NEIGHBORHOOD VARIATION IN THE RATE OF CHILD WELFARE CONTACT

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ABSTRACT

In the United States, the child welfare system serves a vulnerable population of children with extensive health needs. With momentum building for place-based interventions to promote community health, population-level evidence is needed to identify critical elements of interventions and inform potential collaboration across service sectors.

Through a systematic review of small-area ecological research on neighborhood effects (Aim 1), we framed the literature on neighborhood context and child welfare contact through a population health lens. Four constructs describing the neighborhood structure (economic disadvantage, percent of the population from racial/ethnic minority group, social disadvantage, and residential instability) and two constructs describing neighborhood processes (alcohol access, drug arrests) were positively associated with the rate of child welfare contact in multiple studies. Evidence on neighborhood processes was identified as a priority for future research and guidance for improving study design was provided.

Using existing observational data from the Neighborhood Inventory for Environmental Typology (NIfETy), we developed area-level indicators for six specific constructs within the context of neighborhood processes (Aim 2). Three neighborhood process indicators were accurate for identifying areas with high levels of risk (criterion validity) and associated with all area-level measures of the neighborhood structure and youth population health outcomes included in the assessment (construct validity): physical disorder index, drug and alcohol index and violence index.

We examined the relationship between neighborhood disadvantage, violence, drug and alcohol activity and the rate of child welfare investigation (Aim 3). While both the violence index and drug and alcohol index were strongly associated with the outcome in bivariate analysis, only violence was associated with a significant increase in the rate of child welfare investigation in the multivariable regression analysis. Applying concepts from spatial epidemiology, several important methodological improvements were illustrated, including person years of observation, age-adjusted rates, and the use of negative binomial regression models.

Focusing child maltreatment prevention interventions in areas with the greatest density of child welfare contact is an avenue by which interventions can reduce both the incidence of child maltreatment and the rate of child welfare involvement. Considering the high rate of child welfare contract in Baltimore City, the need to reduce the burden on the child welfare system, and growing attention for the need to prevent child maltreatment in high risk neighborhoods, child welfare services may benefit from further coordinating their prevention efforts with other public sectors serving children and youth at risk of maltreatment. Collaborative efforts between hospitals, public service sectors, and community-based resources are likely to be both effective and efficient methods for targeting resources to the most vulnerable children and families in the city. While the current research sheds light on the relationship between violence, substance use activity, and the rate of child welfare contact, further evidence on neighborhood processes is needed. Small-area ecological research on other neighborhood processes, such as social cohesion and collective efficacy, is imperative to informing place-based efforts in child welfare.

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INTRODUCTION

Child welfare in the United States, a public health imperative

There is clear evidence that child abuse and neglect have serious harmful consequences across the life course, and agreement that the prevention of child maltreatment should be considered a public health priority.[1] Each year, four percent of children in the United States are the subject of a child welfare investigation.[2] Across states, the rate of investigation ranges from 9 per 1,000 in Pennsylvania to 95 per 1,000 in West Virginia and the District of Columbia.[2] While only a subset of investigations are substantiated (19%),[3] longitudinal research indicates that children who come in contact with the child welfare system, regardless of the results of the investigations, have a broad range of social and health needs and would benefit from services that promote optimal child development.[4-6]

Compared to the general population, children who are the subject of a report to the child welfare system are nearly four times as likely to have exposure to four or more adverse childhood experiences (13% vs. 51%, respectively).[7] Alongside victimization via child maltreatment, these experiences include exposure(s) in their home to intimate partner violence, mental illness (including suicidality and hospitalization), substance abuse, and the incarceration of family members.[7] Outside of the household, this population is also more likely to experience trauma through community violence and persistent polyvictimization (e.g. bullying, physical assault, sexual assault) into adulthood.[8, 9]

The majority of children in this population have functional impairments across developmental, academic, and social domains identified during childhood.[10, 11] During adolescence, half of child welfare-involved youth have clinically significant mental and behavioral health symptoms, but only a quarter of those in need report service receipt.[12] During adolescence this group is more likely to have behavioral problems, be arrested, and experience multiple forms of victimization (e.g., physical assault, sexual assault, witnessing violence).[8, 13, 14] As young adults, this population continues to encounter poverty, unemployment, and significant health problems.[14] During their transition to adulthood, many children from the child welfare system become disconnected from health providers, despite their continued need for services.[15]

Upon reaching adulthood, childhood maltreatment remains a well-documented risk factor for mental and behavioral health problems in adulthood.[16-24] Maltreatment exposure is associated with a quarter of psychiatric disorders and more than a third of the suicide attempts in the United States.[25] The relationship between child maltreatment and adult psychopathology is partially mediated by an increased sensitivity to stress throughout the lifespan.[22] Additional research illustrates the enduring impact on physical health, with strong associations between child maltreatment and many of the leading causes of death in the United States including, but not limited to, heart disease, cancer, and obesity.[24, 26]

In the United States, the economic cost attributable to child abuse and neglect is substantial.[27] The largest cost for individual victims of child maltreatment is associated with the loss of productivity, which accounts for an estimated loss of $144,000 in reduced lifetime income.[27] After including estimates for special education services and medical

costs, the lifetime cost for each victim of nonfatal maltreatment is $210,000.[27] The fatal and nonfatal cases identified by child welfare services in the United States *each year* are associated with an economic burden of $124 billion over the lifetime of the victims.[27] Annually, states collectively spend over $26 billion annually to manage child welfare services.[27]

Momentum for place-based interventions in child welfare

While extensive evidence on risk factors for child maltreatment guides prevention efforts at the individual level, public health and child welfare experts agree programs targeted at the individual level alone are an incomplete approach to preventing child maltreatment.[1, 28] Interventions aimed at the neighborhood context are needed to complement individual-level efforts by promoting an environment that buffers against, rather than fosters, maladaptive responses to adversity experienced by vulnerable families.[29-31] Sometimes termed neighborhood-based initiatives, place-based interventions are delivered at the neighborhood level through community-wide eligibility for services, changes to the built environment, and collaborative efforts tailored to address the unique needs of individual communities.[32]

Responding to the need to extend prevention efforts beyond the individual level, federal legislation shifted resources to support community-based programs to prevent maltreatment among vulnerable families in high-risk communities.[1, 30, 33-35] Momentum for community-based prevention in child welfare is bolstered by concurrent health systems reform, which also shifts funding to community-based health promotion and disease prevention efforts.[33, 36-38] For child welfare services, collaborative, multi-

component child maltreatment prevention and health promotion efforts in disadvantaged areas may be an effective means to reduce the incidence of child maltreatment and child welfare contact in areas with the greatest need.[1, 29, 39]

Small-area ecological research to inform place-based interventions

Much of the literature on neighborhoods and child maltreatment uses multilevel modeling techniques to estimate the independent effects of contextual variables while controlling for characteristics of the child and family.[40-42] Though this evidence provides the foundation for our understanding of the causal role of neighborhood context in an individual's risk for maltreatment, further information is needed to understand how social processes operating at the population level may increase the rate of child maltreatment and welfare contact within particular geographic areas.[42, 43] Small-area ecological research, defined as the study of populations rather than individuals,[44] using geographic areas as the unit of analysis is necessary for drawing inferences about variation in neighborhood-level outcomes and processes.[45]

In their health determinants framework, Glass and McAtee describe how individual behavior is contingent on the opportunities and constraints of the social and built environment in which the individual lives (**Figure 1**).[46] They present the concept of risk regulators as variables that "capture aspects of the social structure that influence individual action" in a probabilistic fashion, in contrast to a causal effect (deterministic fashion) as understood in etiologic research.[46] Glass and McAtee encourage the use of small-area ecological research to understand determinants of disease rates among populations (in contrast to research on the cause of disease in the individual).[46]

Figure 1. Risk regulators and population health
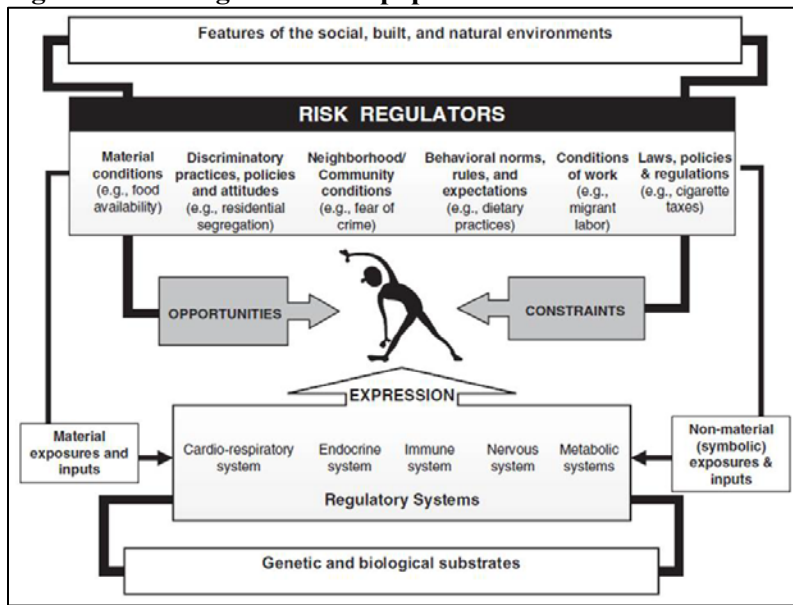
Source: Glass TA, McAtee MJ. Behavioral science at the crossroads in public health: extending horizons, envisioning the future. *Soc Sci Med*. Apr 2006;62(7):1650-1671.

By definition, a risk regulator is a relatively stable contextual factor that resides "at levels of organization above the individual" but below the macro level (e.g., nation/state).[46] In the case of child welfare, neighborhood-level processes that contribute to variation in the rates of child maltreatment and child welfare contact among populations could be classified as risk regulators. By identifying risk regulators that could be leveraged to facilitate change, small-area ecological research can inform the next generation of place-based interventions to promote the health and well-being of vulnerable populations.[46]

Neighborhoods, and child maltreatment, and child welfare contact

Coulton and colleagues propose two key pathways by which neighborhood structure and neighborhood processes influence the likelihood of child maltreatment behaviors and contact with child welfare services at the individual level (**Figure 2**).[42] The residential concentration of disadvantaged populations, most often populations of

Figure 2. Alternative pathways of neighborhood influences on child maltreatment and child welfare contact
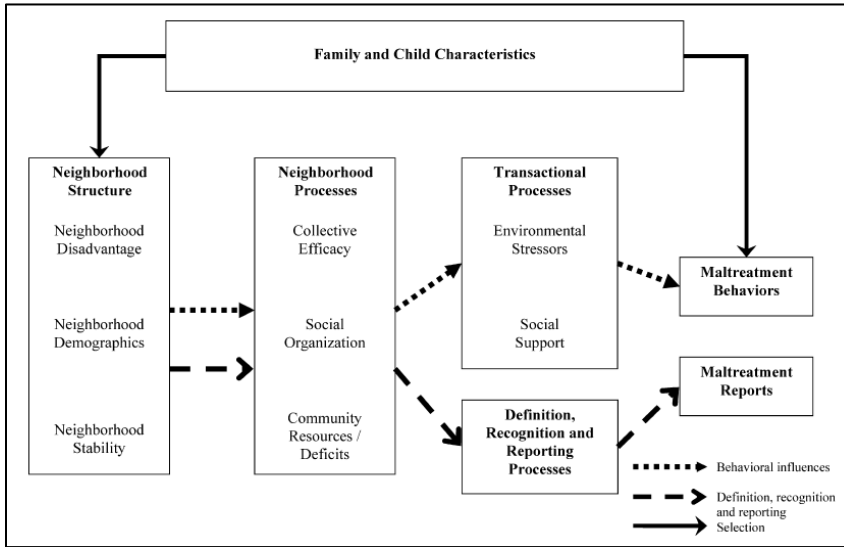
Source: Coulton, C. J., et al. (2007). "How neighborhoods influence child maltreatment: a review of the literature and alternative pathways." *Child Abuse Negl* 31(11-12): 1117-1142

color, is associated with a number of neighborhood-level processes, including social

disorganization and physical disorder. These negative social processes influence the

transactional processes between individuals and other members of their community. The

resulting context becomes one that nurtures maladaptive responses to adversity and

increases the likelihood of maltreatment (i.e., abuse, neglect). While an impoverished and

disordered neighborhood environment is associated with the likelihood of maltreatment,

evidence suggests the contact rate for child welfare services in some neighborhoods may

be more concentrated than expected.[42, 47] In the only study of its type, variation in self-

reported child maltreatment behaviors across urban neighborhoods was modest in

comparison to substantial variation in the rate of child maltreatment reports.[38, 47] The

framework includes the process of neighborhood selection, a complex process by which

family and child characteristics (such as socioeconomic status) influence both options for

residential neighborhood and likelihood of maltreatment behaviors.[42] The process of

neighborhood selection is also a known contributor to multi-generational poverty and the persistence of racial inequities in urban settings.[48]

Existing studies using spatial regression methods describe a relationship between the built environment and child maltreatment rates across geospatial populations that remains after accounting for neighborhood structure. Aspects of the built environment associated with maltreatment include alcohol outlets[49, 50] and inadequate health and supportive resources.[51-53] Other studies focus on drug arrests,[54, 55] a measure that provides information about drug markets but must be considered within the current sociopolitical context of disproportionate surveillance and arrests of minority populations. The current body of research contains valuable information about the relationship between neighborhood disadvantage, the neighborhood context, and child maltreatment reports; however, it lacks *objective* evidence on neighborhood-level processes that may be driving variance.[41, 42] Research on small-area social processes is needed to provide evidence of potential pathways to disproportionate child welfare contact at the neighborhood level.[41, 42] Evidence on neighborhood processes and variation in the rate of child welfare contact will also inform collaboration with other public health and social service sectors to meet the needs of vulnerable populations.[41, 42]

Child well-being and place-based interventions in Baltimore City

Of the more than 130,000 children and youth under age 18 currently living in Baltimore City, 73% of the population is Black non-Hispanic, 17% is White non-Hispanic, and 6% is Hispanic. One in three children in the city is living below the poverty line, 58% live in female-headed households, and 20% of adults do not have high school

diplomas.[56] While Baltimore City has seen an overall decline in violent crime in the past two decades, a long history of violence, drug trafficking, and substance abuse has resulted in considerable social and health needs among the city's most vulnerable populations.[57] Furthermore, since the death of Freddy Gray, an unarmed young Black male, at the hands of the police force in April 2015, violent crime has risen again in the city.[58]

In 2012, there was approximately 1 child maltreatment report for every 25 children in Baltimore City.[59, 60] Considering the high rate of child welfare contract in Baltimore City, the need to reduce the burden on the child welfare system, and growing attention for the need to preventing child maltreatment in high risk neighborhoods, child welfare services may benefit from further coordinating their prevention efforts with other public health sectors serving children at risk of maltreatment. Place-based interventions have considerable momentum in the city and provide an opportunity for collaboration. Examples of current place-based strategies to promote the health and well-being of children, youth, and families in Baltimore City include home visiting for parents of young children, community health worker programs, violence prevention interventions, and efforts to amend zoning laws to promote healthy communities.[61-64]

Momentum for place-based strategies is further driven by the state of Maryland's legislated Health Enterprise Zones (HEZ) Initiative.[65, 66] The HEZ Initiative is a place-based strategy to "reduce health disparities, improve health outcomes, and reduce health cost and hospital admissions in specific areas of the state."[65] By focusing resources into small geographic areas with significant health burdens, Maryland's HEZ Initiative is in line with the efforts to shift to a population health promotion framework driven by the

Affordable Care Act and recommendations put forth by the World Health Organization for action to address health inequities.[29, 67] One of the five Maryland HEZs is a subsection of West Baltimore, an area where additional coordination and collaboration across public sectors (health, social services, and education) could produce measureable results for vulnerable children, youth, and families.

Research Framework

Using a comprehensive research strategy, this study answers important questions needed to inform place-based initiatives for child welfare in urban areas across the United States. The research is focused on a specific pathway within the conceptual framework presented by Coulton et al. in 2007 (**Figure 2** on page 6) and is particularly suited for small-area ecological research (**Figure 3**). The reduced conceptual framework depicts the pathway between neighborhood context (i.e., neighborhood structure and neighborhood processes) and the rate of child welfare contact.[47]

Figure 3. Neighborhood context and the rate of child welfare contact

Incorporating research methods from spatial epidemiology and concepts from the social determinants of health,[29, 67-69] this work applies a population health framework to small-area ecological research in child welfare. The research fills a gap in the literature with descriptive measures of spatial variation in the rate of child welfare contact and provides strong methodological evidence on the relationship between neighborhood

structure, neighborhood processes, and the rate of child welfare contact.[1, 41, 42] While disaggregation of the risk of maltreatment and the risk of child welfare contact is not possible with evidence available for these analyses, the current work generates hypotheses on potential reasons for such variation.

Specific Aims

Aim 1. Systematically review evidence from small-area ecological research on the relationship between the neighborhood context (i.e., structure and processes) and the rate of child welfare contact.

Aim 2. Extend application of the Neighborhood Inventory for Environmental Typology through an assessment of the psychometric properties of area-level measures consistent with the concept of risk regulators.

Aim 3. Assess neighborhood processes as possible explanatory variables for the cross-sectional association between neighborhood structure and variation in the rate of child welfare contact for children across neighborhoods in Baltimore City.

