

**Community Violence and Urban Childhood Asthma:
A Multilevel Analysis**

Michelle J. Sternthal, PhD¹

Hee-Jin Jun, PhD²

Felton Earls, MD^{3,4}

Rosalind J. Wright, MD, MPH^{2,5}

¹Department of Environmental and Occupational Medicine & Epidemiology, Harvard School of Public Health, Boston, MA; ²Channing Laboratory, Brigham & Women's Hospital, Harvard Medical School, Boston, MA; ³Department of Global Health & Social Medicine, Harvard Medical School, Boston, MA; ⁴Department of Society, Human Development, & Health, Harvard School of Public Health, Boston, MA; ⁵Department of Environmental Health, Harvard School of Public Health, Boston, MA

Corresponding author:

Michelle Sternthal, Department of Environmental and Occupational Medicine & Epidemiology, Harvard School of Public Health, 401 Park Drive, Boston, MA 02215, 617-384-8994 (fax) msternth@hsph.harvard.edu. The PHDCN was supported by grants from the grants from the National Institute of Justice, the National Institute of Mental Health and the John D. and Catherine T. MacArthur Foundation. Collection of the asthma outcomes data was, in part, funded through K08 HL04187(RJW). During preparation of the manuscript, RJW was funded by R01 HL080674; MJS by grant T32-ES07069-29 and RJW and MJS by the Leaves of Grass Foundation.

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ABSTRACT

We examined the association between community violence exposure and childhood asthma risk in a multilevel, multi-method longitudinal study controlling for individual- and neighborhood-level confounders and pathway variables.

Analyses included 2071 children aged 0-9 at enrollment from the Project on Human Development in Chicago Neighborhoods (PHDCN). Multilevel logistic regression models estimated the likelihood of asthma, controlling for individual-level (child's age, gender, race/ethnicity; maternal asthma, socioeconomic status, and family violence in the home) and neighborhood-level confounders (concentrated disadvantage, collective efficacy, social disorder), and pathway variables (maternal smoking, breastfeeding).

In adjusted analyses, medium (OR 1.60; 95% CI 1.17, 2.19) and high levels (OR 1.56; 95% CI 1.12, 2.18) of community violence were associated with increased asthma risk, relative to low levels. The increased asthma risk remained for African Americans when models included community violence and all other individual-level covariates but attenuated to borderline non-significance when further adjusting for collective efficacy.

Community violence is associated with asthma risk when controlling for individual- and neighborhood-level confounders. Neither community violence nor the other individual-level factors fully accounted for the excess asthma burden among African Americans.

These data suggest that public health interventions outside of the biomedical model may be needed to reduce asthma in disadvantaged populations.

In the United States (US), those living in impoverished urban neighborhoods have the highest asthma rates and associated morbidity relative to their higher socioeconomic status (SES) and non-urban counterparts.(1) Such disparities are not adequately explained by physical environmental factors.(2)) The recognized importance of the social environment in child health, coupled with knowledge of mechanisms linking psychological stress and asthma(2, 3) indicate that children may be raised in social contexts potentially as detrimental to their development and health as physical toxins.(4)

Chronic community violence has been identified as a prevalent and extreme stressor confronting many urban poor communities.(5, 6) In one inner-city cohort in Chicago, Illinois, 42% of children ages 7 to 13 years had seen someone shot and 37% had seen someone stabbed.(6)

Moreover, community violence contributes significantly to urban childhood morbidity.(5) Witnessing or being a victim of community violence adversely affects a child's cognitive, emotional, and social functioning.(7, 8) Research links community violence exposure to alterations in the physiological stress response, including increased blood pressure and heart rate, and disrupted cortisol expression.(8, 9) Such biobehavioral and physiological sequelae may lead to broader health effects. Accumulating evidence suggests that community violence may contribute to the burden of asthma in urban populations.(5) Increased exposure is associated with more symptom days,(10) higher hospitalization rates,(11) increased asthma prevalence among children in communities with both elevated crime/violence and other environmental hazards (i.e., ambient air pollutants),(12) and increased risk of wheezing at ages 2-3.(13)

While evidence suggests that community violence may contribute to asthma expression, there are methodological limitations. First, studies have not accounted for the co-occurrence of other childhood adversities that may also contribute to psychological stress and asthma (e.g., interfamilial violence).(14) Second, none of the existing studies consider neighborhood structural measures. This is problematic because community violence clusters in areas characterized by other community-level social stressors that also tax individuals living in these neighborhoods. These include constructs of neighborhood disadvantage, social disorder, and low collective efficacy.(5, 15) For example, the real or perceived threat of crime, and the broader construct of social disorder, fosters a distrust of others, disrupted collective efficacy, and social isolation,(15) which, in turn have been linked to asthma outcomes in low-income families.(16) Moreover, those experiencing greater community violence may also be exposed to physical toxins linked to asthma expression (air pollution, indoor allergens).(17) Third, studies to date have been cross-sectional or retrospective, preventing demonstration of a temporal relationship between community violence exposure and asthma development.

We address some of these limitations by examining whether higher level exposure to community violence is associated with an increased risk of asthma in a prospective study of urban children, after controlling for individual-level sociodemographics, behaviors (smoking, breastfeeding), family violence and neighborhood-level measures of disadvantage, social disorder, and collective efficacy.

METHODS

Study Design and Analytic Sample

<Figure 1 about here>

Data are from the Project on Human Development in Chicago Neighborhood (PHDCN), a multilevel, multi-method longitudinal study of contextual factors and individual development-(18). Figure 1 illustrates the data collection schema and current analytic sample. Briefly, 343 Chicago neighborhood clusters (NCs) were identified using 1990 US census data. In 1995, an interview-administered community survey (CS) was conducted with a representative sample of adults within each of the NCs (n=8,782) to derive neighborhood-level constructs (i.e., social disorder and collective efficacy detailed below) independent of the sample from which individual-level data were ascertained.

For the longitudinal study, a stratified probability sample of 80 neighborhoods was selected from the 343 NCs. Conceived using an accelerated cohort design, English and Spanish speaking households were screened for eligible children within 6 months of 7 target cohort ages [0 (in utero through age 6 months), 3, 6, 9, 12, 15, and 18 years]. Within each household, all eligible children were invited to participate, along with the primary caregiver for those younger than 18. Participants were enrolled in 1995 and followed in 3 waves of data collection – wave 1 (1994-1997), wave 2 (1997-1999), and wave 3 (2000-2001). The institutional review board of the Harvard School of Public Health approved secondary analyses using the public use database.

