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Neighborhood disadvantage in context: the influence of urbanicity on the association between neighborhood disadvantage and adolescent emotional disorders

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Abstract

Purpose—Inconsistent evidence of a relationship between neighborhood disadvantage and adolescent mental health may be, in part, attributable to heterogeneity based on urban or rural residence. Using the largest nationally representative survey of US adolescent mental health available, we estimated the association between neighborhood disadvantage and adolescent emotional disorders and the extent to which urbanicity modified this association.

Methods—The National Comorbidity Survey Replication Adolescent Supplement (NCS-A) sampled adolescents aged 13–17 years ($N = 10,123$). Households were geocoded to Census tracts. Using a propensity score approach that addresses bias from non-random selection of individuals into neighborhoods, logistic regression models were used to estimate the relative odds of having a DSM-IV emotional disorder (any past-year anxiety disorder, major depressive disorder or dysthymia) comparing similar adolescents living in disadvantaged versus non-disadvantaged neighborhoods in urban center, urban fringe, and non-urban areas.

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Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Human participant protection The survey was administered by the professional staff of the Institute for Social Research at the University of Michigan. The recruitment and consent procedures were approved by the Human Subjects Committees of Harvard Medical School and the University of Michigan.

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Results—The association between neighborhood disadvantage and emotional disorder was more than twice as large for adolescents living in urban centers versus non-urban areas. In urban centers, living in a disadvantaged neighborhood was associated with 59 % (95 % confidence interval 25–103) increased adjusted odds of emotional disorder.

Conclusions—Urbanicity modifies the relationship between neighborhood disadvantage and emotional disorder in adolescents. This effect modification may explain why evidence of a relationship between neighborhood disadvantage and adolescent mental health has been inconsistent. Recognizing the joint influence of neighborhood socioeconomic context and urbanicity may improve specificity in identifying relevant neighborhood processes.

Keywords

Adolescent; Mental health; Psychiatric epidemiology; Neighborhood; Propensity score; Survey

Introduction

A nationally representative survey of US adolescents showed that nearly one-half met criteria for ever having a mental disorder and nearly one-fourth met criteria for ever having a mental disorder with severe impairment [1]. Children with mental disorders are more likely to miss school and sociodevelopmental opportunities, which can lead to difficulties in academic achievement and future employment, earnings, and family life [2–5]. Moreover, these disorders often extend into adulthood [6].

An array of factors at multiple levels—genetic, family, and environmental—may influence mental health. Adolescents may be particularly susceptible to the influences of their neighborhood environment, because of the shift from the home to the external environment during this developmental period [7]. Neighborhood socioeconomic disadvantage (henceforth, neighborhood disadvantage)—a “proxy for a variety of specific features of neighborhoods potentially relevant to health,” [8]—is the most widely studied neighborhood characteristic that may influence mental health.

Research into the relationship between neighborhood disadvantage and child/adolescent emotional disorders (i.e., anxiety and depressive disorders) has resulted in inconsistent evidence [e.g., 9–13]. No study has explained these discrepant findings, nor identified which disadvantaged neighborhoods may be particularly detrimental to child/adolescent mental health. A characteristic that identifies neighborhoods that have systematically different relationships between neighborhood disadvantage and mental health—and therefore could offer an explanation for the inconsistencies—is called an effect modifier.

It is possible that urbanicity is an effect modifier of the neighborhood disadvantage—adolescent mental health association. The previous studies that found an association between neighborhood disadvantage and emotional disorders tended to sample from urban populations [e.g., 10, 11, 13], whereas studies reporting no association tended to sample from non-urban populations and broader metropolitan areas [e.g., 9, 12]. Living in a disadvantaged neighborhood in an urban area likely entails exposure to a different set of stressors than living in a disadvantaged neighborhood in a rural area. Although certain

exposures detrimental to mental health are more prevalent in rural disadvantaged neighborhoods, such as a lack of access to mental health care and resources [14], other stressors may be more prevalent in disadvantaged urban neighborhoods. Lack of green space, noise, residential instability and exposure to violence in the neighborhood and in the neighborhood school may be more prevalent in disadvantaged urban neighborhoods, and research has linked these stressors to emotional disorders [e.g., 15–17]. Therefore, we hypothesize that urbanicity modifies the association between living in a disadvantaged neighborhood; specifically, we hypothesize that the positive relationship between neighborhood disadvantage and emotional disorders is greater in urban areas than in non-urban areas.