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NEIGHBORHOOD CONTEXT AND THE RATE OF CHILD WELFARE CONTACT: AN EVALUATION AND SYNTHESIS OF POPULATION-LEVEL RESEARCH (AIM 1)

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Abstract

Based on the significant effects of child abuse and neglect on health and well-being across the lifespan, child maltreatment is among the most pressing public health problems in the United States. Research on the social determinants of health bolsters expert agreement that efforts targeting individual behavior alone are inadequate for maltreatment prevention. Interventions aimed at neighborhood-level processes can complement individual-level efforts by promoting an environment that buffers against, rather than fosters, maladaptive responses to adversity. As support for place-based initiatives continues to grow, it is imperative that population-level evidence from ecological research is used to guide intervention efforts. Applying concepts from spatial epidemiology, we present a systematic review of the ecological research on neighborhood context and variation in the rate of child welfare contact at the population level. Three databases (PubMed, PsycInfo, and Proquest Digital Dissertations and Theses) were used for the literature search, which identified 1,327 references. After dual abstract and full text review, 17 distinct studies were included in the study. The average neighborhood-level rate of child welfare contact varied substantially across studies and within studies by maltreatment type and population subgroups. Within the major categories of neighborhood structure and processes, several neighborhood constructs were consistently associated with child welfare outcomes specifically economic disadvantage, racial and ethnic composition, social disadvantage, and residential instability. Despite consistency in studies of the total population, evidence of variation in the relationship between neighborhood context and the rate of child welfare contract (i.e., effect modification) for different racial and ethnic populations emerged in stratified analyses. Though nearly all

studies assessed measures of neighborhood structure, only a few studies included any

assessments of neighborhood processes, which is key information for place-based

interventions that aim to modify the neighborhood context. Application of concepts from

spatial epidemiology and additional reporting of research methods in future studies will

increase confidence in the internal validity of ecological research on neighborhood

variation in the rate of child welfare contact.

Introduction

With the detrimental effects of childhood trauma on well-being firmly established, child maltreatment can be viewed as a public health problem.[1] Each year in the United States, nearly 2.8 million children, or 1 in 25 children, are the subject of child maltreatment reports investigated by child welfare services.[2] The percentage of children who come in contact with child welfare services varies substantially between states, ranging from less than 9 per 1,000 children in Pennsylvania to 95 per 1,000 children in West Virginia and the District of Columbia.[2] While only 19% of all investigations of child maltreatment are substantiated, longitudinal research indicates that children who come in contact with the child welfare system, regardless of the results of the investigation, have a broad range of social and health needs warranting services to promote optimal child development.[3-6]

Compared to the general population, children in contact with the child welfare system are nearly four times as likely to report exposure to multiple (four or more) adverse childhood experiences, many of which are traumatic in nature.[7] Alongside victimization via child maltreatment, these experiences include exposure(s) in their home to intimate partner violence, mental illness (including suicidality and hospitalization), substance abuse, and the incarceration of family members.[7] Outside of the household, this population is also more likely to experience trauma through community violence and persistent polyvictimization (e.g. bullying, physical assault, sexual assault) into adulthood.[8, 9]

In adulthood, maltreatment exposure is associated with one quarter of psychiatric disorders and more than one third of all suicide attempts.[10] The relationship between child maltreatment and adult psychopathology is partially mediated by an increased sensitivity to stress throughout the lifespan.[11] Additional research illustrates the enduring impact on physical health, with strong associations between child maltreatment and many of the leading causes of death in the United States, including heart disease, cancer, and obesity.[12, 13]

Research on the social determinants of health makes clear that efforts targeting individual behavior alone are inadequate for public health promotion.[1, 14-17] Predominant theories on the importance of environmental context for child development have been strongly supported by evidence that the physical and social environments in which an individual lives and grows have considerable bearing on his or her life experiences, as well as on the outcomes of his or her decisions.[18-20] In essence, each individual's decisions are limited by the opportunities and constraints that exist in his or her environment.[14] In addition to numerous interventions that target *individuals*, modification of the *neighborhood* environment can play a complementary role in improving individual child welfare outcomes.[1]

Coulton and colleagues describe how neighborhood-level factors can influence caregiver maltreatment behaviors and contact with the child welfare system in their theoretical framework, illustrated in **Figure 1** below.[21] The authors disaggregate two aspects of a neighborhood that may influence behavior: (1) neighborhood structure – the composition of the neighborhood's population, and (2) neighborhood processes – the components of a neighborhood that shape the context of interpersonal interaction, such as

social and physical disorder and the neighborhood's built environment.[21, 22] These

structural factors and neighborhood process effects are in turn associated with both

parenting practices (including abuse and neglect) and the likelihood a child will be

identified as at risk for abuse or neglect by child welfare services.

The concentration of disadvantaged populations in impoverished areas is strongly

associated with the institutional practice of residential segregation and concentration of

racial and ethnic minority populations.[23] Structural factors, including socioeconomic

disadvantage and residential instability (or geographic mobility) of the population, are

associated with a number of neighborhood-level processes.[23] Negative processes, such as

social and physical disorder, influence the transactional processes between individuals

and other members of their community; the resulting context is one that nurtures

maladaptive responses to adversity.[21, 24] However, evidence suggests the rate of child

Figure 1. Alternative pathways of neighborhood influences on child maltreatment
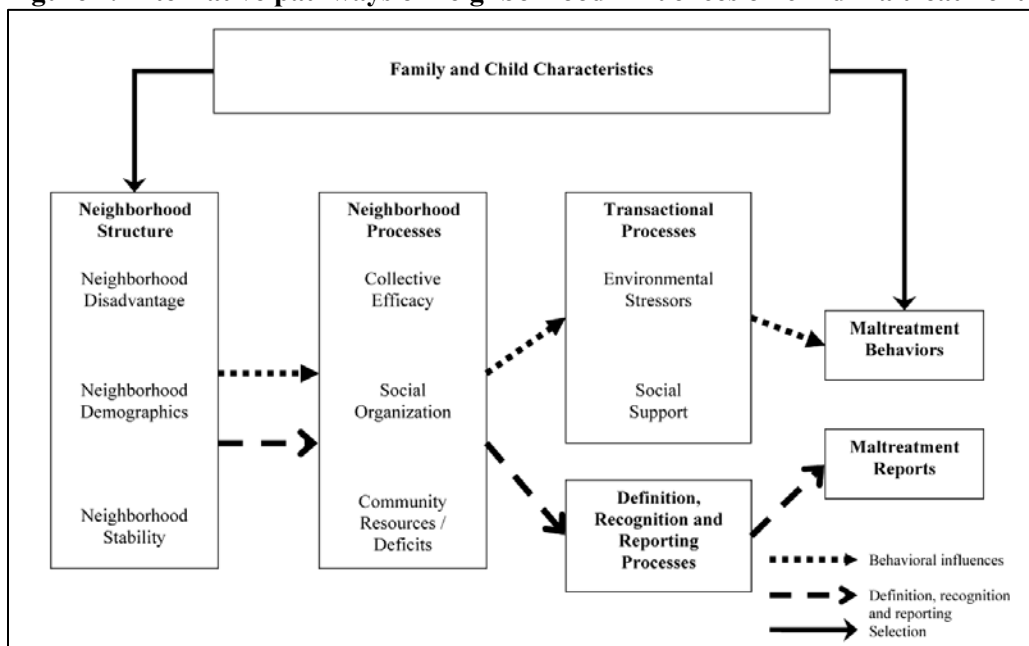
Source: Coulton, C. J., et al. (2007). "How neighborhoods influence child maltreatment: a review of the literature and alternative pathways." Child Abuse Negl 31(11-12): 1117-1142.

welfare contact in some neighborhoods may be more concentrated than warranted, based on maltreatment behavior.[21, 25] Neighborhood-level characteristics may be moderating the risk of identification by child welfare services. An understanding of neighborhood-level "risk regulators" for child welfare contact would be informative for efforts to reduce burden to the child welfare system alongside maltreatment prevention efforts.

Etiologic research supports a causal relationship between elements of the neighborhood context and child well-being at the individual level.[1, 20, 26, 27] Evidence generated through multilevel modeling is particularly well suited for establishing a causal relationship, as it allows for assessment of the independent effects of neighborhood context on risk while adjusting for individual-level characteristics.[21] By contrast, using a small-area ("neighborhood") ecological research design (i.e., neighborhood-level variables only) has significant limitations for causal inference at the individual level; nevertheless, ecological research that examines how neighborhood-level variables may moderate the rate of disease or injury in a geographically defined community is essential to informing place-based interventions.[28]

Through a population health perspective, evidence from small-area ecological research with child welfare data can be used to inform place-based interventions and prevention efforts.[14] Using a modified subset of the Coulton et al framework, **Figure 2** illustrates the population-level framework applied in the current review. Place-based intervention efforts from this perspective may prove particularly useful for reducing undue burden on the child welfare system while supporting the development of social capital to promote health and well-being among the most vulnerable families in urban areas.[17, 29] The current study builds on earlier reviews of ecological research (published in

2006 & 2007) by applying a population health lens and concepts from clinical and spatial epidemiology to summarize the evidence from small-area research on the rate of child welfare contact.[21, 24]

Figure 2. Neighborhood context and the rate of child welfare contact

Methods

A systematic review was conducted to answer four key questions. The first two questions focused on neighborhood variation in the rate of child welfare contact, while the second two were focused on the relationship between neighborhood context and the rate of child welfare contact, including the potential for effect modification:

1. How does the rate of child welfare contact compare *between* studies with the same outcome (e.g., rate of reports, rate of substantiated maltreatment)?

2. How does the rate of child welfare contact compare *within* studies by outcome or population subgroup?

3. How is the neighborhood context associated with the rate of child welfare contact?

4. Does the relationship between the neighborhood context and the rate of child welfare contact vary by outcome or population subgroup?

Literature search

To identify articles relevant to the review, we searched (1) PubMed, (2) PsycINFO, and (3) ProQuest Dissertations and Theses using a comprehensive list of search terms informed by previous studies and reviews of ecological research in child welfare. According to the specifications of each database, we generated a list of terms for "child welfare" and "neighborhoods" and required both terms for article identification (**Table 1**). Only publications subjected to peer review (i.e., peer reviewed-journal articles and scholarly works such as dissertations) were included, while books, conference abstracts, and reports in the grey literature were excluded. The search was limited to research published between January 1, 1990, and December 31, 2016. Though we were aware of a small number of relevant studies published prior to 1990, we chose to limit the study to a 25-year timeframe to reduce temporal heterogeneity.

Table 1. Literature search strategy

PubMed	(("child welfare"[MeSH Terms] OR "child abuse"[MeSH Terms]) OR "foster home care"[MeSH Terms]) AND (("residence characteristics"[MeSH Terms] OR "sociology, medical"[MeSH Terms]) OR "social determinants of health"[MeSH Terms] OR "small-area analysis"[MeSH Terms]) AND ("1990/01/01"[PDAT] : "2015/12/31"[PDAT])
PsycInfo	((DE "Neighborhoods" OR DE "Communities" OR DE "Social Processes" OR DE "Regional Differences" OR DE "Ecological Factors")) AND ((DE "Child Neglect" OR DE "Child Abuse" OR DE "Child Neglect" OR DE "Child Welfare" OR DE "Foster Care" OR DE "Protective Services")) Limiters - Publication Year: 1990-2015
Proquest Digital Dissertations and Theses	su(child abuse neglect) AND su(neighborhoods)

To verify the completeness and accuracy of the literature search, we cross-checked our database with the studies identified in two previous summaries of ecological research in child welfare.[21, 24] We also reviewed the reference lists of included articles to identify studies that may not have been captured by the literature search. All citations

were imported into an EndNote® X7 electronic database for management during the review process.

Study selection and eligibility criteria

All abstracts identified in the literature search were reviewed by two independent reviewers for eligibility against the following *a priori* determined inclusion and exclusion criteria. Inclusion criteria were defined using a modified PICOTS (Population, Intervention, Comparison group, Outcome, Timing, and Setting) framework[30] adjusted to fit the research questions for the review of small-area ecological research on the rate of child welfare contact. The categories of inclusion criteria for the current review were: Population, Independent variable, Comparison, Outcome [dependent variable], Timing, and Setting. Each criterion is described in detail in **Table 2**. In summary, studies had to examine variation in child welfare contract between populations *defined by geographic areas smaller than the city or county level* (e.g., "neighborhoods"). As an independent variable, the study had to include *a measure of neighborhood context.* The study outcome needed to be defined as the rate of child welfare contact; all measures of child welfare contact (e.g., referrals, reports, investigations, substantiated maltreatment, and foster care entry) were included.

All reviewers (SL, KF, MD, and AG) were trained on a systematic approach to reviewing study abstracts and full text articles against each criterion. To maximize the consistency of our literature search across reviewers, we used the abstracts of studies identified in the two previous systematic reviews for training and beta-testing the review form.[21, 24] At each stage, two people independently reviewed the articles. Reviewers first assessed whether the small-area ecological research methods were used. Next reviewers assessed all small-area ecological studies against the inclusion criteria in **Table 2**.

Table 2. Study inclusion criteria

Population	Study examines variation in the rate of child welfare contact between populations defined by designated geographic area, often labeled as "neighborhoods," within a county or metropolitan area. Studies comparing populations defined at larger levels (e.g. city- or county-level variation across a state) are not small-area studies.
Independent Variable	Study includes a measure of neighborhood context.
Comparison	Study compares areas within a specific geographic region.
Outcome [dependent variable]	Study uses the rate of child welfare contact as the primary outcome. Child welfare contact includes every aspect on the spectrum of interaction with the child welfare system for which we use federal definitions. A *referral* is a notification of concern to the child welfare system which, if screened in for a response, becomes a *report*. While some reports result in a reference to other types of services (e.g. alternative response), others will receive a formal *investigation*. An investigation disposition of *unsubstantiated maltreatment* "determines that there is not sufficient evidence under State law or policy to conclude that the child has been maltreated or is at risk of being maltreated." An investigation disposition of *indicated maltreatment* "concludes that maltreatment cannot be substantiated under State law or policy, but there is reason to suspect that the child may have been maltreated or was at risk of maltreatment." An investigation disposition of substantiated maltreatment "concludes that the allegation of maltreatment or risk of maltreatment was supported or founded by State law or State policy." *Foster-care entry* is another measure of child welfare contact and can take place at any time during contact, when service providers suspect the child is in imminent danger.
Timing	Study is cross-sectional or longitudinal.
Setting	Study is set in the United States.

At the abstract review level, only one reviewer had to assess the abstracts for all inclusion criteria for the article to move forward for full text review. Any disagreements on inclusion at the full text level would have been resolved by discussion until consensus could be reached; however, conflict resolution was not required for any of the full text articles reviewed in the current study. Results from the abstract and full text reviews were entered in an EndNote® database for tracking purposes with results summarized using the standard PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) study flow diagram.[31]

Data extraction

For studies that met our inclusion criteria, we extracted pertinent evidence verbatim into structured data abstraction forms (i.e., evidence tables). The data abstraction forms were created and pilot tested (SL) using a subset of included articles to ensure relevant study information was included in the form. Data abstraction forms included study characteristics (setting, level of aggregation, data source(s), observation period, characteristics of study populations, a description of the outcomes used in the study, and variation in outcome across populations), data analysis strategy, neighborhood variables, and study results. All data abstractions were initially conducted by trained research assistants and verified for completeness and accuracy by the lead author.

Assessment of threats to validity

All included studies and outcomes within studies were assessed for internal validity, or limitations in study design and analytic methods that may reduce confidence that study results were achieved without significant bias. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement checklist [32, 33] was reviewed to identify possible limitations in study design specific to observational ecological studies. A list of predefined criteria related to the measurement and statistical analysis, provided in **Table 3**, was used to evaluate the research methods applied in each study. In addition to threats to internal validity, we also examined studies for the inclusion of descriptive statistics and visual presentation of the spatial data to inform the reader's assessment of external validity, or generalizability of the study results.