Community Violence Exposure

Primary caregivers completed the My Exposure to Violence (ETV) survey at wave 2, a structured, interviewer-administered measure ascertaining the child's lifetime

exposure to violent events in their neighborhood.(19, 20) Internal consistency, test-retest reliability, and validity have been established including the Spanish translation.(21) For endorsed items, follow-up questions inquire about factors known to influence the impact of violence including: familiarity with the perpetrator or victim, events occurring more than once, and whether events occurred outside the home. For the main exposure, we considered only events witnessed and/or experienced outside the home (i.e., neighborhood violence) in the child's lifetime prior to asthma diagnosis.

Rasch modeling was used to summarize the multi-item responses (Table 1) into a continuous ETV composite variable.(7) Models were fit using logistic nonlinear mixed models (NLMIXED) in SAS 9.0 (SAS Institute, Cary, NC) specifying a binary distribution and a random effect defined to have mean 0 and a variance estimated by the model-fitting process. Higher scores indicate greater exposure. ETV was examined as a continuous indicator and divided into tertiles to test for an exposure-response relationship.

Asthma Outcome

In wave 3, standardized questions adapted from the American Thoracic Society – Division of Lung Diseases (ATS-DLD-78) questionnaire (22) was administered to the primary caregivers of children from the age cohorts who were 0 to 9 years at enrollment. The analytic sample included everyone in these age groups who completed the survey (n=2228) (response rate 75.8%) excluding 152 children missing information on community violence exposure and five missing information on race/ethnicity for a final

n=2071. The primary outcome was defined as ever being diagnosed with asthma or ever taking asthma prescription medicine.

We considered alternative definitions in sensitivity analyses. Because having a diagnosis with current wheeze is associated with more objective measures including airway responsiveness,(23) we alternatively examined current asthma, which was defined as having both a diagnosis and reporting symptoms or medication use indicative of asthma (i.e., wheezing or using prescription medication for wheezing) in the past year. We also considered the potential for unconfirmed possible asthma, defined as never being diagnosed with asthma but reporting symptoms (ever wheezing) or prescription medication use for wheezing illnesses. The latter definition was considered to address concerns about underdiagnosis of asthma potentially attributable to racial/ethnic disparities in access to healthcare (24) or cultural differences in acceptability of a diagnosis of asthma.(25)

Covariates

Variables previously related to community violence exposure and childhood asthma were examined (5, 11, 14, 26, 27) as summarized in Figure 2.

<Figure 2 about here>

Individual-level Confounders.

Sociodemographics. Variables ascertained in wave 1 included: maternal education, child's race/ethnicity and gender. Child's age at wave 3 was used.

Equivalized income was calculated by dividing household income by the square root of the number of household members.(28)

Maternal Asthma. Maternal asthma, ascertained at wave 3, was defined as ever having physician-diagnosed asthma. (22)

Family Violence in the Home. Maternal-report of the child's exposure to family violence was obtained in wave 2 using the Conflict Tactics Scale (CTS) Form R(29) assessing the extent to which she and her partner psychologically and physically attacked one another in the past year. Reliability and validity data are available including the Spanish translation.(30) Items assessed psychological aggression (e.g., insulting/swearing; threatening violence) and physical violence (e.g., pushing or slapping; kicking, hitting, or beating; using a weapon). Participants rated whether items occurred never, once, twice, 3-5, 6-10, 11-20, or more than 20 times as both victim and perpetrator. Each category was assigned the midpoint value (e.g., "3-5 times" was assigned 4, "20" was assigned 25). Summed scores were included as a 3-level categorical indicator representing none (score of 0), low (less than the median value, range 1-25) and high (above the median value, range 26-488).

Neighborhood-level Confounders

Neighborhood Disadvantage. Neighborhood disadvantage, characterized by community-level stressors beyond violence (e.g., concentrated poverty, unemployment, segregation) may also be a surrogate marker of increased exposure to other environmental exposures not directly assessed in this study (e.g., ambient pollutants, indoor allergens).(17) A disadvantage index was derived for each NC using aggregated

data from the 1990 US Census (independent of the PHDCN-CS) based on an average z score for: (1) percentage living below poverty, (2) percentage unemployed, (3) percentage on public assistance, (4) percentage female-headed households, (5) percentage youth, and (6) percentage African Americans.(31)

Social Disorder. Research links social disorder to crime and poor health.(32) Social disorder itself, or increased crime in this context (i.e., crime that subjects are aware of but have not personally experienced) may independently affect health, including asthma.(11) The three-item scale asked how much of a neighborhood problem [ranging from (0) “no problem” to (2) “serious problem”] is: drinking in public, selling or using drugs, and teenagers or adults loitering and causing trouble. Items were summed with higher scores indicating greater disorder.

Collective Efficacy. Collective efficacy measures the level of trust among residents and their perceived willingness to engage in collective action.(18) Conversely, increased disorder fosters mistrust and isolation and a perception of community indifference to individuals in need.(15) Neighborhoods with high collective efficacy often report less crime (31) and better health.(33) Collective efficacy was derived using a composite measure based on the PHDCN-CS’ social cohesion and informal social control scales.(18) The social control measure asked whether neighbors would take action (from 1 “strongly agree” to 4 “strongly disagree”) if: children were skipping school/loitering, spray-painting graffiti on a building, or showing disrespect to an adult; or if a fight broke out in front of their house, or the fire station closest to home was threatened by budget cuts. Social cohesion assessed respondents’ level of agreement (from 1 “strongly agree” to 4 “strongly disagree”) that people in their neighborhood: generally don’t get along, do

not share the same values, can be trusted, are willing to help their neighbors, and are close-knit (last 3 items reverse coded). Items were summed with higher scores indicating greater collective efficacy.

Pathway Variables

Maternal Health Behaviors. Maternal smoking and breastfeeding behaviors were obtained in wave 3. These behaviors may be disrupted through violence exposure (26, 27) and are associated with childhood asthma/wheeze risk.