A central challenge to testing this hypothesis, and to neighborhood research in general, is addressing non-random selection of families into neighborhoods [8]. The population of one neighborhood may look very different (e.g., in terms of race/ethnicity, income distribution) from another. This issue is typically addressed with regression adjustment. However, when trying to estimate the effect of living in one type of neighborhood versus another, this form of adjustment poses a problem if adolescents living in disadvantaged neighborhoods do not have similar (also called exchangeable) counterparts living in non-disadvantaged neighborhoods [18]. To address this challenge, researchers have increasingly drawn on propensity score tools [8]. However, we know of no study of the relationship between neighborhood and adolescent mental health that has used these methods.

Our objectives were to estimate the association between neighborhood disadvantage and emotional disorders in adolescents within levels of urbanicity and to test for effect modification by urbanicity, addressing non-random selection into neighborhoods through a propensity score approach. We used data from the National Comorbidity Survey Replication Adolescent Supplement (NCS-A), a nationally representative survey of adolescent mental health. Design-based, survey-weighted logistic regression models were combined across propensity score subclasses to estimate the relative odds of having an emotional disorder comparing similar adolescents living in disadvantaged versus non-disadvantaged neighborhoods in urban center, urban fringe, and non-urban areas.

Methods

The NCS-A is a nationally representative sample of adolescents in the continental United States designed as a survey of adolescent DSM-IV syndromes/disorders. The background, sampling and recruitment methods, and weighting scheme have been described elsewhere [19, 20]. Adolescents aged 13–17 years were sampled via dual-frame household and school samples. Professional interviewers at the Survey Research Center at the Institute for Social Research at the University of Michigan administered face-to-face, laptop computer-assisted personal interviews in the adolescents' homes between February 2001 and January 2004. While an adolescent was being interviewed, one parent or parent surrogate was asked to complete a self-administered questionnaire; those who did not complete this questionnaire were asked to complete a short-form version. Weighting procedures adjust the sample of 10,123 adolescents to be representative of students in the US population in 2000 and are described in more detail elsewhere [19]. Informed assent and consent were obtained from

each adolescent and his/her parent or guardian. The Human Subjects Committees of Harvard Medical School and the University of Michigan approved recruitment and consent procedures.

Participant residential addresses were geocoded to 3367 US Census tracts by the Survey Research Center at the Institute for Social Research at the University of Michigan. Excluding adolescents residing in Census tracts with missing or inestimable Short Form 3 (SF3) indicators resulted in a final sample size of 10,074 adolescents in 3347 Census tracts.

Contextual measures

Neighborhood disadvantage—Neighborhood socioeconomic status (SES), based on a summary score derived from factor analysis by Diez-Roux et al. [21], has been used in multiple epidemiologic studies [e.g., 22]. It is composed of six indicators from the US Census SF3: (1) log median household income, (2) percent households with interest, dividend, or rental income, (3) log median value of housing units, (4) percent persons over age 25 with high school degree, (5) percent persons over age 25 with college degree, and (6) percent persons in executive, managerial, or professional specialty occupations. Indicators were transformed to z-scores and summed to make a normally distributed summary score. We re-examined the factor structure and fit statistics in our sample and confirmed the one-factor structure. In our sample, the summary score had a Cronbach's alpha of 0.83 and ranged from -13.6 to 17.8 with a median value of -0.36. Neighborhoods in the lowest SES tertile were defined as disadvantaged, and neighborhoods in the two upper tertiles were defined as non-disadvantaged.

Urbanicity—Urbanicity was analyzed using the following Census-derived categories: (1) large mid-urban center (henceforth, urban center), (2) urban fringe, or (3) non-urban. Adolescents were categorized as living in a large mid-urban center area if they resided in a central county of a metropolitan statistical area. Urban fringe areas were defined as non-central counties of a metropolitan statistical area. Non-urban areas were defined as small to large towns or rural areas. The non-urban category was used as the reference category for the two dummy variables of urban center and urban fringe.