Table 3. Assessment of threats to validity

Measurement	
1. Data Sources: Valid and reliable population estimates • Gold Standard: Census Bureau Population Estimates Program (PEP), not available below city/county-level • ACS 5-year uses the PEP data and is better than Decennial Census, both acceptable	Y N
2. Outcome is clearly described • Definition of outcome numerator clearly reported (referral/report/substantiated case/indicated case, etc.) • Describes how children with duplicate cases are handled (unique or duplicate count)	Y N
3. More than 80% of cases were successfully geocoded. • Yes = reports ≥ 80% were geocoded • No = reports <80% were geocoded • Unclear = not at all discussed or reported in article	Y N U
4. Data Sources: Valid and reliable data for independent variables • ACS 5-year is better than Decennial Census, both acceptable • Yes = Psychometric properties of measures from primary data collection (e.g., not ACS, Census, or administrative data) described as both valid and reliable with specific figures (e.g. internal consistency, Cronbach's alpha = 0.86) or a reference provided • Unclear = Psychometric properties described as both valid and reliable but no figures or reference is provided , there is no reference to psychometric properties	Y U
5. Adequate period of observation • Observation period is ≥ 2 years	Y N
6. Clear description of all measures • able to be replicated	Y N
7. Geographic unit of analysis was selected with adequate attention to population size • size ≥ census tract	Y N
Statistical Analysis	
1. A bivariate analysis preceded multivariate analysis • Yes = described in terms of both methods and results • Unclear = described in terms of methods only • No = not at all discussed or reported in article	Y N U
2. Clear description of model building strategy • Able to be replicated	Y N
3. Adequate attention to the potential for collinearity in model *Is more than one variable measuring the same construct?* • Yes = described in terms of both methods and results • No = not at all discussed or reported in article • Unclear = described in terms of methods only	Y N U
4. Adequate attention to parsimony in model *Does adding variables improve model fit?* • Yes = described in terms of both methods and results • Unclear = described in terms of methods only • No = not at all discussed or reported in article	Y N U
5. Assessed models for residual spatial variation and adjusted if needed. • Yes = described methods for assessing/adjusting models for spatial variation and described whether such controls were used in the reported results • Unclear = described in terms of methods only • No = not at all discussed or reported in article	Y N U
6. Adjusted analysis for variation in population distribution across areas • Yes = described methods used to account for variation in the population distribution across areas of observation • No = not at all discussed or reported in article	Y N
7. Used model appropriate for the distribution of the outcome • Yes = described distribution of the outcome (expect Poisson/Negative binomial) and statistical methods to account for distribution observed • No = not at all discussed or reported in article • Unclear = described distribution statistical methods to account for distribution expected but did not describe distribution observed	Y N U
Descriptive Statistics	
1. **Study provides demographic statistics using the same unit of analysis as study results**	Y N
2. **Spatial dependence of the outcome is described** • Usually in the form of Moran's I, but can be others (e.g. Geary's c)	Y N
3. **Data is presented visually in map form.**	Y N

Evidence synthesis

To summarize evidence variation in child welfare contact at the neighborhood level, we first describe how the average rate of child welfare contact compares *between studies* using the same outcome (research question 1). Next, we summarize evidence on the variation in the rate of child welfare contact *within studies* when measures are stratified by maltreatment type or population subgroup (research question 2). We then summarize the evidence for each construct included in the body of research examining the relationship between neighborhood context, specifically neighborhood structure and neighborhood processes,[21] and the rate of child welfare contact (research questions 3) and provide evidence of effect modification for each of the relationships studied (research question 4).

To describe the strength of the evidence, we applied guidance established by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) working group.[34] While the GRADE approach is designed for summarizing causal evidence on the effectiveness or comparative effectiveness of a clinical intervention, we were able to apply principles to the current study on the association between neighborhood context and the rate of child welfare contact. Specifically, we applied assessments of consistency and risk of bias (threats to internal validity) in our assessment of the body of evidence.[32-36] For each conclusion drawn from the evidence synthesis for questions 1-4, we describe the body of literature according to these three areas of assessment:

1. A summary of consistency across studies informing the conclusion: Yes, No, Unknown[35]

2. A summary rating of concerns regarding the risk of bias (threats to validity) across studies informing the conclusion: Low, Moderate, High[32, 33, 36]

3. A summary rating for the strength of evidence, described as confidence in the

    conclusion: Low, Moderate, High[34]

Results

We identified 1,327 articles to be reviewed for inclusion at the abstract level

(**Figure 3**). Of these abstracts, 1,255 were excluded because they did not meet the *a*

priori defined study inclusion criteria, and 71 moved forward to full text review. Articles

excluded at the full-text level were coded by reason for exclusion (wrong publication

type, study design, population, independent variables, and setting). The largest reason for

study exclusion was wrong study design (n = 17), a code applied to studies that did not

analyze data at the population level and studies that included only a subset of the area

without information about adjacency of the incomplete sample. These studies often used

multilevel modeling to understand how the neighborhood affects individual-level health

and child welfare outcomes. The second most common reason for exclusion was wrong

publication type (n = 11), which was applied to editorial articles and other forms of

publication that did not include empirical data (e.g., theoretical articles). The third most

common reason for study exclusion was wrong study population, which pertained to all

studies that did not include child welfare outcomes (n = 10). While reason for exclusion

was not systematically tracked at the abstract level, wrong population and wrong study

design were by far the most common reasons for article exclusion. The literature search

yielded 28 articles for inclusion in the review, from which we identified 17 distinct

studies.

Figure 3. Study flow diagram
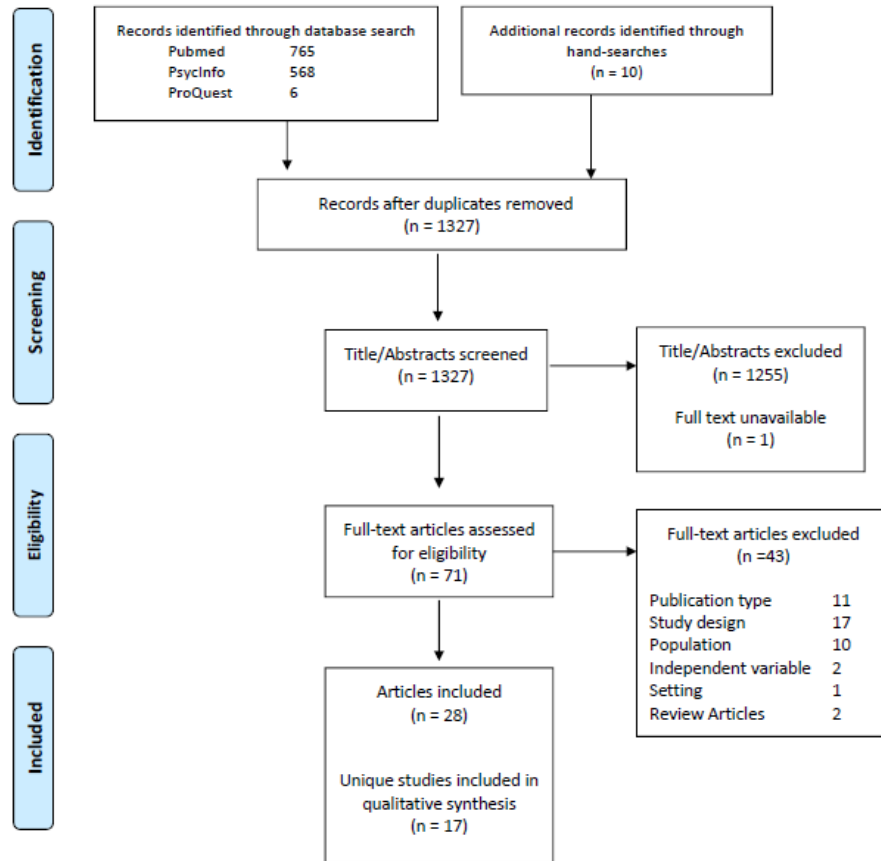
Of the 17 studies included **(Table 4)**, [37-62] seven were conducted in California,[37-41, 45-52] six were on the East Coast (one each in New Jersey,[43, 44] North Carolina,[53] South Carolina,[54] and Georgia,[42] and two in Maryland[55-57]), and four were set in the Midwest (one in Ohio,[59, 60] one in Missouri,[58] and two in Illinois[61, 62]). Four studies examined differences across large areas such as multiple counties or an entire state,[37-42, 47, 58] while thirteen examine differences within a single city or county.[43-46, 48-54, 57, 61, 62] Ten studies used census tracts as the area of aggregation,[37-45, 49-53, 55-57, 59, 60] four use zip codes,[47, 48, 51, 52, 58] two use block groups,[46, 51, 52] and three used other levels of neighborhood aggregation;[54, 61, 62] of note, some studies used more than one level of aggregation.

Population demographics differed between studies, and six did not report mean characteristics by unit of analysis. The average percentage of the population in poverty ranged from 4% to 34%. The racial and ethnic composition of the areas under study also varied. The average percentage of the population that was Black ranged from 5% to 58%; the average percentage Hispanic or Latino ranged from 10% to 40%; and two studies reported on Asian populations (10.5% and 19.1%). In **Table 4**, the mean and standard deviation for all population-level measures of child welfare contact are listed for each study where the data were available; results from multiple articles of the same study population are collapsed.

Variation in the rate of child welfare contact at the neighborhood level

Evidence for variation *between studies* (research question 1) was limited to studies using child welfare outcomes without disaggregation by maltreatment type or population subgroup; twelve unique studies meeting these criteria described variation in the rate of child welfare contact for 15 data points.[37-41, 43-52, 54, 59-61] Child maltreatment referrals ranged from 42 per 1,000 to 98 per 1,000 (n = 3 studies)[45, 47-50] and had the largest range among outcomes reported in at least two studies. The rate of substantiated maltreatment had the second largest range (6-36 per 1,000; n = 6)[37-41, 45-47, 49, 50, 54, 59-61]

Table 4. Study and population characteristics for included studies

First author, year of publication	Observation period and setting unit of analysis (n)	Population Characteristics Mean (sd)		Variation in Rate of Child Welfare Contact Mean (sd); Moran's I *P<.05, **P<0.01, ***P<0.001
Coulton et al. 1995[59] Korbin et al. 1998[60]	1991 Cleveland, OH Census tracts (177)	% Poverty % Black	33.9 (18.9) 48.0 (44.2)	Maltreatment*/1,000 children: 36.3 (20.7) **Maltreatment*/1,000 children** Non-Hispanic White tracts: 13.07 (16.15) Non-Hispanic Black tracts: 42.79 (20.23)
Drake et al. 1996[58]	1992 Missouri Zip codes (185)	% Poverty *Range* % White *Range*	0.3-61.8 0.4-100	*Reports/1,000 families* *Neglect* Least poverty: 5.0 Mdn poverty: 27.1 Highest poverty 88.0 *Physical abuse* Least poverty: 6.7 Mdn poverty: 20.9 Highest poverty: 44.9 *Sexual abuse* Least poverty: 2.9 Mdn poverty: 6.6 Highest poverty: 12.4 *Substantiations/1,000 families* *Neglect* Least poverty 0.6 Mdn poverty: 5.4 Highest poverty 27.4 *Physical abuse* Least poverty: 0.5 Mdn poverty: 3.1 Highest poverty: 10.1 *Sexual abuse* Least poverty: 1.2 Mdn poverty: 2.9 Highest poverty: 5.0
Ernst. 2000[55] Ernst. 2001[56]	1995 Montgomery County, MD Census tract (159)	% Poverty % Black	4.3 (3.5) 11.5 (10.4)	Investigations/1,000 families: 12.7 (9.9) Investigation for neglect/1,000 families: 4.8 (5.1) Investigation for physical abuse/1,000 families: 6.0 (5.6) Investigation for sexual abuse/1,000 families: 2.7 (3.0)

Table 4. Study and population characteristics for included studies (continued)

First author, year of publication	Observation period and setting unit of analysis (n)	Population Characteristics Mean (sd)	Variation in Rate of Child Welfare Contact Mean (sd); Moran's I *P<.05, **P<0.01, ***P<0.001
Freisthler. 2004[37, 38] Freisthler, et al. 2004[39] Freisthler, et al. 2006[40] Freisthler et al. 2007[41]	2000 Alameda, Sacramento, and Santa Clara County, CA Census tracts (940)	% Poverty 11.0 (10.0) % Black 10.7 (14.6) % Hispanic 19.0 (15.5)	Maltreatment/1,000 children: 10.6 (18.3); I = 0.72*** Neglect/10,000 children: 56.3 (101.7); I = 0.59*** Physical abuse/10,000 children: 18.8 (25.0); I = 0.35*** *Maltreatment/10,000 children* Black: 238.6 (536.5); I = 0.41* Hispanic: 96.4 (213.7); I = 0.32* White: 151.8 (441.2); I = 0.53*
Freisthler et al. 2007[47]	1998-2003 California Zip codes (579)	Mdn HH income 42,546 (15,025) % Black 6.7 (12.2) % Hispanic 28.0 (20.1)	Referrals/1,000 children: 52.2 (43.9) Maltreatment/1,000 children: 12.1 (13.9) Foster care entry/1,000 children: 4.5 (6.0)
Freisthler, et al. 2012[45]	2002-2008 Sacramento, CA Census tracts (95)	% Poverty 34.3 (16.8) % Black 14.5 (10.0) % Hispanic 24.4 (13.9)	Referrals/1,000 children: 98.3 (89.8) Maltreatment/1,000 referrals: 243.8 (122.7) Foster care entries/1,000 substantiated: 401.6 (413.7)
Freisthler. 2013[48]	2006 Los Angeles County, CA Zip codes (288)	% Income <$25k 23.1 (15.6) % Black 8.8 (13.7) % Hispanic 40.1 (25.9)	Referrals/1,000 children: 41.9 (30.1) Foster care entry/1000 children: 2.8 (5.0)
Freisthler et al. 2005[46]	2000 Northern City, CA Block groups (304)	% Poverty 19.5 (14.8) % Black 14.3 (11.6) % Hispanic 20.0 (11.5)	Maltreatment/1,000 children: 33.7 (72.1)
Fromm. 2004[61]	Year NR Chicago, IL Neighborhood clusters (343)	% Poverty 20.1 (13.3) % Black 43.0 (42.5) % Hispanic 24.7 (28.1)	Maltreatment/1,000 children: 18.7 (23.3)
Hyde. 2002[57]	1995 Baltimore, MD Census tracts (195)	% Poverty 22.2 (15.0) % Black 57.5 (40.1) % Hispanic 17.9 (14.2)	Not reported
Klein. 2010[63] Klein. 2011[49] Klein et al. 2014[50]	2006 Los Angeles County, CA Census tracts (2052)	% Poverty 17.9 (13.0) % Black 9.8 (15.9)	Referrals/1,000 ages 0-5: 48 (range: 0–769) Maltreatment/1,000 ages 0-5: 11 (range: 0–222) *Referrals/1,000 children* White: 64 (104); I = 0.40*** Hispanic: 56 (171); I = 0.64*** Black: 126 (225); I = 0.57***

Table 4. Study and population characteristics for included studies (continued)

First author, year of publication	Observation period and setting unit of analysis (n)	Population Characteristics Mean (sd)	Variation in Rate of Child Welfare Contact Mean (sd); Moran's I *P<.05, **P<0.01, ***P<0.001
Lery. 2008[51] Lery. 2009[52]	2000-03 Alameda County, CA Zip codes (46) Census tracts (320) Block groups (983)	*Census tracts* % Poverty 12.2 (11.1) % Black 16.9 (20.3) % Hispanic 17.9 (14.2) % Asian 19.1 (15.5)	*Foster care entries/1,000 children* Zip code: 10.3 (8.8); I = 0.34** Census tracts: 17.6 (80.3); I = 0.24** Block groups: 12.7 (47.7); I = 0.18**
McDonell et al. 2009[54]	2002-2007 Greenville County, SC Neighborhoods (168)	Not reported	Maltreatment/1,000 ages 0-19: 11.2 (16.7) Neglect/1,000 children ages (0–19): 3.2 (6.7) Physical abuse/1,000 ages 0–19: 3.4 (6.5) Sexual abuse/1,000 children (0–19): 1.0 (2.8)
Molnar, et al. 2016[62]	1995-2005 Chicago, IL Neighborhood clusters (343)	Not reported	Neglect/1,000 children: 6.5 Physical abuse/1,000 children : 1.5 Sexual abuse/1,000 children: 0.8
Morton. 2012[64] Morton. 2013[43] Morton, et al. 2014[44]	2003 Bergen County, NJ Census tracts (163)	% Poverty 4.8 (3.3) % Black 4.7 (10.9) % Hispanic 10.0 (8.6) % Asian 10.5 (8.5)	Reports/1,000 children: 4.0 (4.1);); I = 0.22* Reports of neglect/1,000 children: 1.2 (2.1); I = 0.11* Reports of physical abuse/1,000 children: 2.6 (2.5); I = 0.19***
Paulsen. 2003[53]	2000 Charlotte, NC Census tracts (NR)	Not reported	Not reported
Zhou. 2006[42]	2000-2 Metro Atlanta (Fulton, DeKalb, Cobb, Gwinnett, and Clayton County), GA Census tracts (478)	% children born to Medicaid beneficiaries: 37.8 Single parent-families: 38.5	Neglect/1,000 person-years children age <4: 7.6 (9.9) Abuse*/1,000 person-years children age <4: 0.6 (1.3) *physical or emotional

and the rate for foster care entry had the smallest range (2.8-10.3 per 1,000; n = 4).[47, 48, 51, 52] An estimate of spatial variation in the form of Moran's I was reported by only two studies addressing this question: the first described spatial autocorrelation for the rate of substantiated maltreatment (census tract level, I = 0.72)[43, 44] and the second study examined the rate of foster care entry across three spatial scales (zip code level, I = 0.34; census tract level, I = 0.24; block group level; I = 0.18).[51, 52]

Fourteen comparisons of two or more subgroups were presented in the included articles, allowing for the evaluation of differences *within a study sample*. Six studies compared rates by maltreatment type;[39, 42, 44, 54, 55, 62] four compared rates by population subgroups;[41, 50, 58, 60] and four compared child welfare outcomes at the same spatial scale.[45, 47-49]

Maltreatment type

Two studies examined early forms of contact with child welfare (one used reports[44] while the other used investigations[55]) and presented results disaggregated by maltreatment type; in both of these studies, the rate of physical abuse was higher than the rate of neglect. In contrast, in three of the four studies that used substantiated cases as the outcome measure, the rate of neglect was found to be higher than the rate of physical abuse.[39, 42, 54, 62] Spatial variation was assessed in only two studies; rates of reports of physical abuse were more strongly spatially correlated than neglect (Moran's I = 0.19 vs. I = 0.11, respectively),[39] but rates of substantiated neglect were more strongly spatially correlated than rates of substantiated physical abuse (Moran's I = 0.59 vs. I = 0.35, respectively).[44]

Population subgroup

Two studies compared variation in the rate of child welfare contact for three racial and ethnic subgroups: White, Black, and Hispanic.[41, 60] The highest rate of child welfare contact was for Black children, who also had the greatest variation in child welfare contact rate (i.e., largest standard deviation) across geographic areas examined within studies; meanwhile, the lowest rate was for Hispanic children. In the study using the rate of referrals as the outcome, spatial correlation was strongest for Hispanic children (I = 0.64), followed by Black and White children (I = 0.57 and I = 0.40, respectively).[50] In the study using the rate of substantiated maltreatment, the strongest spatial correlation was for White children (I = 0.53), followed by Black and Hispanic children (I = 0.41 and I = 0.32, respectively).[41] One study used a different method to study the effects of race and ethnicity and found higher rates of maltreatment in non-Hispanic Black neighborhoods (i.e., ≥75% Black) compared to non-Hispanic White neighborhoods (i.e., ≥75% White).[60]

A single study compared neighborhoods using low-moderate-high levels of poverty and showed a gradient effect for the rates of child welfare reports and substantiated maltreatment, both combined and when disaggregated by maltreatment type.[58]

Child welfare outcomes

The four studies comparing different outcomes all showed patterns in the expected direction, with higher rates for referrals than for substantiated maltreatment or foster care entry.[45, 47-49]

Evidence synthesis

In **Table 5**, we present a synthesis of the evidence on variation in the rate of child welfare contact at the neighborhood level (research questions 1 and 2). We summarize the data for within-studies comparisons according to study, the type of maltreatment (neglect, physical abuse, and sexual abuse), and population subgroup (racial and ethnic subgroups, socioeconomic status). Below, we summarize the key findings from the first portion of the systematic review. Conclusions drawn from the review are in italicized text.