Statistical Analyses

Differences in means or proportions between asthmatics and non-asthmatics were evaluated using chi-squared or Student's *t*-tests, as appropriate. The correlation between continuous variables was examined given the concern for collinearity.

These multi-level data included individuals at level 1 nested within 80 neighborhood clusters at level 2. To account for potential neighborhood variation in asthma, we used multilevel logistic regression models (34) estimated using MLwiN, version 2.10, building models in a stepwise fashion.(35)

As represented in Figure 2, we examined potential pathways linking community violence as well as confounders of these associations. First, we modeled the log odds of asthma as a function of neighborhood violence adjusting for the child's age, gender, and race/ethnicity, and maternal asthma conditional on the random effect for neighborhoods. We then introduced individual-level confounders: socioeconomic covariates (caregiver's education and equivalized household income) (Model 2); family violence exposure in the

home (Model 3); mother's smoking status and breastfeeding history (Model 4). The final model (Model 5) adjusted for neighborhood-level confounding (concentrated disadvantage, collective efficacy, and social disorder at level 2).

Sensitivity Analysis. Sensitivity analyses considered alternative asthma indicators (current asthma, unconfirmed possible asthma).

RESULTS

Sample characteristics are summarized (Table 2). Overall, 19% of the children had diagnosed asthma. A greater proportion of those exposed to medium (35.2%) or high (43%) community violence had asthma, compared with those with low ETV (21.8%) ($p < .01$ for both). More African Americans relative to Whites or Mexicans had asthma [25.8% vs. 17.3% ($p < .004$) and 25.8% vs. 12.1% ($p < .001$), respectively]; fewer Mexicans had asthma than Whites [12.1% vs. 17.3% ($p < .03$)] or non-Mexican Hispanics [12.1% vs. 21.5% ($p < .001$)]. More boys (22.6%) than girls (15.4%) had asthma ($p < .001$). Children of mothers with asthma were more likely to have asthma compared to those without a maternal history [43.1% vs. 15.1% ($p < .0001$)]. Asthma was also higher among children exposed to high (21%, $p < .01$) or low (19%, $p < .03$) family violence, compared with no family violence (13.2%). Asthma was increased in areas of high concentrated disadvantage (23.2%) compared to medium (16.4%, $p < .01$) or low (17.3%, $p < .01$).

Experiencing violence in the neighborhood was significantly related to family violence in the home, child's age, equivalized income and the neighborhood constructs, albeit the correlations were low, minimizing concerns for collinearity (Table 3). Equivalized income, neighborhood disadvantage, social disorder and collective efficacy

were more moderately correlated. However, adding these covariates to the models in various combinations did not significantly influence the beta estimates or standard errors, again lessening concern for collinearity (data not shown).(36)

In hierarchical models, community violence, when measured continuously, was significantly associated with elevated asthma risk. Unadjusted analyses revealed an almost 50% increased risk in asthma for every unit increase in the ETV score (OR 1.47; 95% CI 1.30, 1.68). The effects persisted after adjusting for all individual- and neighborhood- level covariates (OR 1.28; 95% CI 1.09, 1.49). Results were robust to alternative asthma definitions (current asthma and unconfirmed possible asthma) (data not shown).

The odds ratio (OR) for asthma (95% CI) by exposure to community violence (measured in tertiles) is presented (Table 3). Model 1 adjusted for maternal asthma, child race and gender; exposure to medium (OR 1.55; 95% CI 1.14, 2.11) and high (OR 1.53; 95% CI 1.11, 2.10) levels of community violence was associated with a similarly elevated risk of asthma compared to those with low exposure. The effects for community violence were essentially unchanged after further adjusting for all other individual- and neighborhood-level confounders (Model 5).

In the fully adjusted Model 5, male gender and maternal asthma were independently associated with increased asthma risk. Neighborhood-level constructs were not significantly related to asthma.

Notably, African American race remained independently associated with increased asthma risk in models including community violence and all other individual-level covariates (Model 4). Further adjusting for all three neighborhood constructs

simultaneously attenuated this effect (Model 5). In order to ascertain which construct was responsible for the attenuation we added variables one at a time. Further adjustment for concentrated disadvantage and social disorder added to Model 4 (one at a time) did not significantly change the observed relationship with African American race [OR 1.54 (95% CI 1.02, 2.3) and 1.62 (95% CI 1.02, 2.6), respectively]. Upon further adjusting Model 4 for collective efficacy, the elevated risk in African Americans remained, albeit at borderline significance [OR 1.49 (95% CI 0.99, 2.24)] similar to the effect estimate in Model 5 (including all three neighborhood constructs). This suggested that collective efficacy, in part, explains the persistent increased risk for asthma seen in these African American children.

DISCUSSION

To our knowledge, this is the first longitudinal, multilevel study to demonstrate a significant association between community violence exposure and increased risk for asthma development in urban children. This association was robust to controlling for important individual-level factors (race/ethnicity, SES, maternal health behaviors, family violence), and neighborhood-level confounders (concentrated disadvantage, social disorder and collective efficacy), and was consistent across alternative outcomes (e.g., current asthma or undiagnosed possible asthma).

Our findings contribute to a growing body of evidence linking community violence to asthma expression.(10, 11, 13) A number of mechanisms underlying this association have been proposed. Violence exposure has been conceptualized as a psychological and environmental stress that taxes both individual and communities.(5) At

the individual level, increased stress may lead to the dysregulation of the hypothalamic-pituitary-adrenal (HPA) and sympathetic-adrenal-medullary (SAM) axes, disrupting immune and respiratory processes, and producing an increased risk of inflammatory diseases, such as asthma.(3, 5) Indeed, we previously documented psychopathology and cortisol dysregulation in school-aged children exposed to higher levels of community violence in Boston neighborhoods.(8) The child's primary caregiver (primarily mothers) obviously share the violent environment, and thus violence may operate through influencing behaviors and functioning in the mother that then impact asthma expression in the child. For example, violence exposure may result in increased smoking in mothers, thus increasing the child's exposure.(26) Similarly, low-income women living with violence may be less likely to breastfeed (27) which may enhance asthma risk. However, adjusting for maternal smoking and breastfeeding behaviors did not reduce the observed effect. Community violence exposure may also result in poor psychological functioning in mothers (e.g., anxiety, depression)(37) which may in turn disrupt parenting behaviors and lead to greater stress for the child and altered emotional development.(38) Other studies show that children exposed to violence tend to express higher levels of negative emotion (anxiety, depression) and more harmful stress reactivity and negative emotion, in turn, have been linked to asthma.(38) Additionally, concern about safety may cause parents to restrict their children's outdoor activity and close windows, potentially increasing exposure to indoor pollutants. Children kept indoors are also more likely to be sedentary; this, in turn, may be linked to obesity, another risk factor for asthma.(5) Finally, violence-induced stress may potentiate asthma-inducing effects of other

environmental pollutants (e.g., air pollution).(3, 12) Future work should more directly examine these potential pathways.