Individual measures

Outcome measures—During face-to-face interviews, all NCS-A participants were administered a modified version of the World Health Organization Composite International Diagnostic Interview (CIDI) to assess the presence of mental health disorders/syndromes consistent with the DSM-IV [1, 20]. Past 12-month emotional disorder was defined as any anxiety disorder, major depressive disorder, or dysthymia. In accordance with prior recommendations, diagnostic algorithms for emotional disorders included only data obtained from the adolescent [23].

Covariate measures—As recommended by Leventhal and Brooks-Gunn [24], covariates included adolescent age (in years), race/ethnicity, immigrant generation, household income, maternal age at birth, maternal level of education, family structure, and region of residence (i.e., Northeast, Midwest, South, West). Adolescent age, race/ethnicity, immigrant

generation, and family structure were obtained during the adolescent interview. Race/ethnicity was categorized as non-Hispanic white, non-Hispanic black, Hispanic, and Other. Immigrant generation was categorized as first (foreign born), second, or third or greater. Family structure consisted of two variables assessing whether or not the adolescent had lived his/her whole life with his/her (1) mother and (2) father. Maternal education, maternal age at birth (in years, modeled with linear and quadratic terms), and household income (log transformed) were obtained from the parent questionnaire. Maternal education was divided into four ordered categories: less than high school, high school, some college, and college graduate.

Statistical analysis

We used multiple imputation by chained equations to address missing data [25]. This procedure has been shown to be an effective way to address missing data in large datasets and requires less strict assumptions than excluding those with missing data [26]. Variables in the imputation model included variables hypothesized to influence response as well as all variables to be used in the analysis.

In implementing the propensity score approach, we followed previous recommendations for combining propensity score subclassification with complex survey data [27]. Additional details of this approach can be found in Online Resource 1. A propensity score [28] was estimated for each adolescent that is the predicted probability of living in a disadvantaged neighborhood at the time of the study as a function of the covariates specified above and their interactions with sex. We restricted the analysis to ensure that we compared participants living in disadvantaged neighborhoods to exchangeable participants living in non-disadvantaged neighborhoods for a final sample size of 9,600 adolescents.

Propensity score subclassification controlled for the bulk of confounding. Figure 1, below, compares the imbalance in covariates (as measured by standardized mean difference) before and after subclassification. Covariate balance between the two exposure groups was achieved (all standardized mean differences less than 10 %) with the nine subclasses.

We ran design-based, survey-weighted logistic regression models within each propensity score subclass to estimate the log odds of having an emotional disorder as a function of neighborhood disadvantage, neighborhood disadvantage $\times$ urbanicity interaction (to assess effect modification), and propensity score (to help control for residual confounding). Variances were approximated using Taylor linearization using the survey package in the R statistical language (version 2.14.1). Coefficient estimates and variances were combined across subclasses using the Mantel–Haenszel method. Then, these average effects were pooled across the 100 imputed datasets using Rubin’s combining rules [29]. All analyses were performed using R.

Results

Table 1 presents design-based, weighted descriptive statistics of the sample by neighborhood disadvantage status. The mean age of the participants was just over 15 years, and 49 % were female. A greater percentage of adolescents in disadvantaged neighborhoods were Hispanic

or Black. Similar percentages reported living with their mother for their whole life, but fewer adolescents in disadvantaged neighborhoods had lived with their father for their whole life. In non-disadvantaged neighborhoods, mean household income was about \$30,000 greater, and more mothers had a college education and were about 2 years older at the time of birth. Adolescents living in disadvantaged neighborhoods were more likely to live in the urban fringe and non-urban areas. The prevalence of emotional disorders was slightly higher in disadvantaged neighborhoods.

We examined the associations between disadvantaged neighborhood residence and odds of emotional disorder by the level of urbanicity by running unadjusted and adjusted models, both incorporating the survey design and weights (shown in Table 2). The adjusted model also uses the propensity score methods described above to control for potential confounding.

In the unadjusted model, living in a disadvantaged versus non-disadvantaged neighborhood within an urban center was associated with a 70 % increased odds of emotional disorder (OR 1.70, 95 % CI 1.23, 2.34). The unadjusted association between emotional disorder and neighborhood disadvantage was not statistically significant in urban fringe or non-urban areas.

The inferences remained the same in the adjusted model. Living in a disadvantaged versus non-disadvantaged neighborhood was associated with a 59 % increased odds of emotional disorder (OR 1.59, 95 % CI 1.25, 2.03) among those living within an urban center. The adjusted association between emotional disorder and neighborhood disadvantage was not statistically significant in urban fringe or non-urban areas.