Table 5. Variation in rate of child welfare contact at the neighborhood level

Comparison	Results	N study	Consistent	Risk of Bias Strength of Evidence (SOE)
Question 1: How does the rate of child welfare contact compare *between* studies with the same outcome (e.g., rate of reports, rate of substantiated maltreatment)?				
Between studies[37-41, 43-52, 54, 59-61]	• Variation in the rate of child welfare contact varies substantially across studies, with the greatest variation in early indicators (i.e., child welfare referrals)	15	Yes	Bias: Low SOE: High
Question 2: How does the rate of child welfare contact compare *within* studies by maltreatment type? By population subgroup?				
Within studies by maltreatment type[39, 42, 44, 54, 55, 62]	• Mixed evidence on greatest mean rate	6	No	Bias: Moderate SOE: Insufficient
	• Mixed evidence on differences in spatial variation	5	No	Bias: Moderate SOE: Insufficient
Within studies by population subgroup[41, 50, 58, 60]	• Highest rates for populations of Black children, followed by White children, and Hispanic children	3*	Yes	Bias: Moderate SOE: Low
	• Mixed evidence on differences in spatial variation	2	No	Bias: Moderate SOE: Insufficient
	• Highest rate for high poverty populations	1	Unknown	Bias: Moderate SOE: Low

*One study did not include Hispanic children

The rate of child welfare contact varies substantially between studies with the same child welfare outcome (15 studies; risk of bias – low; strength of evidence – high).[37-41, 43-52, 54, 59-61] Variation in the methods used to measure the rate of child welfare contact is likely to affect the precision of estimates for the ranges provided.

The rate of child welfare contact is higher for populations of Black children compared to White children. Populations of Hispanic children have lower rates of child welfare contacts compared to White children (3 studies; risk of bias – moderate; SOE – low).[41, 50, 60]

The rate of child welfare contact increased across tertiles of poverty (1 study; risk of bias – moderate; SOE – low).[58]

Based on analysis stratified according to maltreatment type, evidence was insufficient to draw conclusions on differences in the magnitude of contact rates and strength of spatial autocorrelation by maltreatment type.

Neighborhood context and rate of child welfare contact

Evidence on the relationship between neighborhood structure and processes (research question 3) was limited to studies that presented the results of regression models with child welfare outcomes without disaggregation by maltreatment type or population subgroup.[37, 38, 40, 45-47, 49, 53, 54, 56, 57, 59, 61]

Neighborhood structure

All seventeen studies included at least one neighborhood structure variable and found a statistically significant relationship between one or more categories of constructs (economic disadvantage, racial and ethnic composition, social disadvantage, and residential stability) and the rate of child welfare contact. Many of the studies included

variables for disadvantage that were comprised of indicators from more than one construct; these indicators were consistently positively associated with the rate of child welfare contact.[40, 43, 47, 51, 52, 54, 56, 57, 59, 64]

An indicator specific to *economic disadvantage* was positively associated with child welfare involvement in six studies included for this question.[37, 38, 45, 46, 49, 57, 61] The most commonly used indicator was the percent of the population with income below the poverty level (n = 3), [37, 38, 45, 46] and only one study used a composite indicator for economic disadvantage.[57] Several studies examined potential variation in this relationship by outcome, population, or spatial scale.

Indicators for *racial and ethnic composition* of the neighborhood were included in five studies.[43, 45, 46, 49, 51, 52, 64] The most common indicators for racial and ethnic composition included the percent of the population that was Black (n = 3)[37, 38, 45, 47] and percent Hispanic (n = 4).[37, 38, 45-47] Indicators for the proportion of racial and ethnic minority populations were consistently associated with higher rates of child welfare contact.

The construct of *social disadvantage* consisted of numerous measures describing household and population structure and was often associated with the rate of child welfare contact (n = 10 studies). The most common indicator within this construct was a measure of "child care burden," which was positively associated with the rate of child welfare contact in three studies.[51, 52, 57, 59] The following more specific measures within the construct produced mixed evidence on the significance and direction of the associations: percent of female-headed households, ratio of adults to children, ratio of

adult males to adult females, percent of the population over age 65, population density, and ratio of children to adults.[37, 38, 48, 49, 51, 52]

Residential instability was positively associated with the rate of child welfare contact in seven studies[37, 38, 40, 43, 46, 49, 51, 52, 54, 56, 57, 59] and was most often defined using a composite variable (n = 4).[51, 52, 56, 57, 59] Composite indicators for residential stability often included vacant housing and population change, indicators which were used alone in regression models of other studies.

Neighborhood processes

All eight studies that examined the relationship between neighborhood processes and the rate of child welfare involvement included one or more structural variables (i.e., neighborhood disadvantage, economic disadvantage, social disadvantage, and residential instability) in the final regression models to adjust for key relationships documented in prior research.

Social order was measured differently in two studies. The first study included multiple single-item indicators of social processes with mixed results.[54] A positive association with the rate of child welfare contact was found for several indicators (resident interaction and indicators of communication network) while others (indicators of cultural traditions and indicators of organized neighborhood life) showed a negative association, making results difficult to interpret.[54] The second study included a large number of social process variables and interactions between social process variables.[61] While the results were often in the expected direction, with positive social processes (i.e., social order) negatively associated with rate of child welfare contact, redundant indicators within a construct and variation in measurement limited the evidence base. In the realm

of antisocial activity, two studies found the rate of drug possession and the rate of drug sales "incidents" (arrests and other police contact) to be positively associated with the rate of referrals.[45, 46]

Only a single study included an assessment of physical disorder and contained redundant indicators within the construct (e.g., litter in neighborhood, poor street conditions, boarded/abandoned buildings), making the results difficult to interpret, though many were in the expected direction (i.e., physical disorder is positively associated with child welfare contact).[54]

Seven studies included aspects of the built environment as indicators of access to services that promote healthy families and the well-being of children in the neighborhood [43, 45, 49, 63, 64] and/or aspects of the built environment that represent a detriment to the environmental context.[37, 38, 43, 46, 47, 64] Resource indicators presented mixed results across studies depending on the type of resources provided. In one study, the local availability of substance abuse services and domestic violence services was positively associated with child welfare contact rates; concurrently, availability of housing services and services for children with special needs showed a negative association.[48] Distance to substance abuse services was positively associated with referrals in a second study.[43] One study examining access to early childhood resources found a positive association between the density of child care centers locally and the rate of child welfare contact.[49, 63] The same study included a measure of preschool/nursery school enrollment and found an inverse association between the proportion of enrolled children aged three to four and the rate of child welfare contact.[49, 63]

Alcohol outlet access had a positive association with child welfare contact in four studies.[37, 38, 43, 46, 47, 64] Three studies found the concentration of bars had a positive association, and one study, using a combined indicator for the concentration of all alcohol outlets (liquor/beer stores, bars, and restaurants) also found a positive association. In contrast, a study that analyzed the outlets separately found a positive association with the density of bars but a negative association between the concentration of restaurants and the rate of child welfare contact.[47]

Effect modification: neighborhood context and rate of child welfare contact

Evidence on potential effect modification for the relationship between neighborhood structure and processes (research question 4) was limited to studies that presented the results of stratified regression models. One study compared differences in the same outcomes across three spatial scales (block groups, census tracts, zip codes).[51, 52] Three studies compared child welfare outcomes[47-49] and eight studies compared maltreatment types.[39, 42, 44, 53-55, 58, 62, 64] Three studies assessed differences between population subgroups.[41, 50, 60, 63] Evidence for effect modification is summarized in **Table 5** alongside the evidence for the construct measured and is described in the evidence synthesis below. While the majority of evidence on effect modification came from studies included in question 3, four additional studies provided only stratified data to the analysis and are new to this portion of the analysis.[42, 53, 58, 62]

Evidence synthesis

We summarize evidence on the relationship between neighborhood structure and processes and the rate of child welfare contact (question 3), as well as evidence of

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possible effect modification (research question 4) in **Table 6** and in the section below summarizing each construct.

As a whole, the body of evidence is robust with a large number of studies with consistent findings that *disadvantage is positively associated with the rate of child welfare contact*; evidence for effect modification was limited (8 studies; risk of bias: low – SOE: moderate). Eight studies incorporated composite indicators for neighborhood structure that included more than one of the constructs identified (economic disadvantage, racial/ethnic composition, social disadvantage, and residential instability).[40, 43, 47, 51, 52, 54, 56, 57, 59, 64]

A large number of studies with consistent findings support the conclusion that *economic disadvantage is positively associated with the rate of child welfare contact*; evidence for effect modification was limited (7 studies; risk of bias – low; SOE – moderate).[37, 38, 45, 46, 48, 49, 57, 61]

Six studies included a variable for racial and ethnic minority composition. [37, 38, 45, 46, 48, 49, 57, 61] Though results were consistent for the six studies with all children together, evidence from two studies suggested the racial/ethnic composition of the neighborhood may differentially affect the rate of child welfare contact for children of different race/ethnicity.[50, 63 41] The first found the proportion of population that was Black was negatively associated with the rate of child welfare contact for Black children but not White children, and the proportion Hispanic was positively associated with the rate only for White children.[41] The second found racial and/or ethnic heterogeneity to be consistently associated with higher rates of contact for children of different races.[50, 63] While the potential for effect modification is an important consideration for potential

Table 6. Neighborhood context and the rate of child welfare contact

Question 3: How is the neighborhood context associated with the rate of child welfare contact?
Question 4: Does the relationship between the neighborhood context and the rate of child welfare contact vary (i.e. effect modification) by outcome? population subgroup? spatial scale?

Construct	+ -	Consistent	Evidence for Effect Modification	Risk of Bias Strength of Evidence (SOE)
Neighborhood Structure (n = 17)				
Disadvantage, multi-construct (n = 8)[40, 43, 47, 51-54, 56, 57, 59, 60, 64]	+	Yes	Possible by maltreatment type (2/2) None by race/ethnic composition of pop (0/1) None by spatial scale (0/1)	Bias: Low SOE: Moderate
Economic disadvantage (n = 7)[37-39, 41, 42, 44-50, 55, 57, 58, 61-64]	+	Yes	Possible by child welfare outcome (1/3) Possible by maltreatment type (2/6) Possible by race/ethnicity of child (1/2)	Bias: Low SOE: Moderate
Racial and ethnic [minority] composition (n = 6)[39, 41, 43-52, 63, 64]	+	Yes	None by child welfare outcome (0/3) Likely by race/ethnicity of child (2/2) Possible by maltreatment type(2/2)	Bias: Moderate SOE: Low
Social disadvantage (n = 10)[39-44, 46-52, 55-61, 63, 64]	+	Yes	Possible by child welfare outcome (1/3) Possible by maltreatment type (5/5) Possible by race/ethnicity of child/pop (3/3) None by spatial scale (0/1)	Bias: Moderate SOE: Low
Residential Instability (n = 7)[37, 38, 40, 41, 46, 50-52, 55-57, 59-61, 63]	+	Yes	Possible by maltreatment type (2/2) Possible by race/ethnicity of child or pop (3/3) None by spatial scale (0/1)	Bias: Moderate SOE: Low
Neighborhood Processes (n = 9)				
Social order (n = 2)[54, 61, 62]	-	●	Possible by maltreatment type (1/2)	Bias: Moderate SOE: Insufficient
Drug arrests (n = 2)[45, 46]	+	Yes	None by child welfare outcome(0/1)	Bias: Low SOE: Low
Physical disorder (n = 1)[54, 62]	+	●	Possible by maltreatment type (1/2)	Bias: Moderate SOE: Insufficient
Built environment (n = 7)[37, 38, 43, 45-47, 49, 63, 64]				Disaggregated
Health/Social services (n = 3)[43-45, 48, 64]	●	●	None by maltreatment type (0/1)	Bias: Moderate SOE: Insufficient
Early child care/PreK services (n = 1)[49, 50, 63]	●	●	None by child welfare outcome (0/1) Possible by race/ethnicity of child (1/1)	Bias: Moderate SOE: Insufficient
Alcohol outlets (n = 4)[37-39, 41, 43, 44, 46, 47, 64]	+	Yes	None by child welfare outcome(0/1) Possible by maltreatment type(1/2) Possible by race/ethnicity of child(1/1)	Bias: Low SOE: Moderate

bias, consistency across the majority of studies suggest a *higher concentration of minority populations is positively associated with child welfare contact* (6 studies; risk of bias – moderate; SOE – low).

When indicators of social disadvantage were summarized as meaningful indicators such as child care burden and the broader context of disadvantage, results consistently support the conclusion that *social disadvantage has a positive association with the rate of child welfare contact* (10 studies; risk of bias – moderate; SOE – low).[40, 43, 46-48, 51, 52, 56, 57, 59, 61, 64] In some studies, a large number of social disadvantage indicators were included with the intent of serving as control variables, making interpretation difficult and potentially biasing results. Studies that stratified the analysis by maltreatment type or race of the child consistently showed potential for effect modification. We graded the strength of evidence for this relationship as low due to concerns regarding effect modification.

Summary indicators for *residential instability had a positive association with the rate of child welfare contact* (7 studies; risk of bias – moderate; SOE – low).[37, 38, 40, 41, 46, 50-52, 55-57, 59-61, 63] While studies using composite indicators found consistent results, studies that stratified results by maltreatment type or race of the child showed potential for effect modification. We graded the strength of evidence for this relationship as low due to concerns regarding effect modification.

Two studies found a *positive association between drug arrests and child welfare contact*, and no evidence for effect modification was provided (2 studies; risk of bias – low; SOE – low).

Four studies found a *positive association between the density of alcohol outlets and the rate of child welfare contact* (4 studies; risk of bias – low; SOE – moderate). When studies included both on- and off-premise alcohol outlets (restaurant vs. bars and liquor stores), restaurants did not have the same positive association as off premise outlets. Both limited evidence of effect modification and the consistency of results with overall maltreatment rates support this relationship.

While results for the other four constructs (social order (n = 2),[54, 61] physical disorder (n = 1),[54] access to health social services (n = 3),[43, 45, 48, 64] and access to early childhood/pre-K resources (n = 1))[49, 63] were sometimes in the expected direction, other times they were not statistically significant. Each of the studies included a large number of variables to measure the same or very similar neighborhood process construct; in turn, the potential for collinearity increases, as does the potential for biased results. We graded the risk of bias for each of these constructs as moderate and considered the evidence for the relationship between the constructs and the rate of child welfare contact as insufficient to draw a conclusion with confidence.

Limitations of the evidence-base (threats to internal validity)

For each outcome in the included studies, the risk of bias was rated either low or moderate with only minor threats to internal validity suspected. The potential for measurement error, both random and non-random, was at times present in the measurement of the rate of child welfare contact. In some studies, the description of analytic methods would have benefited from a more lengthy description of decisions made during the model selection process. Most studies appropriately used statistical methods to adjust for spatial autocorrelation but spent little time describing preliminary

analysis (e.g., bivariate), assessments of collinearity or efforts towards a parsimonious model, which are also key analytic considerations. The potential for Type-1 errors (an erroneous rejection of the null hypothesis) is also a notable concern, as some studies tested a large number of hypotheses without adjusting for multiple comparisons.