In models including community violence, concentrated disadvantage and social disorder, as well as individual-level covariates, an increased risk of asthma in African American children remained. Notably, when accounting for collective efficacy at the neighborhood level, the elevated risk in African-Americans was no longer significant. This finding is corroborated by a Chicago study showing lower prevalence of a composite of respiratory problems (e.g., asthma, emphysema, and other breathing problems) in association with increased collective efficacy in adults.(39) As pointed out by these authors, mechanisms may include: 1) social control of adverse health behaviors (e.g., smoking); 2) access to high-quality healthcare promoting advantageous health practices (e.g., breastfeeding); 3) empowerment to act collectively to address adverse environmental factors (e.g., polluting traffic sources, housing conditions); and 4) less social isolation.(40, 41) These pathways should be empirically examined in future work.

Strengths and Limitations

Strengths of the study include the use of longitudinal data, a large urban sample, application of item response theory to summarize community violence exposure, control for other forms of violence (i.e., family violence) as well as other important confounders, and the employment of multilevel analyses to, at least in part, control for unmeasured neighborhood factors. Moreover, findings were robust to alternative specifications of the asthma/wheeze outcome. Results should also be interpreted in light of study limitations. We cannot rule out some unmeasured confounding factor that is correlated both with

community violence and asthma risk. Exposure to community violence is just one type of stressor experienced by children, particularly those living in lower-income urban environments. While we adjust for other forms of violence (i.e., family violence in the home), we did not have information on other stressors (e.g., other negative life events, racism, housing stress) in this dataset. Violence exposure was ascertained through questionnaires only; there were no available biomarkers of potential stress pathways operating between community violence and asthma (e.g., cortisol disruption) in the PHDCN sample. Those experiencing higher levels of community violence may also be exposed to poorer quality housing and greater traffic or other polluting sources. Although we considered neighborhood disadvantage to partly account for this, the study did not include questions on household characteristics (e.g., allergens, and housing quality) or more direct measures of the physical toxins that may also disproportionately burden residents in more disadvantaged communities.⁽¹⁷⁾ We do have an ongoing birth cohort study examining risks for childhood asthma in Boston that is directly measuring indoor allergens and indoor/outdoor air pollution, violence exposure measures and other relevant stressors as well as biomarkers that will be able to address these limitations in the future.⁽⁴²⁾ Finally, the analysis was limited to Chicago and may not be generalizable beyond this region.

Our findings underscore the potential role of community violence in explaining urban asthma risk in the US. From a policy perspective, our findings suggest that public health interventions outside of the biomedical model (e.g., neighborhood safety programs) may be advantageous in reducing the asthma burden in disadvantaged populations. Research to more fully elucidate the excess asthma burden among African

American children, and the potential role of collective efficacy in reducing that burden, is also warranted. These analyses begin to address the recognized need to consider a shared conceptual framework considering social, physical and behavioral factors integrating multi-level methods to elucidate the complexities of asthma disparities.(42, 43)

REFERENCES

1. Cesaroni G, Farchi S, Davoli M, Forastiere F, Perucci CA. Individual and area-based indicators of socioeconomic status and childhood asthma. *Eur Respir J* 2003; 22: 619-24.
2. Wright RJ, Subramanian SV. Advancing a multilevel framework for epidemiologic research on asthma disparities. *Chest* 2007; 132: 757S.
3. Wright RJ, Cohen RT, Cohen S. The impact of stress on the development and expression of atopy. *Curr Opin Allergy Clin Immunol* 2005; 5: 23-9.
4. Wright RJ. Moving towards making social toxins mainstream in children's environmental health. *Curr Opin Pediatr* 2009; 21: 222.
5. Wright RJ. Health effects of socially toxic neighborhoods: the violence and urban asthma paradigm. *Clin Chest Med* 2006; 27: 413-21.
6. Sheehan K, DiCara JA, LeBailly S, Christoffel KK. Children's exposure to violence in an urban setting. *Arch Pediatr Adolesc Med* 1997; 151: 502-4.
7. Suglia SF, Ryan L, Wright RJ. Creation of a community violence exposure scale: accounting for what, who, where, and how often. *J Trauma Stress* 2008; 21: 479.
8. Suglia SF, Staudenmayer J, Cohen S, Wright RJ. Posttraumatic stress symptoms related to community violence and children's diurnal cortisol response in an urban community-dwelling sample. *Int J Behav Med* 2010; 17: 43-50.
9. Murali R, Chen E. Exposure to violence and cardiovascular and neuroendocrine measures in adolescents. *Ann Behav Med* 2005; 30: 155-63.
10. Swahn MH, Bossarte RM. The associations between victimization, feeling unsafe, and asthma episodes among US high-school students. *Am J Public Health* 2006; 96: 802-4.
11. Wright RJ, Mitchell H, Visness CM, Cohen S, Stout J, Evans R, Gold DR. Community violence and asthma morbidity: the Inner-City Asthma Study. *Am J Public Health* 2004; 94: 625-32.
12. Clougherty JE, Levy JI, Kubzansky LD, Ryan PB, Suglia SF, Canner MJ, Wright RJ. Synergistic effects of traffic-related air pollution and exposure to violence on urban asthma etiology. *Environ Health Perspect* 2007; 115: 1140.
13. Berz JB, Carter AS, Wagmiller RL, Horwitz SM, Murdock KK, Briggs-Gowan M. Prevalence and correlates of early onset asthma and wheezing in a healthy birth cohort of 2-to 3-year olds. *J Pediatr Psychol* 2007; 32: 154.
14. Suglia FS, Bosquet Enlow M, Kullowatz A, Wright RJ. Maternal intimate partner violence predicts increased asthma incidence in children: buffering effects of supportive caregiving. *Arch Pediatr Adolesc Med* 2009; 163: 244-50.
15. Saegert S, Winkel G. Crime, social capital, and community participation. *Am J Community Psychol* 2004; 34: 219-33.
16. Fisher EB, Strunk RC, Sussman LK, Sykes RK, Walker MS. Community organization to reduce the need for acute care for asthma among African American children in low-income neighborhoods: the Neighborhood Asthma Coalition. *Pediatrics* 2004; 114: 116.
17. O'Neill MS, Jerrett M, Kawachi I, Levy JI, Cohen AJ, Gouveia N, Wilkinson P, Fletcher T, Cifuentes L, Schwartz J. Health, wealth, and air pollution: advancing theory and methods. *Environ Health Perspect* 2003; 111: 1861-70.

18. Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science* 1997; 277: 918 - 24.
19. Bingenheimer JB, Brennan RT, Earls FJ. Firearm violence exposure and serious violent behavior. *Science* 2005; 308: 1323-6.
20. Brennan RT, Molnar BE, Earls F. Refining the measurement of exposure to violence (ETV) in urban youth. *J Community Psychol* 2007; 35: 603.
21. Selner-O'Hagan MB, Kindlon DJ, Buka SL, Raudenbush SW, Earls FJ. Assessing exposure to violence in urban youth. *J Child Psychol Psychiatry* 1998; 39: 215-24.
22. Ferris BGJ. Epidemiology standardization project (American Thoracic Society). *Am Rev Respir Dis* 1978; 118: 7-53.
23. Jenkins MA, Clarke JR, Carlin JB, Robertson CF, Hopper JL, Dalton MF, Holst DP, Choi K, Giles GG. Validation of questionnaire and bronchial hyperresponsiveness against respiratory physician assessment in the diagnosis of asthma. *Int J Epidemiol* 1996; 25: 609.
24. Flores G, Tomany-Korman SC. Racial and ethnic disparities in medical and dental health, access to care, and the use of services among Hispanics in the United States. *Pediatrics* 2008; 18: 93-7.
25. Zwarenstein M, Bheekie A, Lombard C, Swingler G, Ehrlich R, Eccles M, Sladden M, Pather S, Grimshaw J, Oxman AD. Educational outreach to general practitioners reduces children's asthma symptoms: a cluster randomised controlled trial. *Implement Sci* 2007; 2: 30.
26. Ganz ML. The relationship between external threats and smoking in central Harlem. *Am J Public Health* 2000; 90: 367-71.
27. Chin NP, Solomonik A. Inadequate: A metaphor for the lives of low-income women? *Breastfeed Med* 2009; 4: S41-3.
28. Buhmann B, Rainwater L, Schmaus G, Smeeding T. Equivalence scales, well-being, inequality, and poverty: Sensitivity estimates across ten countries using the Luxembourg Income Study (LIS) database. *Rev Income Wealth* 1988; 34: 115-42.
29. Straus MA. The conflict tactics scales and its critics: an evaluation and new data on validity and reliability. In: Straus MA, Gelles RJ, editors. *Physical violence in American families: risk factors and adaptations to violence in 8,145 families*: Transaction Publishers; 1990. p. 49-73.
30. Connelly CD, Newton RR, Aarons GA. A psychometric examination of English and Spanish versions of the revised conflict tactics scales. *J Interpers Violence* 2005; 20: 1560.
31. Sampson RJ, Morenoff JD, Felton E. Beyond social capital: spatial dynamics of collective efficacy for children. *Am Sociol Rev* 1999; 64: 633-60.
32. Markowitz FE, Paul E B, Allen E L, Jianhong LIU. Extending social disorganizaion theory: modeling the relationship between cohesion, disorder, and fear. *Criminology* 2001; 39: 293-319.
33. Browning CR, Cagney KA. Neighborhood structural disadvantage, collective efficacy, and self-rated physical health in an urban setting. *J Health Soc Behav* 2002; 43: 383-99.
34. Raudenbush S, Bryk A. Hierarchical linear models: Applications and data analysis methods. Thousand Oaks, CA: Sage Publications; 2002.

35. Rasbash J, Steele F, Browne W, Prosser B. A user's guide to MLwiN version 2.10. London, UK: Centre for Multilevel Modelling, Institute of Education; 2008.
36. Hosmer DW, Lemeshow S. Applied logistic regression. New York, NY: John Wiley & Sons; 1989.
37. Clark C, Ryan L, Kawachi I, Jacobson Canner M, Berkman LF, Wright RJ. Witnessing community violence in residential neighborhoods: a mental health hazard for urban women. *J Urban Health* 2007; 85: 22-38.
38. Wright R, Bosquet EM. Maternal stress and perinatal programming in the expression of atopy. *Exp Rev Clin Immun* 2008; 4: 535-8.
39. Cagney KA, Browning CR. Exploring neighborhood-level variation in asthma and other respiratory diseases. *J Gen Intern Med* 2004; 19: 229-36.
40. Ahern J, Galea S, Hubbard A, Syme SL. Neighborhood smoking norms modify the relation between collective efficacy and smoking behavior. *Drug Alcohol Depend* 2009; 100: 138-45.
41. Fullilove MT. Promoting social cohesion to improve health. *J Am Med Womens Assoc* 1998; 53: 72-6.
42. Wright RJ, Suglia SF, Levy J, Fortun K, Shields A, Subramanian S, Wright R. Transdisciplinary research strategies for understanding socially patterned disease: the Asthma Coalition on Community, Environment, and Social Stress (ACCESS) project as a case study. *Cien Saude Colet* 2008; 13: 1729-42.
43. Cruz AA, Bateman ED, Bousquet J. The social determinants of asthma. *Eur Respir J* 2010; 35: 239-42.

Table 1. Exposure to Community Violence Items Summarized using Rasch Modeling

Has the child ever seen or been present when someone was shoved/kicked/punched?*

If so:

Did that happen outside the home?