Figure 2 depicts each odds ratio and its associated 95 % confidence interval. There is a dose-response relationship between neighborhood disadvantage and odds of emotional disorder with higher odds ratios across increasing levels of urbanicity. The formal statistical test for interaction of the urban center and neighborhood disadvantage terms was statistically significant; the association between neighborhood disadvantage and emotional disorder is more than twice as large (ratio of odds ratios 2.08, 95 % CI 1.23, 3.55) for adolescents living in urban centers versus non-urban areas. However, there is no statistically significant difference in the association between urban fringe and non-urban areas.

Discussion

In a large, nationally representative sample of US adolescents, we found that urbanicity modified the association between neighborhood disadvantage and emotional disorder. Disadvantaged neighborhood residence was associated with emotional disorder if the neighborhood was within an urban center, but there was no association if the neighborhood was within a rural or urban fringe area. These results advance previous research that did not consider the potentially modifying effect of urbanicity, and in part, address their conflicting results through demonstrating the impact of the urban environment [9–13].

We recognize that the measurement of neighborhood disadvantage may differ depending on whether the neighborhood is in an urban or rural area. This issue is typically called measurement variance, and we performed a sensitivity analysis to assess whether our results

could be an artifact of measurement variance of neighborhood disadvantage across levels of urbanicity. Multiple-group confirmatory factor analysis that allowed the loading coefficients of the neighborhood disadvantage measurement model to differ by urbanicity was used to estimate factor scores using the regression method [30]. Defining neighborhood disadvantage based on these factor scores did not change our inferences (results not shown but available from the first author).

As discussed in the introduction, urbanicity may exacerbate the association between neighborhood disadvantage and emotional disorders, because risk factors of poor mental health may be more prevalent in urban disadvantaged neighborhoods than in non-urban disadvantaged neighborhoods. A meta-analysis of twenty population-based surveys of adults in developed countries found 21 % greater odds of anxiety disorders in urban areas compared to rural areas and 38 % greater odds of mood disorders (e.g., major depressive disorder, bipolar disorder) [31]. Despite a long history of research into the association between urbanicity and mental health, there has been surprisingly little research regarding specific characteristics of urban living that confer increased risk of emotional disorders [15]. Possibilities include lack of green space, residential instability, noise, and exposure to violence [e.g., 15–17].

Our research findings have implications for future work and policy. Previous research suggested that children and adolescents in disadvantaged neighborhoods had poorer mental health than those in more advantaged neighborhoods [e.g., 10, 11, 13]. Our findings add that adolescents in disadvantaged urban areas may be particularly vulnerable to anxiety and depression, and therefore, targeting resources to this subpopulation may be appropriate. Risk conferred by the neighborhood and urban environment argues for policies that aim to improve neighborhood conditions [32]. Future work should identify specific neighborhood conditions that are detrimental to or protective of adolescent mental health. These findings can then be used to inform specific policy interventions, such as crime prevention strategies, school climate and safety interventions, and housing policies such as those designed to reduce racial and economic segregation.

In addition, future research should examine whether urbanicity modifies the associations between neighborhood conditions and adolescent behavioral disorders and substance misuse. Although researchers have studied the relationship between neighborhood conditions and substance use, externalizing problems, and risky sexual behavior [e.g., 33, 34], few have used behavioral disorders that correspond to DSM criteria. In addition, there has been little research in exploring possible effect heterogeneity.

Our analysis is subject to several assumptions and limitations. We assume that the sampling weights correctly account for sample selection and non-response, and thus the results generalize to the population of US adolescents. We also assume that the propensity score model is correctly specified with no omitted variables. Omitted variables could result in biased effect estimates if there is confounding beyond that for which we have controlled. To test the sensitivity of our results to an unobserved confounder, we used the bias formulas in Vanderweele and Arah [35]. Taking the simple case of a binary confounder and imposing several assumptions, an unobserved confounder must be twice as prevalent in disadvantaged

versus non-disadvantaged neighborhoods and 2.5 times more prevalent among adolescents with versus without emotional disorders to render our effect estimate non-significant (Online Resource 2 details this sensitivity analysis for an unobserved confounder.)