Discussion

In this summary of small-area ecological research, we found considerable variation in the rate of child welfare contact across studies of the same measure and within studies comparing different child welfare outcomes. Evidence by population subgroup or maltreatment type illustrates the potential variation between groups within the same source population. Building on the framework presented by Coulton and colleagues,[21] we identified six neighborhood-level constructs with sufficient evidence to draw a conclusion on their association with the rate of child welfare contact. In addition to strong evidence for multi-component measures of neighborhood structure (i.e., disadvantage), four specific constructs within neighborhood structure were positively associated with the rate of child welfare contact: economic disadvantage, population composition (i.e., racial and ethnic minority representation), social disadvantage (i.e., household and population structure according to age and gender), and residential instability. While evidence for the relationship between neighborhood structure and the rate of child welfare contact has grown substantially in recent years, the results from this study are consistent with the findings of earlier literature reviews.[21, 24] With only two constructs with adequate evidence for conclusion (drug arrests and alcohol access), evidence on neighborhood processes remains limited.

The current body of research contains valuable information about the relationship between the neighborhood context and child welfare contact; however, it continues to lack objective evidence on neighborhood-level processes that may be driving variation in rates of maltreatment.[21, 24, 62] Additional research on small-area social processes is needed to provide evidence on potential pathways to child welfare contact at the neighborhood level.[21, 24] Evidence on neighborhood processes and variation in the rate of child welfare contact will also inform collaboration with other public health and social service sectors to meet the needs of vulnerable populations.[21, 24]

Results from this study provide a new lens through which we can further our understanding of the relationship between neighborhood context and the rate of child welfare contact in a geographically defined population. Results can be used to generate new hypotheses on how child welfare reporting processes may be related to neighborhood variation in child welfare contact beyond that associated with actual variation in maltreatment behaviors. For example, the ethnic and racial composition of the population was associated with differences in the rate of child welfare contact; however, the indicators did not appear to have the same effect on all racial and ethnic subgroups.[39, 41, 43-52, 63, 64] With evidence that racial heterogeneity at the neighborhood level is positively associated with child welfare contact across population subgroups (White, Black, and Hispanic), future research on population-level effects of neighborhood diversity are warranted. Racial heterogeneity may be an indicator of cultural differences or distrust that could lead to more referrals to child welfare services.

The purpose of this study was both to assess the population-level evidence and to apply a critical appraisal of the analytic methods applied. The critical evaluation of

ecological studies in child welfare points to two key areas where refined research methodology and reporting would increase confidence in the internal validity of a study: measurement and statistical analysis. Differences in the research methods (e.g., definition of spatial scale) and setting (e.g., urban vs. rural areas, population demographics) may affect variation in the rate of child welfare contact and should be considered when interpreting the literature on spatial variation at the neighborhood level.

Measurement error in the studies was most often possible due to selection of data sources and lengths of observation periods. Data sources for population estimates were often drawn from the United States Census, which is affected by the systematic undercounting of some populations during enumeration, and of racial and ethnic minorities in particular.[65] The American Community Survey (ACS), another publically available option for population estimates, uses sophisticated sampling techniques and multiple years of data to generate population estimates that are more reliable and valid.[65] ACS data is summarized at the census tract level using five years of data. To decrease measurement error associated with using only a single year of child welfare data, studies would benefit from combining multiple years of data, thus increasing precision in the measurement of the outcome. Another key issue that is important to consider in child welfare research is variation in the distribution of population by age, interacting with variation in the rate of child welfare contact by age. The potential confounding in studies from aggregating measures for children across ages 0-17 is notable and worthy of consideration in future research. Only one study identified for the current review adjusted for differences in the distribution of population by age group.[62] For future research, standardization of measurement for the rate of child welfare contact through the inclusion

of person-years of observation and age-adjusted rates will increase precision of estimates and the comparability of results across studies.

While the analytic methods in most studies included a description of the statistical procedures used to adjust for spatial autocorrelation, some of the early parts of the model-building process were not adequately described. Inclusion of bivariate analyses, even in a limited form, allows the reader to understand the results of the multivariate models with a more comprehensive understanding of the relationships being assessed and/or adjusted through various strategies. Many of the regression models included a large number of variables, raising concerns about collinearity of variables and model parsimony. Future research on neighborhood processes would benefit from a smaller, refined list of control variables to capture the constructs of neighborhood structure. Summary frameworks, like that presented by Coulton and colleagues,[21] can guide the selection of variables to capture the concepts relevant for the research and avoid inclusion of an excessive number of "nuisance" control variables.

Strengths and limitations of the systematic review

Using a multi-disciplinary approach, the current review applied concepts from clinical and spatial epidemiology to ecological child welfare studies. Use of child welfare statistics as a proxy for the incidence of child maltreatment has significant limitations due to the systematic process of identification by child welfare. However, in the context of ecological research, child welfare statistics can inform policies for child welfare services at the population level. Specifically, this evidence can be used to inform placed-based child maltreatment prevention efforts, focusing interventions at areas with the highest rates of child welfare service utilization.

The review was limited to and thus is *most* applicable to child welfare in the United States in the last 25 years. While evidence from other developed Western counties with similar historical forces (e.g., colonialism) may to be informative, our choice to limit evidence focuses on the political and cultural context of child welfare policy in the United States. As with all systematic reviews, the potential for publication bias should also be considered. Evidence from non-peer reviewed literature, including books and organization reports represents another body of work that may inform our understanding of variation in the rate of child welfare across neighborhoods. It is unclear how the evidence might vary between the peer-reviewed and non-peer reviewed literature, making the potential effects of publication bias difficult to surmise. Our focused assessment of spatial variation and the potential for effect modification highlights the need for additional research in these areas.

Conclusions

Recent advancements in the field of spatial epidemiology are now being applied to the study of child welfare contact among populations. This growing body of evidence continues to support a variety of relationships between the neighborhood context and the rate of child welfare contact. Improvements in measurement can increase confidence in the validity of the relationships described in the current review; however, the potential for effect modification by maltreatment type or population subgroups is also important to consider through stratified analyses. Further research with objective measures of neighborhood *processes*, such as social and physical disorder, substance use activity, and violence, will provide further insight for collaborative action across public service

agencies to prevent maltreatment and reduce undue burden to the child welfare system

through place-based interventions.

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MEASUREMENT OF NEIGHBORHOOD RISK REGULATORS IN BALTIMORE CITY, DEVELOPING METRICS FOR YOUTH POPULATION HEALTH

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Abstract

Interest in population health has grown in recent years as federal, state, and local public health entities consider the important role environmental context plays in the opportunity for health within communities. Small-area ecological research is a critical area of research to inform place-based interventions at the neighborhood level; however, research on objective measurement of the environmental context has been limited. The current study extends the application of the Neighborhood Inventory of Environmental Typology (NIfETy) to small-area ecological research through thorough measure development and the evaluation of psychometric properties. Observations at the block-face level were conducted annually on 793 randomly selected locations over a three-year period (2010-2012) in Baltimore City. Through a multi-step process including replication of previous measures researched, data reduction, factor analysis, and aggregation to the neighborhood level (i.e., 55 Community Statistical Areas), we developed six indicators to describe the environmental context: substance use activity, violence, physical disorder, activity hub, youth activity, and improvements/beautification. Assessment of internal and temporal consistency, spatial variation, criterion validity, and external construct validity provided support for some indicators but not all. The current study provides guidance for the measurement of multi-year, area-level constructs of neighborhood conditions. At the local level, the precision of constructs measured in this study provides local policymakers and public health practitioners with evidence needed to respond to the unique needs of individual neighborhoods through place-based interventions. Further, evidence of the overlapping needs can be used to foster collaboration across public sectors, including education, social services, public health, and criminal justice.

Introduction

A growing body of research illustrates a causal relationship between the neighborhood context and the health and well-being of children, youth, and families.[1-4] Public health and child development experts agree intervention efforts targeted at the individual level alone are an incomplete approach to promote population health and child development.[5-10] Population health interventions aimed at the neighborhood level (i.e., place-based interventions) are necessary to complement individual-level efforts by supporting an environment that buffers against, rather than fosters, maladaptive responses to adversity experienced by families.[5, 7, 11-13] Momentum for place-based intervention efforts is bolstered by health systems reform, which renewed focus on population health promotion and disease prevention efforts.[10, 11, 14-19] In light of growing support, population-based evidence is necessary to inform the development and evaluation of place-based initiatives.[20]

The World Health Organization (WHO) describes the social determinants of health as "the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life" and health outcomes across the lifespan.[21] Multilevel modeling methods have expanded over the past 25 years, allowing for disaggregation of neighborhood- and individual-level effects on the health and well-being of individuals.[1-4] Evidence garnered from individual-level research provides the basis of our understanding on the etiologic pathway through which the neighborhood context affects health; however, evidence at the population level is necessary to ensure appropriate translation of evidence to action. Place-based interventions are targeted above the level of the individual and are delivered through

community-wide eligibility for services, changes to the built environment, and collaborative efforts tailored to address the unique needs of individual communities.[22] Targeted at the neighborhood level, place-based interventions should be informed by population-based evidence.[20]

The unique contribution of small-area ecological studies becomes apparent when goals of the research are framed differently from traditional, etiologically-focused investigations.[20] In their health determinants framework, Glass and McAtee describe how individual behavior is contingent on the opportunities and constraints of the social and built environment in which the individual lives **(Figure 1)**.[20] They present the concept of risk regulators as variables that "capture aspects of the social structure that influence individual action" in a probabilistic fashion, in contrast to a causal effect (deterministic fashion) as understood in etiologic research.[20] By definition, a risk regulator is a relatively stable contextual factor that resides "at levels of organization above the individual" but below the macro level (e.g., nation/state).[20] Identifying risk regulators that could be leveraged to facilitate change, social ecological research can inform the next generation of place-based interventions.[20] While Glass and McAtee's model also includes the interaction between risk regulators and the health of the individual through genetic and biological pathways, the risk regulators portion of the model is most appropriate for etiologic research at the level of the individual.

Figure 1. Risk regulators and population health
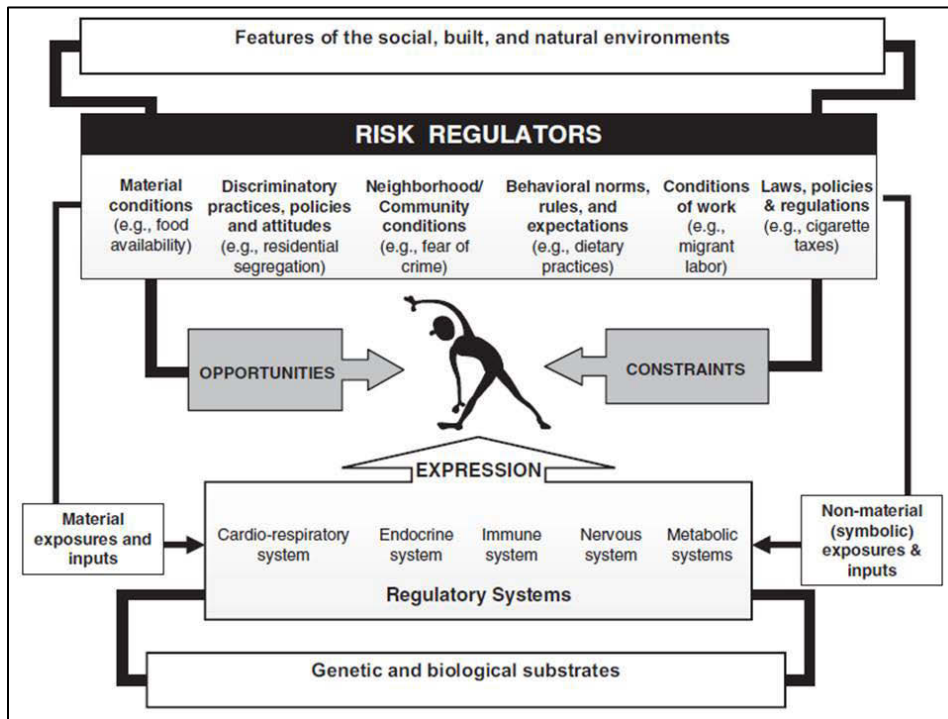
Source: Glass TA, McAtee MJ. Behavioral science at the crossroads in public health: extending horizons, envisioning the future. *Soc Sci Med*. Apr 2006;62(7):1650-1671.

Many neighborhood-level indicators have been identified using public data from the Decennial Census and the American Community Survey. Evidence from these sources can be primarily characterized as structural determinants and includes features of the population composition (e.g., socioeconomic status) summarized at the area level.[23] While structural indicators are important for small-area ecological research, evidence on neighborhood processes (i.e., "risk regulators") is required to design interventions responsive to the unique needs of individual neighborhoods.[19, 23] Objective environmental assessments can provide insight that goes beyond what can be provided by individuals, whose perspectives are also shaped by their own personal circumstances.[24]

Via observational assessments, Furr-Holden and colleagues have collected more than one dozen waves of observational data over the last decade using the Neighborhood Inventory for Environmental Typology (NIfETy) Instrument, an objective tool to measure the neighborhood physical and social context.[25, 26] Previous research provides evidence of excellent inter-rater reliability for NIfETy observations as well as significant correlations for the majority of items in test-retest assessments.

NIfETy items are aligned with well-researched theories regarding neighborhood conditions and human behavior, most specifically the family of incivility theories, the social cognitive model of learned behaviors, and differential opportunities theory.[25] According to the incivilities theories, broken windows and other indicators of urban decay (i.e., physical disorder) are indicative of a lack of concern for the neighborhood and generate distrust among residents, limiting positive social interactions and collective efficacy to address neighborhood concerns (e.g., substance use activity, gang activity, violence).[27, 28] A second framework, the social cognitive model, describes the interactive process through which human behavior is learned from others, mimicked, and reinforced via positive or negative responses (i.e., reward or punishment).[29] For youth living in areas where substance abuse and criminal activity are high, there is a higher likelihood of positive reinforcement for what may be deemed as unacceptable and antisocial activity in other areas.[30] Most applicable to the concept of risk regulators defined by Glass and McAtee,[20] differential opportunities theory describes individual behavior as contingent of the opportunities available in one's environment.[31, 32] For youth in many disadvantaged urban areas, opportunities for traditional success (e.g., school completion, employment)

are limited in contrast to the opportunities for engaging in non-traditional pathways to success (e.g., criminal enterprise).[30]

Utilized primarily in multilevel research designed within a causal framework, a substantial body of work has used the NIfETy to study the effects of exposure to neighborhood-level constructs such as physical and social disorder, violence, and alcohol, tobacco, and drug activity on the health and well-being of the population in Baltimore City.[33-40] For children and youth specifically, neighborhood-level constructs measured using the NIfETy have been associated with academic achievement,[33] motivation to learn,[34] overweight/obesity,[35] depression and anxiety,[36] risk-taking behavior,[37] substance use,[38, 39] and sexually-transmitted infections.[40] A major strength of the NIfETy is the assessment of variation in the neighborhood context at a micro level with observations conducted on small areas (i.e., block faces). Such variation is likely to be important for research within a causal model, where the measurement of exposure requires greater precision at the individual level. However, aggregating data to a higher level of geography and over time may provide macro-level variables better suited to measuring the neighborhood context and evaluating changes in the environmental conditions.

The push for place-based interventions is currently strong in Baltimore City, presenting a significant opportunity for collaboration across health, social services, and education to promote optimal health among disadvantaged populations. Examples of current place-based strategies to promote the health and well-being of children, youth, and families in Baltimore City include home visiting for parents of young children, community health worker programs, violence prevention interventions, and efforts to amend zoning laws to promote healthy communities.[41-44]

Despite the momentum, evidence designed to inform the formulation, targeting, and evaluation of place-based interventions is limited. Measurement of specific constructs is of particular importance as it becomes part of the formula for identifying interventions responsive to the unique needs of individual communities. The current study aims to extend the application of NIfETy data to larger geographic areas more akin to the concept of neighborhoods than block-level or census tract level areas used in previous research.[35, 39] Applying the concept of risk regulators, we develop indicators at the neighborhood level with the goal of identifying stable, multi-year summary variables that accurately identify specific constructs within the concept of neighborhood processes. Through the current study, evidence is generated to inform and evaluate place-based interventions.

Methods

Study population

Of the more than 130,000 children and youth under age 18 in Baltimore City, 73% are Black non-Hispanic, 17% are White non-Hispanic, and 6% are Hispanic.[45] One in three children in the city is living below the federal poverty line, 58% live in female-headed households, and 20% of adults do not have high school diplomas.[46] Over the last two decades, Baltimore City saw a decline in violent crime; however, a long history of violence, drug trafficking, and substance abuse has resulted in considerable social and health needs amongst the city's most vulnerable populations.[47] Since the death of Freddy Gray, an unarmed young Black male, at the hands of the police force in April 2015, violent crime has risen again in the city.[48]

Though Baltimore City as a whole has significant health challenges, there is substantial intra-urban variation in child well-being. A wide array of area-level indicators describing the health and well-being of children and youth across Baltimore's 55 Community Statistical Areas (CSAs) is well documented due to the concerted efforts of the data owners (e.g., state and local government entities) and the Baltimore Neighborhood Indicators Alliance.[46] The Baltimore Neighborhood Indicators Alliances is part of the National Neighborhood Indicators Partnership, a network of organizations that collect, organize, and use longitudinal neighborhood data to help local communities develop data-driven responses to the health needs of their residents.[49] The CSAs are aggregates of socio-demographically similar and adjacent census tracts that are respectful of (but not identical to) residents' conceptions of their own neighborhoods.[50] On average, census tracts have a population of around 4,000, while the average population for CSAs is closer to 20,000.[50] As a way of defining "neighborhoods" in Baltimore City, CSAs are primarily used by researchers in public health, urban planning, and human services.