Did she/he know the person or people who this happened to?

Was she/he the person who this happened to?

Did she/he know the person or people who did this?

Has she/he seen this more than once?

Has the child ever seen or been present when someone was attacked with a knife?

If so:

Did that happen outside the home?

Did she/he know the person or people who this happened to?

Was she/he the person who this happened to?

Did she/he know the person or people who did this?

Has the child ever seen or been present when someone was shot?

If so:

Did that happen outside the home?

Did she/he know the person or people who this happened to?

Has she/he ever heard a gun shot?

If so:

Has she/he heard a gun shot outside the home?

Has she/he heard a gun shot more than once?

Have any of your family members or close friends been hurt by a violent act?

Have any of your family members or close friends been killed by a violent act?

Note: all responses were yes or no

Table 2. Distribution of covariates across the primary asthma outcome¹

	All		Asthma		No Asthma		p-Value²
	n=2071		n=395 (19%)		n=1676 (81%)		
Exposure to Community Violence n (%)							<0.000
Low	693	(33.5)	86	(21.8)	607	(36.2)	
Medium	672	(32.4)	139	(35.2)	533	(31.8)	
High	706	(34.1)	170	(43.0)	536	(32.0)	
Exposure to Family Violence n (%)							0.07
No Violence	242	(11.7)	32	(8.1)	210	(12.5)	
Low Violence Exposure	783	(37.8)	149	(37.7)	634	(37.8)	
High Violence Exposure	767	(37.0)	161	(40.8)	606	(36.2)	
Missing	279	(13.5)	53	(13.4)	226	(13.5)	
Child Age (mean ± SD)	2071	(10.5)	395	(10.7)	1676	(10.5)	0.26
Child Race n (%)							<0.000
White	300	(14.5)	52	(13.2)	248	(14.8)	
African American	706	(34.1)	182	(46.1)	524	(31.3)	
Mexican	664	(32.1)	80	(20.3)	584	(34.8)	
Non-Mexican Hispanic	325	(15.7)	70	(17.7)	255	(15.2)	
Other Race/Ethnicity	76	(3.7)	11	(2.8)	65	(3.9)	
Child's Sex n (%)							<0.0001
Female	1018	(49.2)	157	(39.8)	861	(51.4)	
Male	1053	(50.8)	238	(60.3)	815	(48.6)	
Caregiver's Education n (%)							0.001
<High School	816	(39.4)	138	(34.9)	678	(40.5)	
High School Degree	279	(13.5)	38	(9.6)	241	(14.4)	
Some College +	936	(45.2)	213	(53.9)	723	(43.1)	
Missing	40	(1.9)	6	(1.5)	34	(2.0)	
Equivalized Income n (%)							0.20
Less than 20,000	462	(22.3)	93	(23.5)	369	(22.0)	
More than 20,000	1491	(72.0)	273	(69.1)	1218	(72.7)	
Missing	118	(5.7)	29	(7.3)	89	(5.3)	
Maternal Physician-diagnosed Asthma n (%)							<0.000
Never	1730	(83.5)	261	(66.1)	1469	(87.7)	
Ever	288	(13.9)	124	(31.4)	164	(9.8)	
Missing	53	(2.6)	10	(2.5)	43	(2.6)	
Maternal Smoking n (%)							0.22
Never	1282	(61.9)	229	(58.0)	1053	(62.8)	
Past	269	(13.0)	61	(15.4)	208	(12.4)	
Current	501	(24.2)	100	(25.3)	401	(23.9)	
Missing	19	(0.9)	5	(1.3)	14	(0.8)	
Breastfeeding Status n (%)							0.45
No breastfed	1078	(52.1)	216	(54.7)	862	(51.4)	
Breastfed	959	(46.3)	174	(44.1)	785	(46.8)	
Missing	34	(1.6)	5	(1.3)	29	(1.7)	
Concentrated Disadvantage n (%)							0.002
Low	612	(29.6)	106	(26.8)	506	(30.2)	
Medium	725	(35.0)	119	(30.1)	606	(36.2)	
High	734	(35.4)	170	(43.0)	564	(33.7)	
Collective Efficacy n (%)							0.25
Low	697	(34.0)	127	(32.15)	570	(34.0)	

Medium	775	(37.0)	162	(41.01)	613	(36.6)	
High	599	(29.0)	106	(26.84)	493	(29.4)	
Social Disorder n (%)							0.80
Low	600	(0.29)	109	(27.59)	491	(29.3)	
Medium	695	(0.34)	135	(34.18)	560	(33.4)	
High	776	(0.37)	151	(38.23)	625	(37.3)	

¹ Childhood asthma outcome is defined as ever being diagnosed with asthma or ever taking asthma prescription medicine.

²For differences between non-missing multi-group comparisons using Chi-squared distribution.

Table 3. Correlations Between Continuous Neighborhood Constructs and Individual-Level Measures

		Pearson Correlations (p-value)						
		1	2	3	4	5	6	7
1	Community Violence	1.00 (0.00)						
2	Child Age	0.16 (0.00)	1.00					
3	Equivalized Income	-0.08 (0.00)	-0.01 (0.65)	1.00				
4	Violence in Family	0.17 (0.00)	-0.02 (0.33)	-0.15 (0.00)	1.00			
5	Concentrated Disadvantage	0.34 (0.00)	0.03 (0.19)	-0.35 (0.00)	0.16 (0.00)	1.00		
6	Social Disorder	0.11 (0.00)	0.02 (0.29)	-0.46 (0.00)	0.13 (0.00)	0.56 (0.00)	1.00	
7	Collective Efficacy	-0.06 (0.00)	-0.02 (0.30)	0.38 (0.00)	-0.10 (0.00)	-0.38 (0.00)	-0.73 (0.00)	1.00

Table 4. Associations between community violence exposure and childhood asthma: Hierarchical Logistic Regression (n=2071)