We also assume that measurement error is minimal and does not affect our inferences. However, our exposure variable is subject to measurement error for at least two reasons. First, Census tract is a proxy for neighborhood—how residents and/or city planners would map neighborhood boundaries may differ from Census tract boundaries. Nevertheless, Census tracts allow neighborhood measures to be “compared over time and across regions” [36], and are better than zip codes at detecting differences in socioeconomic gradation across areas [36]. Second, we may have misclassified neighborhoods as disadvantaged or non-disadvantaged. However, we believe that this misclassification is likely minimal as we are using a previously established scale and dichotomizing the exposure. Although using the first tertile as the cut-point may not be optimal, misclassification would likely be non-differential and bias our estimates toward the null.

The outcome variable of emotional disorder is also subject to measurement error. However, the use of the CIDI in assessing mental disorder is a key strength. It is more reliable than unstandardized psychiatric diagnoses and shows good agreement with standardized psychiatric diagnoses [37]. It also has high content validity, as it is designed to correspond to DSM-IV and ICD-10 criteria [20].

The large, nationally representative sample is a major strength of this analysis. With over 10,000 adolescents, the NCS-A is the largest nationally representative survey of adolescent mental health in the US, compiling data collected from adolescents, parents, and GIS-coded residence for an unusually large amount of information on context. Because of these attributes, we were well positioned to examine the role of urbanicity as a potential effect modifier of the association between neighborhood disadvantage and mental health. Incorporation of the survey design and weights into our analysis preserves the NCS-A’s sampling strengths. It accounts for sample selection (incorporating strata and cluster variables) and non-response, thus addressing the clustering of adolescents within neighborhoods (clustering was low in this sample—there were an average of three adolescents per neighborhood). Incorporation of the survey design and weights allows us to interpret the results as being nationally representative, reduces bias from differential non-response, and helps protect our inferences from inflated Type-1 error rates through better standard error estimation [38].

Another strength is our use of propensity score sub-classification. As discussed previously, propensity score methods have an advantage over standard regression methods in that they allow the analyst to look at the data to assess (1) how well bias is controlled for in each covariate and (2) the extent of propensity score overlap and, thus, the range at which the data will support estimates. However, analysis using a standard multivariate logistic regression model did not change our inferences (results not shown but available from the first author).

Conclusion

The associations between urbanicity and mental health and between neighborhood disadvantage and mental health have been studied separately for more than 100 years [39, 40]. No known research has studied effect modification of the association between neighborhood disadvantage and mental health by urbanicity. However, adolescents live in neighborhoods that simultaneously comprise a level of urbanicity and a level of disadvantage. Our results suggest that the effect of neighborhood disadvantage on adolescent depression and anxiety is greater in urban centers than in non-urban areas. Recognizing the dependence of these contexts will aid future research in identifying specific characteristics of urban, disadvantaged neighborhoods (e.g., violence, residential instability, lack of green space) that confer risk of mental disorder, and in this era of shrinking budgets, will help channel funding and services to those youth most at risk.

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References

1. Merikangas KR, He JP, Burstein M, Swanson SA, Avenevoli S, Cui L, Benjet C, Georgiades K, Swendsen J (2010) Lifetime prevalence of mental disorders in U.S. adolescents: results from the National Comorbidity Survey Replication–Adolescent Supplement (NCS-A). *J Am Acad Child Adolesc Psychiatry* 49 (10):980–989. doi:10.1016/j.jaac.2010.05.017 [PubMed: 20855043]
2. Breslau J, Lane M, Sampson N, Kessler RC (2008) Mental disorders and subsequent educational attainment in a US national sample. *J Psychiatr Res* 42(9):708–716. doi:10.1016/j.jpsychires.2008.01.016 [PubMed: 18331741]
3. Glied S, Pine DS (2002) Consequences and correlates of adolescent depression. *Arch Pediatr Adolesc Med* 156(10):1009–1014. pii: poa10284 [PubMed: 12361447]
4. Kessler RC, Heeringa S, Lakoma MD, Petukhova M, Rupp AE, Schoenbaum M, Wang PS, Zaslavsky AM (2008) Individual and societal effects of mental disorders on earnings in the United States: results from the National Comorbidity Survey Replication. *Am J Psychiatry* 165(6):703–711. doi:10.1176/appi.ajp.2008.08010126 [PubMed: 18463104]
5. Kessler RC, Walters EE, Forthofer MS (1998) The social consequences of psychiatric disorders, III: probability of marital stability. *Am J Psychiatry* 155(8):1092–1096 [PubMed: 9699699]
6. Report of the Surgeon General's Conference on Children's Mental Health: A National Action Agenda (2001). Department of Health and Human Services, Washington, DC
7. Wikstrom PH, Sampson RJ (2003) Social mechanisms of community influences on crime and pathways in criminality. In: Lahey BB, Moffitt TE, Caspi A (eds) *Causes of conduct disorder and juvenile delinquency* The Guilford Press, New York
8. Diez Roux AV (2004) Estimating neighborhood health effects: the challenges of causal inference in a complex world. *Soc Sci Med* 58(10):1953–1960. doi:10.1016/S0277-9536(03)00414-3 [PubMed: 15020010]