Neighborhood Inventory of Environmental Typology

The NIfETy covers seven domains: physical layout, types of dwellings, adult activity, youth activity, physical order/disorder, social order/disorder, and violence, alcohol, tobacco, and other drug indicators.[25] Previous research supports the interrater reliability, test-retest reliability, and validity of the NIfETy tool for measuring neighborhood constructs at the block level.[25] Using the 172-item instrument, trained data collectors evaluated the environment for a random sample of block faces stratified by census block groups. For the current study, we used three waves of NIfETy data – 2010, 2011, and 2012 – to derive three-year summary measures. Limiting to locations with data for all

three years, we used 793 of daytime block-face locations surveyed, constituting 99% of all locations surveyed during the observation period. All analyses were conducted using StataIC® version 12.

Development of risk regulator indices

Consistent with previous researchers,[33, 35-38, 51, 52] we excluded items from the first two domains, the physical layout of the block and types of structures present, as this evidence is descriptive but generally uninformative for the study of risk regulators. Also, while some items were collected with additional specificity (e.g., a count of adults present), all items were analyzed in binary form (e.g., adults present: yes/no). Following a review of NIfETy indices used in the research literature, we selected two indices developed by Milam and colleagues for assessment in the current study: the drug and alcohol index and the violence index. In contrast to other measures used these indices provided evidence on two specific constructs under the umbrella of characteristics underlying neighborhood disorder.[36, 52] The drug and alcohol index includes 12 items and the violence index includes 7 items. Items for both indices are drawn from multiple NIfETy domains.

Remaining NIfETy items from the adult activity, youth activity, physical order/disorder, and social order/disorder domains were assessed in respect to inherently positive, negative, or neutral interpretations. Items with neutral interpretations (e.g., fire escape present, live animals present, signs with neutral messages) were removed from the item bank.

Next, items with extremely limited variation, defined as items observed in either very few (< 5%) or too many (> 95%) assessments in at least two annual observations, were reviewed. Several low-frequency (i.e., < 5%) items were collapsed based on similarities between items. Three indicators for observed trash (in street, in alley, or in other open spaces) were collapsed into a single item. Graffiti and other evidence of vandalism were collapsed into a single item. As an indicator of police surveillance, we collapsed evidence of surveillance cameras (e.g., blue lights) and police presence at the time of observation (e.g., parked cars, uniformed officers). Indicators for homeless individuals and people loitering were collapsed based on their similarity in presentation and likely correlation in context. Two indicators of adult and youth activity were created from multiple items. The first collapsed adults making repairs and adults doing yard work into a single indicator. The second activity indicator was created by combining three youth activity indicators: youth riding bicycle, youth playing, and youth congregating in groups. Remaining items with frequencies above 95% or below 5% for at least two of the three years observation were excluded from further analysis based on lack of variance (e.g., >95%: speed bumps, <5% dead animals, prostitution, eviction notices).

Assessment of temporal consistency at the item level

We used the KR-20, a version of Cronbach's alpha for dichotomous indicators, to assess the temporal consistency of the items, though substantial item-level variation was anticipated. Items documenting the built environment (e.g., bus stops, vacant lots, abandoned buildings) are more stable by nature, while items documenting human activity (e.g., youth playing, intoxicated people, evidence of prostitution) would be expected to have less consistency across years and exhibit more variation as function of time of day,

day of week, and time of year. DeVellis provides guidance for interpretation of alpha as follows: α <0.60 unacceptable; 0.60-0.65 undesirable; 0.65-0.70 minimally acceptable; 0.70-0.80 "respectable"; 0.80-0.90 "very good."[53] While these benchmarks are appropriate for evaluating survey constructs that are expected to be stable, application in this context would be overly restrictive; as such, we provide this as a metric of temporal consistency, but not as a criterion for item inclusion.

Extraction of latent constructs

Consistent with the goal of extracting stable constructs, items were averaged across the three-year observation period prior to collective assessment using principal components and factor analysis. Principal components analysis with a polychoric correlation matrix guided the selection of the number of factors. Parallel analysis was used to confirm the number of latent variables to extract. The factor analysis was also conducted using a polychoric correlation matrix and the iterative principal factor method of estimation. Factor loadings and item uniqueness were then examined through factor analysis (promax rotation). Items with a low factor loading (defined as < 0.40) and high uniqueness (defined as 0.60 or higher) were removed. The principal components analysis was then repeated to assess the number of latent variables with the reduced set of items. If the analysis revealed additional items with low loadings and high uniqueness at this stage, the items were removed and the analysis was repeated until no items with both qualities remained.

Evaluation of risk regulator indices

Internal and temporal consistency

Internal consistency for each index was assessed annually and for the three-year summary indicator. Temporal consistency was assessed across the annual scores. Both internal and temporal consistency were measured using Cronbach's alpha and evaluated using the guidance provided by Devellis ($\alpha < 0.60$ unacceptable; 0.60-0.65 undesirable; 0.65-0.70 minimally acceptable; 0.70-0.80 "respectable"; 0.80-0.90 "very good.").[53]

Consistency of indices by level of geographic aggregation

Three-year summary items for each of the constructs identified were summed to create measures at the level at which the data were collected (i.e., block face). Next, the measures were averaged across two other levels of aggregation: census tracts (n = 198) and Community Statistical Areas (CSAs) (n = 55). Statistics describing the frequency and distribution of measures at each level of aggregation are provided, including the mean, standard deviation, median, and interquartile range. To quantify variance within census tracts and CSAs, we used a one- way ANOVA to estimate intraclass correlation of scores. Spatial variance was examined with maps summarizing data at the level of observation (point pattern map), census tract (choropleth map), and CSA (choropleth map). Area-level measures were assessed for spatial dependence using Moran's I, a measure of the similarity of adjacent areas with an interpretation similar to Pearson's correlation coefficient. Moran's I ranges from 0 (no spatial dependence) to 1 (total spatial dependence), with higher values indicative of clustering.[54]

Criterion Validity

To assess the sensitivity and specificity of various points of dichotomization of the risk regulator indices, we compared Baltimore City to other geographic areas in the state. We selected two primarily urban jurisdictions in Maryland based on premature mortality, a comprehensive indicator of population health strongly influenced by youth and young adult mortality. According to *County Health Rankings* using data for 2010-12, Baltimore City has the highest rate of premature mortality in the state, ranking 24th of 24 jurisdictions in the years of potential life lost per 100,000 in the population. For comparison, we selected the adjacent area, Baltimore County (ranked 14th), and the area with the lowest rate of premature mortality, Montgomery County. Jurisdiction-wide statistics were then drawn for each construct identified. Using a simple threshold of above the citywide average, we identified neighborhoods with rates of risk higher than average as "disease" positive.

For the CSA-level analysis, we used data from the Baltimore Neighborhood Indicators Alliance, the American Community Survey, and the Baltimore City Police Department. For the drug and alcohol index, the violence index, and the hub index, we used 2010-2012 crime and arrest data from the Baltimore City Police Department for comparisons (drug arrest rate, violent crime rate, and the total arrest rate, respectively). For comparison to the physical disorder index, we used data from the American Community Survey on the percentage of homes that were vacant. Each variable used to assess validity of the risk regulators is summarized in **Table 1**.

Construct Validity

For the assessment of construct validity, three broad groups of indicators are included in our framework: neighborhood structure/composition (i.e., the social determinants), neighborhood processes (i.e., risk regulators), and population health. Variables from the Baltimore Neighborhood Indicators Alliance and the American Community Survey (five-year small-area estimates, 2008-2012) were considered as potential indicators for the assessment of construct validity.

Neighborhood structure/composition variables were as follows: % poverty, % Black or African-American, % female-headed households with children, % adults with less than a high school diploma or GED, % unemployed, and % adults not in the labor force. The population health outcomes selected incorporate a comprehensive perspective of health that includes academic outcomes and cover the key life-course stages of development: % children born with low birthweight, % 3rd graders scoring advanced or proficient on a standardized reading assessment, rate of chronic absenteeism in middle school (grades 6-8), annual high school (grades 9-12) dropout rate, teen pregnancy rate (females ages 15-19), and youth (ages 16-24mortality rate. We present results in a correlation (Spearman's rank correlation) matrix to illustrate the observed relationship between neighborhood structure/composition, neighborhood processes, and population health variables. Correlation between indicators was evaluated according to Cohen's conventions (small $\geq$ 0.1, moderate $\geq$ 0.3, and large $\geq$ 0.5).

Table 1. Variables for assessment of criterion and construct validity

Variable	Description
Indicators used to assess criterion validity	
Violent crime rate	The rate of victimization via violent crimes (i.e., homicide, aggravated assault, robberies) per 100,000 *people* in the population. City-level data from the RWJF via FBI UCR ; Baltimore City Police Department summarized at CSA-level by BNIA
Drug arrest rate	The rate of drug related arrests (i.e. possession or distribution) per 1,000 *adults*. City-level data from the RWJF via FBI UCR ; Baltimore City Police Department summarized at CSA-level by BNIA
% homes vacant	The percentage of *households* vacant or abandoned. ACS (2008-2012) summarized at CSA-level by BNIA
Arrest rate	The rate of arrests per 1,000 *adults*. City-level data from the RWJF via FBI UCR ; Baltimore City Police Department summarized at CSA-level by BNIA
Neighborhood structure (social determinants)	
% poverty	The percentage of *households* whose income fell below the poverty threshold. ACS (2008-2012) summarized at CSA-level by BNIA
% black or African American	The percentage of *persons* that identify themselves as Black or African American and ethnically non-Hispanic. ACS (2008-2012)
% households, female head	The percentage of all *households* that are headed by a female with children under 18. ACS (2008-2012)
% adults <high diploma	The percentage of *adults age 25 and older* who do not have a high school diploma or equivalent. ACS (2008-2012) summarized at CSA-level by BNIA
% unemployed	The percentage of *adults ages 16-64* who are in the labor force, looking for work, but not currently working. ACS (2008-2012), summarized at CSA-level by BNIA
% adults not in labor force	The percentage of *adults ages 16-64* who are NOT in the labor force. Reasons include: home-based caretaker, in school or job training, disability, or haven given up on finding employment for any reason. ACS (2008-2012), summarized at CSA-level by BNIA
Youth population health	
% born adequate birthweight	The percentage of *babies born* weighing at least 5.5 pounds. Maryland Department of Vital Statistics (2012), US Census (2010), summarized at CSA-level by BNIA
% on-time 3rd grade reading	The percentage of *3rd grade students* who score "advanced" or "proficient" on the Maryland School Assessment for reading. Baltimore City Schools (2011-2012) summarized at CSA-level by BNIA
% chronically absent (middle school)	The percentage of *students in middle school* (grades 6-8) who were absent for 20 days or more during in the school year. Baltimore City Schools (2011-2012) summarized at CSA-level by BNIA
Drop-out rate	The percentage of *students in grades 9-12* who withdraw from public schools without enrolling in another program during the current school year. Baltimore City Schools (2011-2012) summarized at CSA-level by BNIA
Teen birth rate	The rate of births for *females ages 15-19* per 1,000. Maryland Department of Vital Statistics (2012), US Census (2010), summarized at CSA-level by BNIA
Youth mortality rate (per 10,000)	The number of deaths among *persons ages 15-24* per 10,000. Baltimore City Health Department (2008-2012), summarized at CSA-level by BNIA

ACS American Community Survey, BNIA Baltimore Neighborhood Indicators Alliance, CSA Community Statistical Area, FBI UCR Federal Bureau of Investigation Uniform Crime Reporting, RWJF Robert Wood Johnson Foundation

Results

Data Reduction

Item Frequency and Temporal Consistency

In **Table 2**, we present the annual item frequency, a summary measure of the cumulative item frequency (i.e., % never reported), and temporal consistency for the dichotomous items. Frequency of the items on the drug and alcohol index ranged substantially within years. Eight of the twelve items were observed less than five percent for all three years of observation: intoxicated people, people consuming alcohol, people using drugs, signs of drug selling, syringes, marijuana roaches, crack pipes, and "other" drug paraphernalia. For each of these items, less than 10% of block faces were ever observed over the three-year period, and temporal consistency was poor (KR-20 < 0.2). There was greater variation in frequency between years for the remaining four items: baggies (25.2%-48.4%), vials (7.3%-26.1%), blunt guts/wrappers (39.7%-63.8%), and alcohol bottles (34.6%-72.4%). Temporal consistency for these items was higher, with two items with KR-20 equal to 0.5.

Four items on the violence index were not observed at the block-face sample during annual assessments: people fighting, blood in the street/sidewalk, shell casings in the street, and police tape/outlines in the street. Only one item, people yelling, was observed for at least 10% of the sample each year (2010: 17.3%; 2011: 10.2%; and 2012: 15.3%); this item showed little consistency between years (KR-20 = 0.4). People swearing was the next most common item observed from the index (frequency = 6.7%-10.0%),

followed by memorials (frequency = 0.8%-1.5%). Across years, the mean score on the violence index was less than 0.5 and there was limited consistency across years ($\alpha = 0.4$).

After removal of the two indices, twenty items remained from the physical and social disorder domains. Several items were persistently observed at a low frequency (<20%) all three years of observation: vacant lots, new construction or renovations, inoperable vehicles, used condoms, police presence or surveillance, outdoor recreation outlets, and loitering or homeless people. In contrast, three items were observed at a high frequency for all years of observation: evidence of landscaping, damaged sidewalks, and noise. Elements of the built environment had the greatest temporal consistency (KR-20 ≥ 0.6): broken windows, abandoned buildings, vacant lots, evidence of landscaping, unmaintained property, trash, broken bottles, vandalism, vacant commercial buildings, public transportation, and outdoor recreation outlets. For the collapsed physical and social disorder domains, the cumulative mean score for observed block faces was 4.2 and the temporal consistency of score was very good ($\alpha = 0.85$).

Items from the adult (items 1-3) and youth (items 4-6) activity domains were collapsed into a single category for human activity during this step of the analysis. The most commonly observed item from this list was adults sitting on the steps (frequency = 33.8-38.2%); the least commonly observed item was adults making repairs or doing yardwork. The cumulative mean score of activity items for observed block faces was 1.2 and the temporal consistency across years was limited ($\alpha = 0.5$).

Table 2. Frequency and temporal consistency of items at the block-face level

Items	Annual Frequency (% observations with item)			Cumulative (% never)	Temporal Consistency
	2010	2011	2012		KR-20
Drug/Alcohol Index					
1. Intoxicated people	2.5	1.1	2.5	94.2	0.12
2. People consuming alcohol	4.2	0.9	2.6	92.9	0.17
3. People using drugs	0.6	0.4	0.5	98.6	0.21
4. Signs of drug selling	0.5	0.7	0.9	98.0	0.01
5. Syringes	3.7	1.8	2.1	92.7	0.03
6. Baggies	48.4	25.2	27.4	36.6	0.41
7. Vials	26.1	7.3	11.0	64.6	0.26
8. Blunt guts/wrappers	63.8	41.9	39.7	23.5	0.48
9. Marijuana roaches	0.4	2.0	0.5	97.1	-0.02
10. Crack pipes	1.3	0.0	0.4	98.4	-0.01
11. Other drug paraphernalia	0.8	1.4	1.3	96.6	-0.03
12. Alcohol bottles	72.4	34.6	51.5	18.8	0.53
Violence Index					
1. People fighting	0.0	0.4	0.4	99.2	0.0
2. People yelling	17.3	10.2	15.3	67.7	0.36
3. People swearing	10.0	6.7	9.2	79.1	0.34
4. Blood in street or sidewalks	0.1	0	0	99.9	--
5. Shell casings in street	0.1	0	0	99.9	--
6. Police tape/outlines in street	0.5	0	0.4	99.1	-0.01
7. Memorials	1.5	0.8	1.1	96.8	0.17
ITEM BANK					
Physical and social disorder domains					
1. Broken windows	22.3	11.7	24.2	63.9	0.63
2. Abandoned buildings	29.0	28.8	29.6	60.8	0.87
3. Vacant houses	41.9	18.3	27.1	43.9	0.49
4. Vacant lots	15.0	7.2	15.4	78.1	0.70
5. New construction or renovations [a]	19.0	9.6	9.7	67.5	0.15
6. Evidence of landscaping [a]	87.9	93.4	91.3	1.9	0.63
7. Unmaintained property	57.6	40.0	54.7	24.0	0.62
8. Inoperable vehicles	5.8	3.5	5.2	87.6	0.28
9. Trash in street, alley, open spaces	76.3	81.8	66.1	8.9	0.67
10. Broken bottles	55.4	27.0	37.5	33.7	0.58
11. Used condoms	12.5	2.3	5.3	81.9	0.16
12. Vandalism	80.7	70.5	78.3	6.8	0.55
13. Potholes	15.6	38.1	21.3	43.1	0.13
14. Damaged sidewalks	89.4	83.3	93.0	1.5	0.46
15. Vacant commercial buildings	13.7	9.1	13.1	78.3	0.70
16. Surveillance or police present	9.2	6.4	9.6	79.2	0.28
17. Public transportation [a]	48.5	40.2	40.1	38.7	0.75
18. Outdoor recreation outlets [a]	9.0	3.0	6.2	88.5	0.70
19. Homeless/people loitering	13.6	5.3	7.1	78.1	0.21
20. Noisy	89.5	87.5	89.8	0.6	0.36
Adult and youth activity domains					
1. Adults making repairs/yardwork	12.5	9.2	10.6	71.5	0.05
2. Adults watching youth	20.9	11.1	14.1	64.1	0.28
3. Adults sitting on steps	38.2	35.4	33.8	36.8	0.49
4. Unsupervised youth	25.6	13.4	18.0	56.4	0.25
5. Youth in transit	27.5	17.2	15.8	52.6	0.14
6. Youth playing/congregating	19.7	20.4	15.1	68.0	0.35

Extraction of latent variables

Three-year averages for all items from the disorder and activity domains (n = 26) were included in the principal components analysis. Five factors were initially selected for extraction. In **Table 3**, factor loadings and item uniqueness are presented for all items included at this stage. Five of the variables had a loading of less than or equal to 0.4 and a uniqueness greater than or equal to 0.6 and were thus eliminated from further consideration. The principal components analysis and factor analysis was repeated until there were no items remaining that met these criteria, resulting in the exclusion of seven items in total.