	Model 1		Model 2		Model 3		Model 4		Model 5	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Community Violence										
Low	1.00		1.00		1.00		1.00		1.00	
Medium	1.55	1.14 2.11	1.57	1.15 2.14	1.57	1.15 2.15	1.59	1.16 2.18	1.60	1.17 2.19
High	1.53	1.11 2.10	1.52	1.11 2.10	1.55	1.12 2.15	1.56	1.12 2.16	1.56	1.12 2.18
Child's Age										
Centered Age at Wave 3	1.01	0.97 1.06	1.01	0.97 1.07	1.01	0.96 1.06	1.01	0.96 1.06	1.01	0.96 1.06
Gender										
Girls	1.00		1.00		1.00		1.00		1.00	
Boys	1.70	1.35 2.15	1.69	1.34 2.14	1.69	1.33 2.14	1.70	1.34 2.15	1.70	1.34 2.16
Child's Race/Ethnicity										
White	1.00		1.00		1.00		1.00		1.00	
African American	1.43	1.00 2.07	1.52	1.03 2.24	1.55	1.05 2.29	1.61	1.08 2.39	1.57	0.98 2.52
Mexican	0.70	0.47 1.03	0.80	0.52 1.23	0.79	0.51 1.23	0.80	0.51 1.26	0.75	0.47 1.20
Non-Mexican Hispanic	1.13	0.74 1.71	1.25	0.81 1.94	1.25	0.81 1.94	1.30	0.84 2.02	1.18	0.74 1.87
Other Race/Ethnicity	0.77	0.37 1.59	0.84	0.40 1.75	0.84	0.40 1.75	0.86	0.41 1.80	0.82	0.38 1.74
Maternal Asthma										
Never	1.00		1.00		1.00		1.00		1.00	
Ever	3.97	3.02 5.24	3.96	3.00 5.23	4.01	3.03 5.31	4.01	3.03 5.31	4.02	3.04 5.32
Missing	1.07	0.52 2.20	1.07	0.52 2.19	1.05	0.47 2.35	1.05	0.47 2.35	1.03	0.46 2.32
Household income¹										
More than 20k	1.00		1.00		1.00		1.00		1.00	
Less than 20k	0.93	0.69 1.27	0.94	0.69 1.28	0.94	0.69 1.28	0.96	0.70 1.32	0.92	0.66 1.27
Income missing	1.24	0.73 2.12	1.24	0.73 2.12	1.25	0.73 2.13	1.29	0.75 2.21	1.26	0.73 2.18
Maternal Education										
College Education	1.00		1.00		1.00		1.00		1.00	
<High School Graduate	0.81	0.61 1.08	0.83	0.62 1.10	0.83	0.62 1.10	0.84	0.62 1.12	0.83	0.62 1.11
High School Graduate	0.59	0.39 0.87	0.59	0.40 0.88	0.59	0.40 0.88	0.60	0.40 0.90	0.59	0.39 0.88
Education Missing	0.78	0.31 1.95	0.78	0.31 1.96	0.78	0.31 1.96	0.80	0.32 2.00	0.81	0.32 2.04
Family Violence (CTS)										
None	1.00		1.00		1.00		1.00		1.00	
CTS (below the median)	1.19	0.77 1.84	1.19	0.77 1.84	1.19	0.77 1.84	1.19	0.77 1.84	1.19	0.77 1.86

CTS (above the median)	1.01	0.64	1.58	1.01	0.64	1.58	1.00	0.64	1.58
Missing	1.07	0.64	1.78	1.08	0.65	1.81	1.11	0.66	1.86
Maternal Smoking									
Never	1.00			1.00			1.00		
Past	1.25	0.88	1.77	1.25	0.88	1.77	1.26	0.89	1.79
Current	0.90	0.67	1.20	0.90	0.67	1.20	0.91	0.68	1.22
Missing	1.75	0.56	5.49	1.75	0.56	5.49	1.71	0.54	5.40
Breastfeeding									
Never	1.00			1.00			1.00		
Ever	1.03	0.81	1.33	1.03	0.81	1.33	1.02	0.79	1.31
Missing	0.69	0.23	2.03	0.69	0.23	2.03	0.69	0.24	2.05
Concentrated Disadvantage									
Low	1.00			1.00			1.00		
Medium	0.85			0.85			0.85		1.26
High	0.90			0.90			0.90		1.41
Collective Efficacy									
Low	1.00			1.00			1.00		
Medium	0.94			0.94			0.94		1.29
High	0.73			0.73			0.73		1.15
Social Disorder									
Low	1.00			1.00			1.00		
Medium	1.14			1.14			1.14		1.69
High	0.95			0.95			0.95		1.54

¹ Equivalized income was calculated by dividing household income by the square root of the number of household members

Figure 1. Project on Human Development in Chicago Neighborhoods (PHDCN): Data Collection Schema and Current Analytic Sample