9. Gonzales NA, Cox S, Roosa MW, White RMB, Knight GP, Zeiders KH, Saenz D (2011) Economic hardship, neighborhood context, and parenting: prospective effects on Mexican-American adolescent's mental health. *Am J Commun Psychol* 47(1–2): 98–113. doi:10.1007/s10464-010-9366-1
10. Kling JR, Liebman JB, Katz LF (2007) Experimental analysis of neighborhood effects. *Econometrica* 75(1):83–119
11. Leventhal T, Brooks-Gunn J (2003) Moving to opportunity: an experimental study of neighborhood effects on mental health. *Am J Public Health* 93(9):1576–1582 [PubMed: 12948983]
12. Simons RL, Murry V, McLoyd V, Lin KH, Cutrona C, Conger RD (2002) Discrimination, crime, ethnic identity, and parenting as correlates of depressive symptoms among African American children: a multilevel analysis. *Dev Psychopathol* 14(2):371–393 [PubMed: 12030697]
13. Xue Y, Leventhal T, Brooks-Gunn J, Earls FJ (2005) Neighborhood residence and mental health problems of 5- to 11-year-olds. *Arch Gen Psychiatry* 62(5):554–563. doi:10.1001/archpsyc.62.5.554 [PubMed: 15867109]
14. Merwin E, Snyder A, Katz E (2006) Differential access to quality rural healthcare: professional and policy challenges. *Fam Community Health* 29(3):186–194. pii: 00003727–200607000-00005 [PubMed: 16775468]
15. Galea S (2011) The urban brain: new directions in research exploring the relation between cities and mood-anxiety disorders. *Depress Anxiety* 28(10):857–862. doi:10.1002/da.20868 [PubMed: 21818824]
16. Lee AC, Maheswaran R (2011) The health benefits of urban green spaces: a review of the evidence. *J Public Health (Oxf)* 33(2):212–222. doi:10.1093/pubmed/fdq068 [PubMed: 20833671]
17. Slopen N, Fitzmaurice GM, Williams DR, Gilman SE (2012) Common patterns of violence experiences and depression and anxiety among adolescents. *Soc Psychiatry Psychiatr Epidemiol* 47(10):1591–1605. doi:10.1007/s00127-011-0466-5 [PubMed: 22241530]
18. Hernan MA, Robins JM (2006) Estimating causal effects from epidemiological data. *J Epidemiol Community Health* 60(7): 578–586. doi:10.1136/jech.2004.029496 [PubMed: 16790829]
19. Kessler RC, Avenevoli S, Costello EJ, Green JG, Gruber MJ, Heeringa S, Merikangas KR, Pennell BE, Sampson NA, Zaslavsky AM (2009) Design and field procedures in the US National Comorbidity Survey Replication Adolescent Supplement (NCS-A). *Int J Methods Psychiatr Res* 18(2):69–83. doi: 10.1002/mpr.279 [PubMed: 19507169]
20. Kessler RC, Avenevoli S, Green J, Gruber MJ, Guyer M, He Y, Jin R, Kaufman J, Sampson NA, Zaslavsky AM (2009) National comorbidity survey replication adolescent supplement (NCS-A): III. Concordance of DSM-IV/CIDI diagnoses with clinical reassessments. *J Am Acad Child Adolesc Psychiatry* 48 (4):386–399. doi:10.1097/CHI.0b013e31819a1cbc [PubMed: 19252450]
21. Diez-Roux AV, Kiefe CI, Jacobs DR, Jr, Haan M, Jackson SA, Nieto FJ, Paton CC, Schulz R (2001) Area characteristics and individual-level socioeconomic position indicators in three population-based epidemiologic studies. *Ann Epidemiol* 11(6): 395–405. pii: S1047279701002216 [PubMed: 11454499]
22. Diez Roux AV, Borrell LN, Haan M, Jackson SA, Schultz R (2004) Neighbourhood environments and mortality in an elderly cohort: results from the cardiovascular health study. *J Epidemiol Community Health* 58(11):917–923. doi:10.1136/jech.2003.019596 [PubMed: 15483307]
23. Angold A, Weissman MM, John K, Merikangas KR, Prusoff BA, Wickramaratne P, Gammon GD, Warner V (1987) Parent and child reports of depressive symptoms in children at low and high risk of depression. *J Child Psychol Psychiatry* 28(6):901–915 [PubMed: 3436996]
24. Leventhal T, Brooks-Gunn J (2000) The neighborhoods they live in: the effects of neighborhood residence on child and adolescent outcomes. *Psychol Bull* 126(2):309–337 [PubMed: 10748645]
25. van Buuren S (2007) Multiple imputation of discrete and continuous data by fully conditional specification. *Stat Methods Med Res* 16(3):219–242. doi:10.1177/0962280206074463 [PubMed: 17621469]
26. Stuart EA, Azur M, Frangakis C, Leaf P (2009) Multiple imputation with large data sets: a case study of the Children's Mental Health Initiative. *Am J Epidemiol* 169(9):1133–1139. doi: 10.1093/aje/kwp026 [PubMed: 19318618]