After two iterations, four factors were identified. In **Table 3**, the indicators are sorted according to the factors with which they had the greatest loading, with one exception. Evidence of landscaping was most strongly associated with the first factor but also had a low, yet acceptable, loading on the fourth factor. We opted to include this item on the fourth factor because the item, at face value, appeared to be more theoretically linked with the other items loading on this factor, which were all positive indicators of community improvement. The inclusion of the landscaping item with the fourth factor also allowed a more meaningful indicator to be generated with three, rather than only two, items.

The four factors were each hypothesized to represent unique constructs of the neighborhood environment. The first factor was comprised of eight indicators of "physical disorder": abandoned buildings, broken windows, unmaintained property,

Table 3. Rotated factor loadings and item uniqueness

	Initial						Final				
	F1	F2	F3	F4	F5	Uniqueness	F1	F2	F3	F4	Uniqueness
Abandoned buildings	**0.86**	0.01	-0.01	-0.02	0.12	0.22	**0.96**	-0.09	0.03	0.01	0.15
Broken windows	**0.83**	-0.04	-0.01	0.02	0.06	0.33	**0.85**	-0.06	0.03	0.06	0.31
Unmaintained property	**0.82**	-0.05	-0.01	0.06	0.10	0.35	**0.82**	-0.06	0.04	0.08	0.34
Vacant lots	**0.79**	-0.07	-0.11	-0.04	-0.21	0.46	**0.75**	-0.06	-0.11	-0.06	0.53
Broken bottles	**0.69**	0.13	0.10	-0.08	-0.18	0.34	**0.60**	0.17	0.09	-0.11	0.42
Trash street, alley, other open spaces	**0.64**	0.32	0.08	0.04	0.02	0.23	**0.57**	0.34	0.10	0.04	0.25
Vacant houses	**0.54**	0.01	-0.01	0.23	0.20	0.57	**0.47**	0.09	0.03	0.31	0.60
Vandalism	**0.44**	0.30	0.08	0.07	-0.02	0.55	**0.35**	0.33	0.09	0.05	0.58
Noisy	0.11	**0.71**	0.12	0.06	0.09	0.33	-0.01	**0.78**	0.13	0.11	0.35
Public transportation	0.02	**0.68**	-0.05	0.04	-0.21	0.54	-0.14	**0.77**	-0.08	0.01	0.54
Vacant commercial buildings	0.31	**0.56**	-0.17	-0.11	0.08	0.42	0.21	**0.62**	-0.15	-0.11	0.44
Surveillance or police present	0.30	**0.40**	0.12	-0.12	0.05	0.54	0.24	**0.42**	0.12	0.01	0.56
Unsupervised youth	0.04	-0.00	**0.86**	-0.04	-0.04	0.24	0.04	0.02	**0.85**	-0.10	0.27
Youth playing/congregating	0.03	-0.15	**0.81**	-0.04	0.34	0.27	0.13	-0.18	**0.82**	-0.03	0.32
Youth in transit	-0.09	0.21	**0.80**	0.01	-0.04	0.31	-0.08	0.20	**0.79**	-0.05	0.32
Adults watching youth	0.02	-0.02	**0.58**	0.03	0.37	0.50	0.07	0.00	**0.59**	0.10	0.59
New construction or renovations	0.26	0.05	-0.17	**0.65**	-0.03	0.54	0.19	0.12	-0.18	**0.73**	0.47
Adults making repairs/yardwork	-0.12	-0.01	0.03	**0.71**	0.01	0.48	-0.08	-0.06	0.02	**0.66**	0.53
Evidence of landscaping[1]	**-0.43**	-0.19	0.18	**0.40**	-0.05	0.56	**-0.47**	-0.13	0.14	0.37	0.56
Adults sitting on steps	0.27	0.06	0.30	-0.02	**0.51**	0.45	-	-	-	-	-
Potholes	0.20	**0.01**	0.12	0.04	-0.20	0.89	-	-	-	-	-
Damaged sidewalks	**0.44**	0.15	0.00	0.16	0.05	0.69	-	-	-	-	-
Inoperable vehicles	0.37	-0.39	0.13	-0.10	-0.05	0.81	-	-	-	-	-
Used condoms	**0.37**	-0.18	0.10	0.03	-0.19	0.83	-	-	-	-	-
Outdoor recreation outlets	-0.05	0.05	0.29	0.03	-0.26	0.85	-	-	-	-	-
Homeless/people loitering	0.32	0.30	0.15	-0.05	0.09	0.62	-	-	-	-	-

Highest factor loading is in bold, items sorted within construct by highest loading

1. Landscaping was grouped with factor 4 based on the direction of effect, acceptable loading, and construct deemed best fit

Excluded items with uniqueness ≥0.6 <u>and</u> loading <0.4

vacant lots, broken bottles, trash, vacant houses, and vandalism (internal consistency α = 0.85). The second factor consisted of four items: noisy, public transportation, vacant commercial buildings, and police presence or surveillance (internal consistency α = 0.55). In an urban context, these four items combined are indicative of highly active hubs of mobility characterized by commercial disinvestment and criminal activity. The third factor was comprised of four indicators of "youth activity": unsupervised youth, youth playing/congregating, youth in transit, and adults watching youth (internal consistency α = 0.78). Three remaining items comprised the fourth factor: new construction or renovations, adults making home repair or doing yardwork, and evidence of landscaping youth (internal consistency α = 0.38). Items in the fourth factor are evidence of community improvements or efforts toward beautification.

Evaluation of risk regulator indices

Internal and temporal consistency

For internal consistency, three indices were consistently in the acceptable range (α ≥0.6) across all three years: drug and alcohol activity, physical disorder, and youth activity **(Table 3)**; the internal consistency for each of these three-year summary items was at least 0.7. For the hub index, alpha was ≤ 0.4 annually while the three-year summary items were borderline acceptable (α = 0.55). Temporal consistency was in the acceptable range for only two indices: physical disorder and mobility hub.

Table 4. Internal and temporal consistency of indices

| | Internal Consistency | | Temporal Consistency |
| | Annual 2010, 2011, 2012 | 3-year item average | Annual scores |
Index (n items)			
Drug and alcohol index (12)	0.57, 0.57, **0.65**	**0.68**	0.54
Violence index (7)	0.43, 0.50, 0.48	0.48	0.39
Physical disorder index (8)	**0.77, 0.69, 0.79**	**0.85**	**0.86**
Hub index (4)	0.40, 0.34, 0.43	0.55	**0.78**
Youth activity index (4)	**0.78, 0.66, 0.76**	**0.78**	0.37
Improvements/beautification index (3)	0.30, 0.29, 0.34	0.38	0.39

Cronbach's $\alpha \geq 0.60$ in bold

Variation in observed measures according to level of aggregation

When the observed point data (n = 793) were aggregated to the census tract level, the number of observations ranged from 0 to 14; four census tracts had zero observations, while 85% of census tracts had two or more observations. Census tracts with zero observations contained approximately one percent of the total population of the city. At the CSA level, the number of observations ranged from 4 to 32; more than 75% of CSAs had at least 10 observations.

Mean scores for each of the variables were similar across areas of aggregation, though the variance, or the standard deviation and the observed range of scores, decreased as the area sizes increased from points to census tracts to CSAs **(Table 5)**. Within census tracts and CSAs, observations were significantly correlated. The intraclass correlation was stronger for census tracts than CSAs for all measures, though the relationship was statistically significant at both levels of aggregations for all measures (p < 0.01).

In contrast, differences in spatial dependence between census tracts and CSAs differed across measures. For the drug and alcohol index, the violence index, and the youth index, spatial dependence was stronger at the census tract level. The largest

Table 5. Variation in index scores at the level of block face, census tract, and Community Statistical Area

		Mean (sd)	Observed Range	ICC (95%CI)	Moran's I
Drug and alcohol possible range (0-12)	Observed	1.61 (1.06)	0-4.67	--	--
	CT	1.67 (0.44)	0-3.67	0.46 (0.38-0.53)	0.40 (p<0.001)
	CSA	1.56 (0.71)	0.14-2.79	0.39 (0.28-0.49)	0.24 (p<0.001)
Violence possible range (0-7)	Observation	0.24 (0.39)	0-2.33	--	--
	CT	0.26 (0.33)	0-2.17	0.37 (0.29-0.45)	0.27 (p<0.001)
	CSA	0.24 (0.24)	0-1.17	0.26 (0.17-0.36)	0.25 (p<0.001)
Physical disorder possible range (0-8)	Observation	3.32 (1.87)	0-7.67	--	--
	CT	3.46 (1.61)	0.44-7	0.59 (0.52-0.66)	0.25 (p<0.001)
	CSA	3.30 (1.35)	0.67-5.88	0.50 (0.39-0.61)	0.38 (p<0.001)
Epicenter possible range (0-4)	Observation	1.52 (0.72)	0-4	--	--
	CT	1.56 (0.52)	0.33-3	0.25 (0.17-0.33)	0.26 (p<0.001)
	CSA	1.50 (0.39)	0.67-2.27	0.21 (0.13-0.30)	0.40 (p<0.001)
Youth activity possible range (0-4)	Observation	0.68 (0.73)	0-3.33	--	--
	CT	0.74 (0.56)	0-3.33	0.19 (0.11-0.26)	0.19 (p<0.001)
	CSA	0.69 (0.36)	0.08-2.08	0.15 (0.08-0.23)	0.16 (p=0.02)
Improvements possible range (0-3)	Observation	1.14 (0.40)	0-2.67	--	--
	CT	1.13 (0.28)	0.33-2.67	0.13 (0.06-0.20)	0.08 (p=0.04)
	CSA	1.14 (0.14)	0.75-1.48	0.04 (0.00-0.08)	0.23 (p=0.001)

Observed block faces n= 793; Census Tracts n= 194; Community Statistical Areas n=55

difference was for the drug and alcohol index (Moran's I: census tracts = 0.40; CSAs = 0.24), while the differences on the other two indices were minimal. For the three remaining measures (physical disorder, hub index, and improvements/beautification) spatial dependence was substantially stronger at the CSA level compared to census tract level. We provide three choropleth maps to illustrate the spatial variation and data aggregation for the physical disorder index. Across all three maps, clustering of high scores on the physical disorder index is visible in western and eastern portions of the inner city, while low scores are clustered in northern and western areas around the edge of the city.

Figure 2. Spatial variation in physical disorder
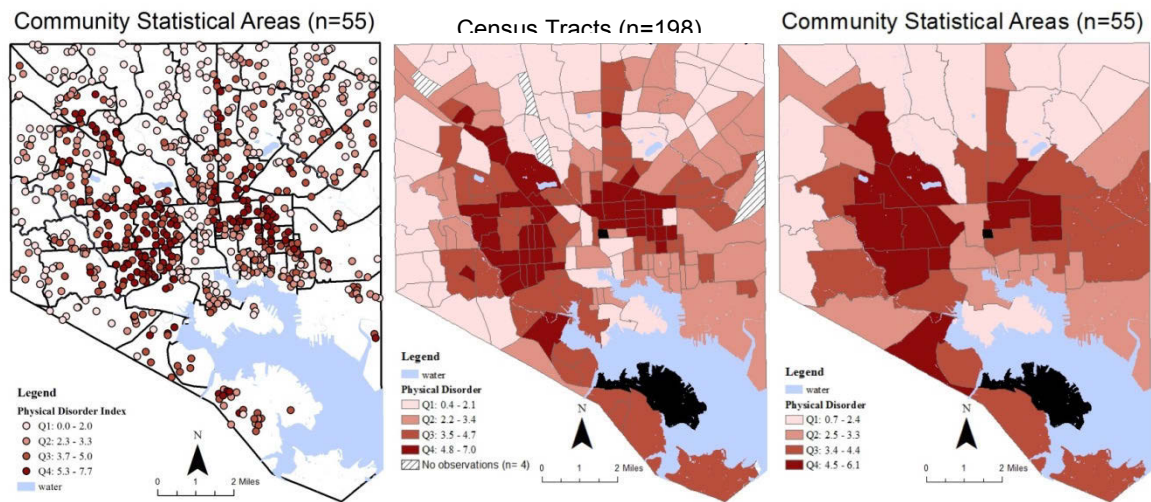
Criterion validity

Indicator performance against the four jurisdiction standards is presented in **Table 6**. We identified 20 CSAs with a drug arrest rate higher than the mean for Baltimore City (i.e., 65 drug arrests/1,000 adults). CSAs with high drug arrest rates were identified with high sensitivity by both the moderate and high designations of the drug and alcohol index (100% and 70%, respectively); meanwhile, specificity was much worse for the moderate, in comparison to the high, designation of the drug and alcohol index (31% and 86%, respectively). In comparison to the Baltimore County and Montgomery County jurisdiction standards, 80% and 87% of Baltimore City CSAs, respectively, had higher drug and alcohol arrest rates; sensitivity and specificity were higher when using the moderate, rather than high, cut point.

We identified 29 CSAs with a violent crime rate higher than the mean for Baltimore City (i.e., 1,449 victims/100,000 people). CSAs with high rates of violent

Table 6. Indicator performance against jurisdiction standards

Index	Baltimore City Standard	Baltimore County Standard	Montgomery County Standard
Drug/alcohol	>65 drug arrest /1,000; n=20	>11 drug arrest /1,000; n=44	>6 drug arrest /1,000; n=48
Observed score	Sens/Spec	Sens/Spec	Sens/Spec
≥1.0 (n=44)	100%/31%	91%/64%	85%/57%
≥2.0 (n=19)	70%/86%	41%/91%	38%/86%
Violence	>1,449 violent crime /100,000; n=29	>526 violent crime /100,000; n=50	>182 violent crime /100,000; n=54
Observed score	Sens/Spec	Sens/Spec	Sens/Spec
≥0.00 (n=52)	100%/12%	100%/60%	94%/ 0%
≥0.25 (n=21)	69%/96%	42%/100%	39%/100%
Physical disorder	>19% homes, vacant;	>7% homes, vacant;	>5% homes, vacant;
Observed score	n=27	n=52	n=54
≥2.0 (n=47)	Sens/Spec	Sens/Spec	Sens/Spec
≥4.0 (n=18)	100%/29%	88%/67%	87%/100%
	63%/96%	34%/100%	33%/100%
Hub	>194 arrests/1,000 adults; n=12	>81 arrests/1,000 adults; n=25	>38 arrests/1,000 adults; n=37
Observed score	Sens/Spec	Sens/Spec	Sens/Spec
≥1.0 (n=50)	100%/12%	100%/17%	97%/6%
≥2.0 (n=6)	42%/98%	20%/97%	16%/100%

Cut points generated by rounding observed scores at 25% and 75% of distribution. The range for the violence score was smaller than other indicators, and required a more precise cut point (0.25) to differentiate areas.

crime were identified with perfect sensitivity by the moderate and acceptable sensitivity by the high designations of the violence index (100% and 69%, respectively). Meanwhile, specificity was very poor for the moderate but very good for the high designation of the violence index (12% and 96%, respectively). In comparison to the Baltimore County and Montgomery County jurisdiction standards, 91% and 98% of Baltimore City CSAs, respectively, had higher rates of violent crime. For both standards, the low violence areas were identified with 100% specificity with the high designation, while the sensitivity was compromised significantly (Baltimore County standard: 42%, Montgomery County standard: 39%).

We identified 27 CSAs with a vacant house rate higher than the mean for Baltimore City (i.e., 19% homes vacant). CSAs with high vacancy rates were identified with acceptable sensitivity by both the moderate and high designations of the physical disorder index (100% and 63%, respectively); meanwhile, specificity was much worse for the moderate, in comparison to the high, designation of the physical disorder index (29% and 96%, respectively). In comparison to the Baltimore County and Montgomery County jurisdiction standards, 95% and 98% of Baltimore City CSAs, respectively, had higher drug and alcohol arrest rates. Unlike the Baltimore City standard, sensitivity and specificity were maximized using the moderate, rather than high, cut point.

We identified 12 CSAs with an arrest rate higher than the mean for Baltimore City (i.e., 194 arrests/1,000 adults). CSAs with high arrest rates were identified with high sensitivity by the moderate, but not high, designations of the mobility hub index (100% and 42%, respectively). Meanwhile, specificity was much worse for the moderate, in comparison to the high, designation of the physical disorder index (12% and 98%, respectively). In comparison to the Baltimore County and Montgomery County jurisdiction standards, 45% and 67% of Baltimore City CSAs, respectively, had higher arrest rates. As with the Baltimore City standard, the moderate designation identified mobility hubs with high sensitivity but low specificity, while the high designation had low sensitivity but high specificity.