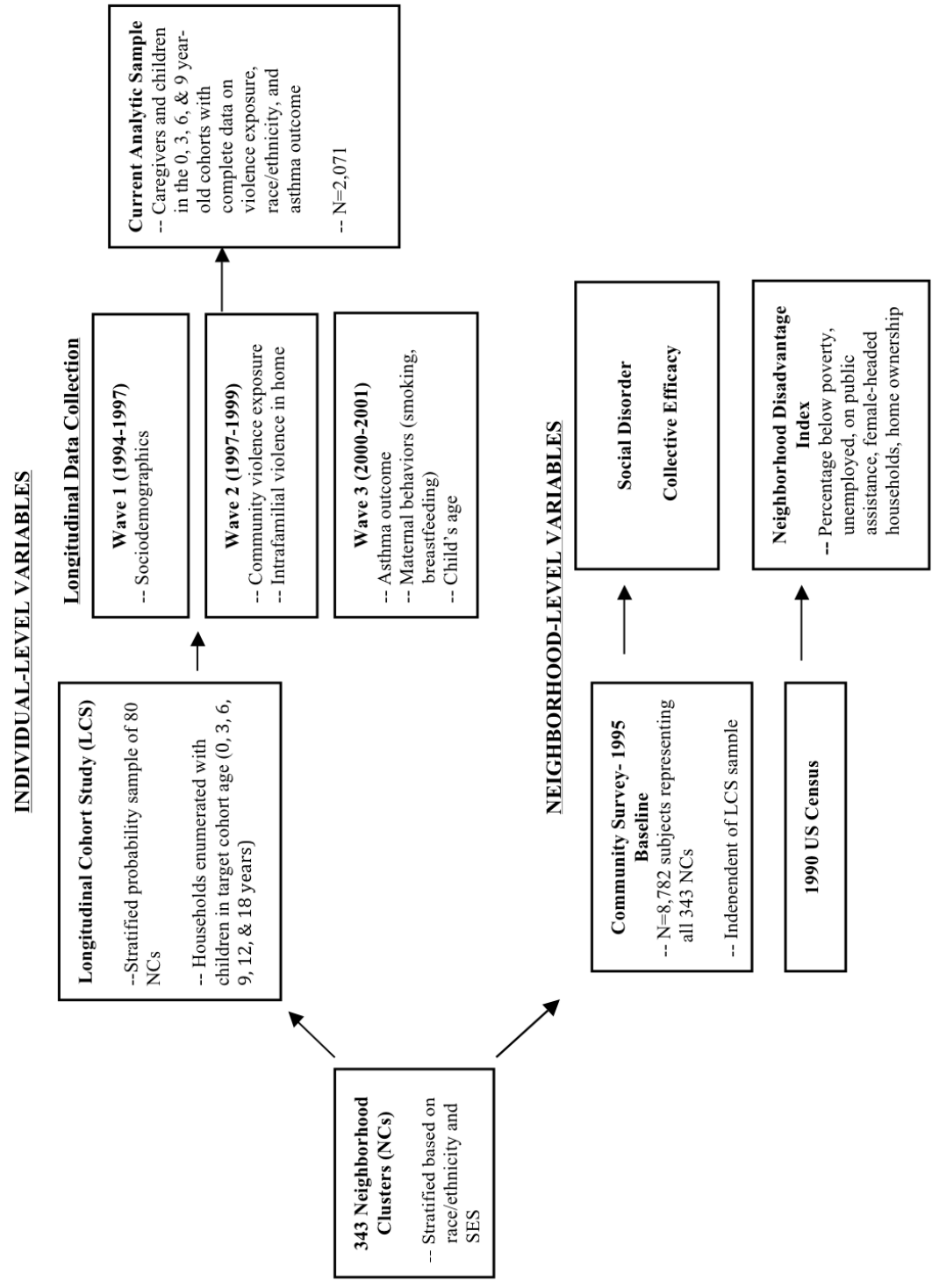
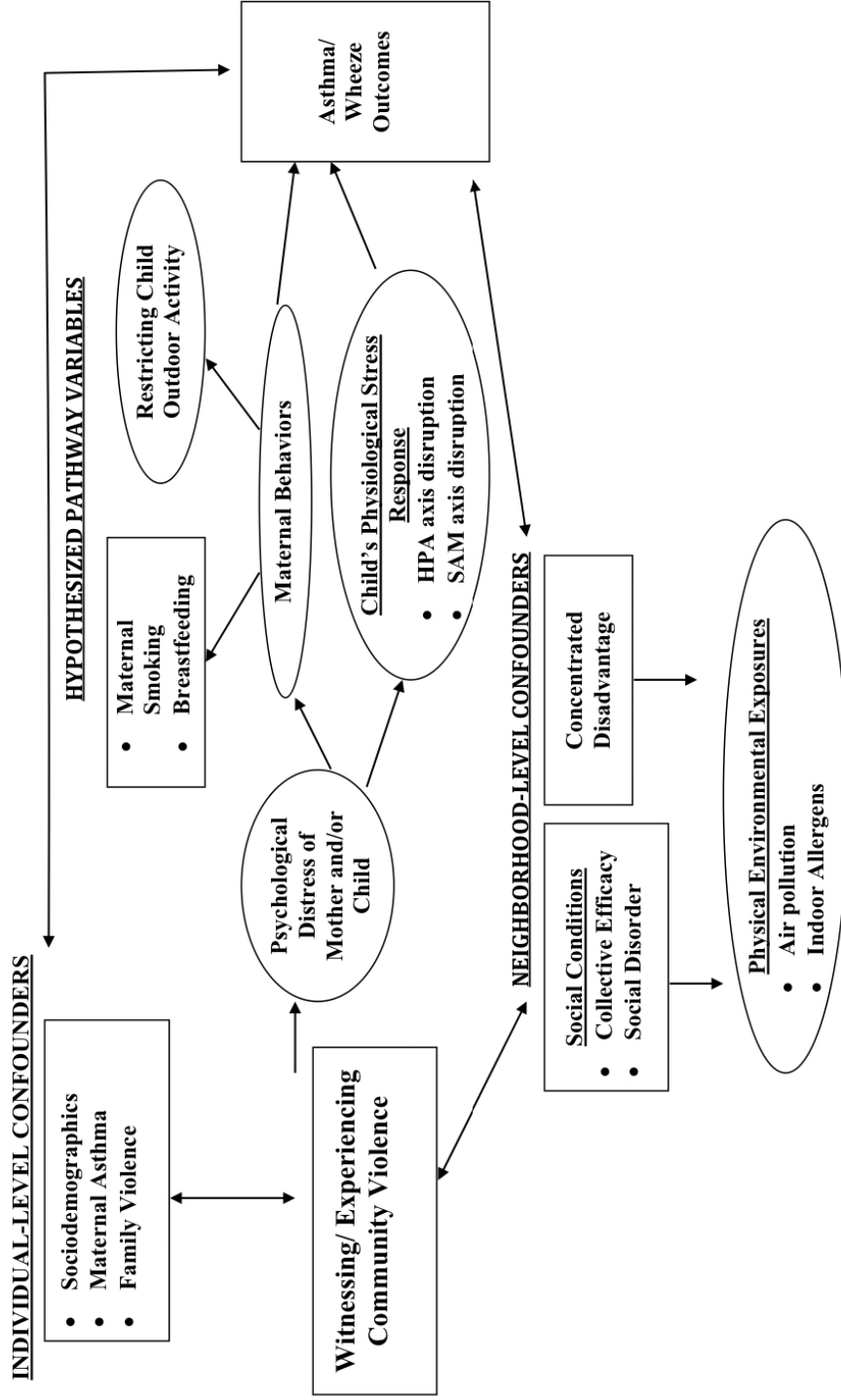


Figure 2: Conceptual diagram illustrating relationships among variables linking community violence and childhood asthma*



*Ovals represent unmeasured or latent variables and boxes represent measured variables.