27. Zanutto E (2006) A comparison of propensity score and linear regression analysis of complex survey data. *J Data Sci* 4:67–91
28. Rosenbaum PR, Rubin DB (1983) The central role of the propensity score in observational studies for causal effects. *Biometrika* 70(1):41–55
29. Rubin DB (1987) Multiple imputation for nonresponse in surveys J. Wiley & Sons, New York
30. Bollen KA, Arminger G (1991) Observational residuals in factor analysis and structural equation models. *Sociol Methodol* 21:235–262
31. Peen J, Schoevers RA, Beekman AT, Dekker J (2010) The current status of urban–rural differences in psychiatric disorders. *Acta Psychiatr Scand* 121(2):84–93. doi:10.1111/j.1600-0447.2009.01438.x [PubMed: 19624573]
32. Neckerman KM, Lovasi GS, Davies S, Purciel M, Quinn J, Feder E, Raghunath N, Wasserman B, Rundle A (2009) Disparities in urban neighborhood conditions: evidence from GIS measures and field observation in New York City. *J Public Health Policy* 30(Suppl 1):S264–S285. doi:10.1057/jphp.2008.47 [PubMed: 19190579]
33. Goodnight JA, Lahey BB, Van Hulle CA, Rodgers JL, Rathouz PJ, Waldman ID, D’Onofrio BM (2012) A quasi-experimental analysis of the influence of neighborhood disadvantage on child and adolescent conduct problems. *J Abnorm Psychol* 121(1): 95–108. doi:10.1037/a0025078 [PubMed: 21942334]
34. Fagan AA, Wright EM, Pinchevsky GM (2013) Racial/ethnic differences in the relationship between neighborhood disadvantage and adolescent substance use. *J Drug Issues* 43(1):69–84 [PubMed: 25147408]
35. Vanderweele TJ, Arah OA (2011) Bias formulas for sensitivity analysis of unmeasured confounding for general outcomes, treatments, and confounders. *Epidemiology* 22(1):42–52. doi: 10.1097/EDE.0b013e3181f74493 [PubMed: 21052008]
36. Krieger N, Chen JT, Waterman PD, Soobader MJ, Subramanian SV, Carson R (2002) Geocoding and monitoring of US socioeconomic inequalities in mortality and cancer incidence: does the choice of area-based measure and geographic level matter? the Public Health Disparities Geocoding Project. *Am J Epidemiol* 156(5):471–482 [PubMed: 12196317]
37. Wittchen HU (1994) Reliability and validity studies of the WHO–Composite International Diagnostic Interview (CIDI): a critical review. *J Psychiatr Res* 28(1):57–84. pii: 0022–3956(94)90036–1 [PubMed: 8064641]
38. Gelman A (2007) Struggles with survey weighting and regression modeling. *Stat Sci* 22(2):153–164
39. Faris RE, Dunham HW (1939) Mental disorders in urban areas: an ecological study of schizophrenia and other psychoses The University of Chicago Press, Chicago/London
40. Dohrenwend BP, Dohrenwend BS (1974) Psychiatric disorders in urban settings. In: Caplan G (ed) *American handbook of psychiatry*, vol 2., Child and adolescent psychiatry Basic Books, Inc., New York, pp 424–449

Fig. 1.

