. To adjust SE for possible clustering of error terms within individuals assessed more than once, all results reported in the main text use the Huber/White sandwich estimator.

The inclusion of tract by survey wave fixed effects means that the estimator relies entirely on variation in the relative timing of individual assessments and local homicides within a given census tract and within a particular survey wave. This method drops from the analysis sample members located in neighborhoods in which there is no variation in exposure to homicides within a given survey wave. For example, in the specification testing for effects of homicides in the census tract that occur within 7 d before the assessment, individuals would be dropped from the analysis if none of the sample members within the tract were assessed within a week after a local homicide or in the unlikely case that all sample members within the tract were assessed within a week after a local homicide. In either case, there would be no variation in exposure to a local homicide among sample members within the census tract. In census tracts where some sample members were sampled within a week after a homicide and others were not, those assessed within a week after the homicide compose the treatment group, and those not assessed within a week after a homicide compose the control group. Calendar year indicators are included to control for period effects. Month of year indicators are included to address the possibility that the time of year in which sample members are assessed could produce a spurious association between exposure to local homicides and cognitive performance. This spurious association might occur because homicides are more common in the summer months, and research shows that students score lower on standardized assessments when school is out of session (40).

The replication analysis is conducted with the same methods using the Chicago sample of the Three City Study of Welfare, Children, and Families. The Three City Study collected information from a sample of low-income families living in low-income neighborhoods, including assessments of cognitive skills based on a lette-word identification subtest and an applied problems subtest from the Woodcock-Johnson Psycho-Educational Battery-Revised (29). The sample comprises families with a focal child in one of two age ranges (as of wave 1): age 0–4 y or age 10–14 y. The current analysis is based on focal children in the older age range, all of whom were eligible for the Woodcock-Johnson assessments at both wave 1 and wave 2 of the survey.

Data from the PHDCN and the Three City Study are accessible through the Inter-University Consortium for Political and Social Research.

ACKNOWLEDGMENTS. Early stages of this research were conducted while the author was a scholar in the Robert Wood Johnson Health and Society Scholars Program at the Columbia University site. Helpful comments and feedback were provided by Larry Aber, Richard Arum, Peter Bearman, Dalton Conley, Martha Farah, David Greenberg, Bruce Link, Jens Ludwig, Sonia Lupien, Andrew Papachristos, Steve Raudenbush, Cybele Raver, Julien Teitler, Florencia Torche, and Larry Wu, National Academy of Science member/editor Robert Sampson, and two anonymous reviewers.

[‖]Block group level analyses use block group by wave fixed effects, and neighborhood cluster analyses use cluster by wave fixed effects.

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