Covariate balance pre- and post-subclassification. *Plotted points* represent the standardized mean differences (difference in means between the disadvantaged neighborhood group and non-disadvantaged neighborhood group standardized by the standard deviation in the disadvantaged group) for each covariate. *Open dots* represent standardized mean differences in the pre-propensity score subclassification data. *Closed dots* represent standardized mean differences in the post-propensity score subclassification data

Fig. 2.
Log odds ratios and 95 % confidence intervals for the effect of neighborhood disadvantage within strata of urbanicity for emotional disorders

Table 1

Design-based, weighted NCS-A sample characteristics by neighborhood disadvantage status

	Disadvantaged (<i>n</i> = 3,597)		Non-disadvantaged (<i>n</i> = 6,003)	
	Mean	95 % CI	Mean	95 % CI
Female	0.49	0.46, 0.53	0.49	0.47, 0.51
Age	15.17	15.02, 15.31	15.19	15.05, 15.34
Race/ethnicity				
Hispanic	0.24	0.19, 0.29	0.11	0.09, 0.13
Black	0.28	0.23, 0.32	0.09	0.08, 0.11
Other	0.04	0.03, 0.05	0.06	0.04, 0.08
White	0.45	0.39, 0.51	0.74	0.71, 0.77
Lived with mother	0.85	0.82, 0.88	0.88	0.87, 0.90
Lived with father	0.48	0.45, 0.50	0.62	0.59, 0.65
Immigrant generation				
1st	0.09	0.07, 0.11	0.06	0.04, 0.07
2nd	0.13	0.11, 0.16	0.11	0.10, 0.13
3rd or greater	0.78	0.73, 0.82	0.83	0.80, 0.85
Household income	52,916	49,450, 56,626	82,742	78,585, 87,118
Maternal education				
Less than high school	0.14	0.12, 0.17	0.05	0.04, 0.06
High school graduate	0.51	0.48, 0.55	0.42	0.40, 0.44
Some college	0.22	0.20, 0.25	0.26	0.24, 0.28
College graduate	0.12	0.10, 0.14	0.26	0.24, 0.29
Maternal age at birth	24.58	24.13, 25.03	26.83	26.52, 27.14
Region				
Northeast	0.16	0.05, 0.26	0.19	0.15, 0.22
Midwest	0.13	0.06, 0.20	0.26	0.22, 0.30
South	0.51	0.42, 0.60	0.30	0.24, 0.37
West	0.20	0.15, 0.25	0.25	0.19, 0.31
Urbanicity				
Urban center	0.38	0.29, 0.47	0.49	0.43, 0.55
Urban fringe	0.41	0.31, 0.51	0.38	0.31, 0.45
Non-urban	0.21	0.11, 0.30	0.13	0.10, 0.16
Emotional disorder	0.28	0.25, 0.32	0.24	0.22, 0.25

Table 2

Relative odds of emotional disorder comparing residence in disadvantaged versus non-disadvantaged neighborhoods by urbanicity

	<u>Unadjusted, weighted^a</u>		<u>Propensity score subclassification, weighted</u>	
	OR	95 % CI	OR	95 % CI
Non-urban	1.102	0.784, 1.549	0.707	0.467, 1.070
Urban fringe	1.103	0.816, 1.492	1.005	0.795, 1.270
Urban center	1.697	1.233, 2.336	1.591 ^b	1.250, 2.025

^aBased on all subjects ($N = 10,074$). Results did not change when based on the 9,600 subjects included in the primary analysis

^bThe interaction term comparing the odds ratios between urban centers and non-urban areas was statistically significant (ratio of odds ratios: 2.08, 95 % CI 1.23, 3.55)