Content validity

To assess content validity, we examined how well the indicators performed in the framework (modeled after the social determinants of health framework). The Spearman

rank correlation matrix for the six social determinants, six risk regulators, and six youth

population health outcomes are presented in **Table 7**. The first three risk regulators –

drug and alcohol, violence, and physical disorder – performed well in the assessment of

content validity, with strong correlations in the expected direction for all social

determinants (rho $\geq$ 0.57, large effect) and health measures (rho $\geq$ 0.46, moderate to large

effect). The hub index was significantly associated with three of the social determinants

(positive association with % poverty, % adults with less than a high school diploma, and

% adults not in the labor force) and two youth health outcomes (positive association with

% chronically absent in middle school; negative association with % reading on-time in 3rd

grade), all with moderate to large effects (rho $\geq$ 0.44). The youth activity index was

positively associated with all social determinants and five out of six youth health

outcomes (excluding high school dropout rate) with moderate to large associations

identified (rho $\geq$ 0.47). The improvements and beautification index was not associated

with any of the social determinants or health outcomes.

Discussion

In this study, we identified six variables describing the environmental context at

the neighborhood level. Each of the measures has strengths and limitations concerning

psychometric properties. Despite limitations, several of the measures are well suited for

research on neighborhood-level social processes that influence the rate of disease and

well-being of the population. Of the six variables assessed, two were indices previously

Table 7. External construct validity of risk regulators, spearman correlation matrix

	Social Determinants						Risk Regulators						Youth Population Health				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Social Determinants																	
1. % poverty																	
2. % black or African American	.61***																
3. % households, female head	.74***	.71***															
4. % adults <high diploma/GED	.80***	.44*	.65***														
5. % unemployed	.69***	.81***	.73***	.68***													
6. % adults not in labor force	.72***	.59***	.51**	.58***	.54**												
Risk regulators																	
7. Drug and alcohol index	.72***	.77***	.67***	.62***	.76***	.65***											
8. Violence index	.75***	.60***	.59***	.67***	.64***	.70***	.81***										
9. Physical disorder index	.78***	.57***	.59***	.77***	.68***	.62***	.88***	.85***									
10. Hub index	.60***	.31	.29	.44*	.40	.65***	.59***	.60***	.70***								
11. Youth activity index	.66***	.61***	.66***	.54***	.66***	.49**	-.09	.72***	.67***	.29							
12. Improvements index	-.43	-.30	-.21	-.38	-.43	-.43	-.41	-.40	-.41	-61***	-.09						
Youth health																	
13. % born adequate birthweight	-.55***	-.70***	-.55***	-.36	-.55***	-.50**	-.61***	-.46*	-.47**	-.34	-.47*	.19					
14. % on-time 3rd grade reading	-.82***	-.62***	-.76***	-.81***	-.78***	-.54***	-.70***	-.66***	-.76***	-.45*	-.65***	.34	.47**				
15. % chronically absent	.56***	.26	.34	.60***	.47*	.33	.49**	.62***	.66***	.52**	.48**	-.40	-.23	-.57***			
16. Drop-out rate	.59***	.22	.36	.72***	.37	.40	.46*	.56***	.68***	.41	.38	-.39	-.15	-.57***	.56***		
17. Teen birth rate	.63***	.45*	.52**	.65***	.60***	.32	.59***	.62***	.68***	.42	.53**	-.43	-.29	-.65***	.63***	.70***	
18. Youth mortality rate	.59***	.55***	.69***	.59***	.66***	.37	.68***	.59***	.64***	.31	.57***	-.31	.64**	-.64***	.52***	.40	.68***

Each indicator uses at least 3 years of data to derive stable estimates

Spearman's rho, Bonferroni adjusted p value: * $p \leq .05$, ** $p < .01$, *** $p < .001$

defined by Milam and colleagues – violence and drug and alcohol activity.[36] The frequency for many of the observed items was very low; in turn, the mean scores for both indices were also low (violence = 0.24; drug and alcohol = 1.61). Temporal consistency was limited for these indices across three years (violence α = 0.39; drug and alcohol α = 0.54). Once summarized across years at the area level, spatial correlation was strongest at the census tract level for both measures, suggesting the clustering of these phenomena is more notable below the CSA level. Dichotomous CSA-level indicators derived from the violence index and drug and alcohol index performed well when compared with data from the Baltimore City Police Department on arrests and crimes reported during the observation period. For both indices, indicators for moderate levels identified 100% of the areas that were above the citywide average; however, the level of specificity was limited (violence = 12%, drug and alcohol = 31%); in contrast, use of the high designation cut point resulted in substantially better specificity, while sensitivity also remained relatively high. Both CSA-level indices also performed as expected within the social determinants of health framework, with strong correlations with each of the social determinants (rho $\geq$ 0.6) and youth population health outcomes (rho $\geq$ 0.5).

Remaining items from the NIfETy were summarized across years and analyzed to extract four latent constructs – physical disorder, youth activity, mobility hub, and improvements/beautification. In contrast to the violence and drug and alcohol activity indices, spatial dependence was higher at the CSA level (vs. census tracts) for the physical disorder index, the hub index, and the improvements/beautification index, suggesting large-scale processes are driving the dependence. Youth activity clustered strongest at the census tract level, suggesting more small-scale processes are at work. The

physical disorder index and the hub index were compared to the jurisdiction standards for vacant housing and total arrests, respectively. For both indices, indicators for moderate levels identified 100% of the areas that were above the citywide average; however, the level of specificity was limited (physical disorder = 29%, hub = 12%). In contrast, use of the high designation cut point resulted in substantially better specificity, though sensitivity was sacrificed. The physical disorder index performed as expected within the social determinants of health framework, with strong correlations with each of the social determinants and youth population health outcomes. Youth activity was strongly associated with each of the social determinants and five of the six youth population health outcomes. In contrast, the hub index was associated with only three of the six social determinants (% poverty, % adults with less than a high school diploma, and % adults not in the labor force) and two of the six youth population health outcomes (% reading on-time in 3rd grade and rate of chronic absenteeism in middle school).

This study extends previous evidence supporting the reliability and validity of the NIfETy tool by establishing measures and describing psychometric properties at a higher level of aggregation (i.e., Community Statistical Areas) and across a longer period than previously researched by using three years of observation. CSAs are used by many stakeholders in the city to identify variation in sociodemographic characteristics and population health. The substantial population size for CSAs (i.e., ~ 20,000) provides a better option for subgroup analysis but still requires aggregation across multiple years to improve stability of the estimates. We aggregated data over a three-year period for the current study to identify environmental conditions that were relatively stable over time, consistent with the concept of risk regulators described by Glass & McAtee.[20] Several of

the indices had limited temporal consistency (i.e., violence index, drug and alcohol index, youth activity index, and improvements/beautification index), and future small-area ecological studies may find it beneficial to use shorter periods of observation to assess changes over time. However, it is important to note the indices with good temporal consistency where those that were primarily comprised of indicators for the built environment, which are more stable in nature than indicators of human activity. Similar to the larger area of aggregation, a slightly longer observation period will improve the stability of the measurement and potentially improve accuracy of the results. In the measurement of risk regulators, it will be important to balance the benefits of aggregation over time and geography with the need to identify changes in the environment over time with greater sensitivity.

While the current study has several strengths concerning measurement of risk regulators there are limitations to this level of aggregation. The number of CSAs is relatively small and thus has limited power for statistical analysis. While CSA-level summary variables are valid indicators for several constructs measured in this study (i.e., violence, drug and alcohol activity, and physical disorder), greater variation in the indices is likely to emerge with the smaller areas of aggregation. In Baltimore City, there are several additional options for area-level aggregation, including zip codes, census-defined areas (e.g., block groups, census tracts), and neighborhood definitions that align better with residents' perceptions of their neighborhoods. However, the large number of neighborhoods (n ~ 300) leads to similar analytical challenges as census tracts with small population sizes. This is an important consideration, particularly so when looking at subgroups that represent only a small portion of the population. Instability in estimates is

likely to emerge when the population is small and the events are rare. While zip codes present another, larger option for aggregation, the heterogeneity of the population over these larger areas, which are not defined by sociodemographic characteristics, is likely to attenuate variation overall.

Through the current analysis, we identified three area-level risk regulator indicators – physical disorder index, drug and alcohol activity index, and violence index – that were accurate for identifying areas with high levels of "disease" and associated with all other area-level constructs as anticipated with the framework, presenting valid options for measuring these risk regulators in future small-area ecological research. A fourth indicator, the hub index, was strongly associated with total arrests and linked to many social determinants and health outcomes for children, suggesting it will also be useful in research in urban areas similar to Baltimore City. While two other area-level indicators were identified in the current study, each needs additional work before it is incorporated into the field. Additional items may improve the improvements/ beautification index, while research on the validity of the youth activity index is needed to clarify the construct captured.

In line with the current efforts to promote the health of children and youth in the city, evidence from this study and future studies with these variables will prove useful in identifying specific elements of the environment interacting with opportunities for healthy decisions. While many neighborhoods have similar characteristics and problems, use of the measures identified herein provides evidence on the unique social and environmental aspects of the neighborhoods and will be useful for planning and implementing place-based interventions tailored to the needs of each community.

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NEIGHBORHOOD STRUCTURE, PROCESSES, AND SPATIAL VARIATION IN THE RATE OF CHILD WELFARE INVESTIGATION

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This manuscript has been prepared for the peer-reviewed *Journal of Urban Health*. The research herein is presented in an unabridged form for the dissertation chapter.

Abstract

With growing support for place-based interventions to promote health and well-being, evidence from a population-based perspective is needed to inform child maltreatment prevention efforts. The current study extends the application of small-area ecological research methods from spatial epidemiology to study neighborhood context and the rate of child welfare contact. Using Baltimore City child welfare data from 2010-2012, we analyzed global and local spatial variation in the age-adjusted rate of child welfare contact per 1,000 child-years across neighborhoods (i.e., Community Statistical Areas or CSAs). Evidence for neighborhood context was drawn from the American Community Survey and through observational assessments conducted using the Neighborhood Inventory for Environmental Typology. Through bivariate analysis and negative binomial regression, we examined the association between neighborhood structure (i.e., disadvantage), processes (drugs and alcohol, violence), and variation in the rate of child welfare investigation in Baltimore City CSAs during a three-year period of observation. Spatial autocorrelation was significant for the rate of child welfare investigation (Moran's $I = 0.28$), and clusters of CSAs with similar rates were identified. The neighborhood disadvantage index, a single composite indicator, explained spatial autocorrelation in the outcome. Both the drug and alcohol index and the violence index were also strongly correlated with the rate of child welfare investigation (rho = 0.55 and 0.65, respectively). After adjusting for neighborhood disadvantage, a high score on the violence index was associated with a rate 1.71 times higher than the rate of child welfare investigation observed in areas with medium or low scores.

Introduction

Evidence of the extensive effects of child abuse and neglect across the lifespan supports the prevention of maltreatment as a public health priority in the United States.[1] Each year, 4% of children are the subject of a child maltreatment report, though annual rates of child welfare investigation vary substantially across states (<1%-9%).[2] While only a subset of investigations are substantiated (19%),[3] longitudinal research indicates the population of children who come in contact with the child welfare system, regardless of the results of the investigation, has a broad range of social and health needs warranting services to promote optimal child development.[4-6] Compared to the general population, children in contact with the child welfare system are nearly four times as likely to report exposure to four or more adverse childhood experiences ("ACEs"; 13% vs. 51%, respectively).[7]

Childhood maltreatment is a well-documented risk factor for mental and behavioral health problems in adulthood.[8-16] Maltreatment exposure is associated with one quarter of psychiatric disorders and more than one third of the suicide attempts in the United States (population attributable fraction – males: 24%, 27%, respectively; females: 50%, 27%, respectively).[17] Additional research illustrates the enduring impact on health throughout the lifespan with strong associations between child maltreatment and many of the leading causes of death in the United States, including heart disease, cancer, and obesity.[16, 18]

Research on the social determinants of health has drawn attention to the importance of the neighborhoods and social conditions for regulating one's life experiences, risk exposures (including trauma), and health outcomes across the lifespan.[19]

Sometimes termed neighborhood-based initiatives, place-based interventions are delivered at the neighborhood level through community-wide eligibility for services, changes to the built environment, and collaborative efforts tailored to address the unique needs of individual communities.[20] Interventions aimed at neighborhood structure and processes are needed to complement individual-level efforts by promoting an environment that buffers against, rather than fosters, maladaptive responses to adversity experienced by vulnerable families.[21-23] Responding to the need to extend prevention efforts beyond the individual level, federal legislation has shifted resources to support place-based programs to prevent maltreatment among vulnerable families in high-risk communities.[1, 22, 24-26]

Coulton and colleagues propose two key pathways by which neighborhood structure (population composition) and neighborhood processes influence the likelihood of child maltreatment behaviors and contact with child welfare services at the individual level **(Figure 1)**.[27] The residential concentration of disadvantaged populations, most often populations of color, is associated with a number of neighborhood-level processes, including social disorganization and physical disorder. These negative social processes influence the transactional processes between individuals and other members of their communities. The resulting context becomes one that nurtures maladaptive responses to adversity and increases the likelihood of maltreatment behaviors. While an impoverished and disordered neighborhood environment is associated with the likelihood of maltreatment behaviors, evidence suggests the contact rate for child welfare services in such neighborhoods may be more concentrated than warranted.[27, 28] In the only study of its type, variation in self-reported child maltreatment behaviors across urban

neighborhoods was modest in comparison to substantial variation in the rate of child

maltreatment reports.[28, 29]

Figure 1. Alternative pathways of neighborhood influences on child maltreatment and child welfare contact
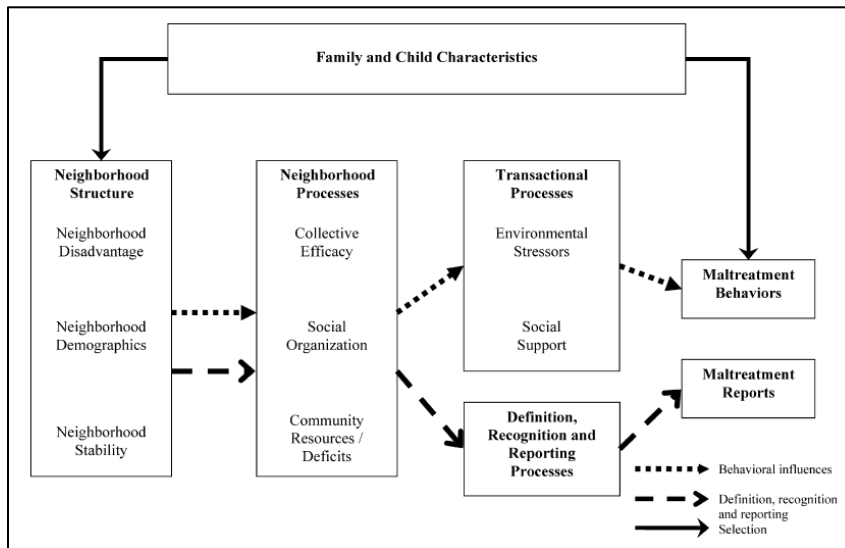
Source: Coulton, C. J., et al. (2007). "How neighborhoods influence child maltreatment: a review of the literature and alternative pathways." *Child Abuse Negl* 31(11-12): 1117-1142.4

Much of the literature on neighborhoods and child maltreatment uses multilevel

modeling techniques to estimate the independent effects of contextual variables while

controlling for characteristics of the child and family.[27, 30, 31] Though this evidence

provides the foundation of our understanding of the causal role of neighborhood context

in an individual's risk for maltreatment, further information is needed to understand how

social processes operating at the population level may increase the rate of child welfare

contact within particular geographic areas.[27, 32] Small-area ecological research, defined as

the study of populations rather than individuals,[33] using geographic areas as the unit of

analysis is necessary for drawing inferences about variation in neighborhood-level

outcomes and processes.[19, 34]

Existing studies using area-level regression methods describe a relationship between the built environment and child maltreatment rates across geospatial populations that remains after accounting for neighborhood structure.[35] Aspects of the built environment associated with maltreatment include alcohol outlets[36, 37] and inadequate health and supportive resources.[38-40] Other studies focus on drug arrests,[41, 42] a measure that provides information about drug markets but must be considered within the current sociopolitical context of disproportionate surveillance and arrests of minority populations.

The use of spatial regression models to analyze child welfare data has just emerged recently within the last decade, along with the emergence of the field of spatial epidemiology.[31, 32, 36-39, 41-43] Many of the existing ecological studies in the child welfare literature have not considered the geospatial configuration of the data, potentially biasing study results.[27, 31, 32] The current body of research contains valuable information about the relationship between neighborhood disadvantage, the neighborhood context, and child maltreatment reports; however, it lacks objective evidence on neighborhood-level processes that may be driving variance.[27, 31] By identifying risk regulators that could be leveraged to facilitate change, social ecological research can inform the next generation of place-based interventions.[19]

Application of public health lens builds to child welfare on the existent individual-level risk factors and strengthens support for maltreatment prevention efforts at the neighborhood level as a priority in child welfare.[1, 22, 23] Momentum for community-based prevention in child welfare is bolstered by health systems reform, which also shifts funding to community-based health promotion and disease prevention efforts.[24, 44, 45]

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Such consistency in programmatic goals opens the doors for collaboration across health and human service agencies to meet the needs of the most vulnerable children, youth, and families.[29] For child welfare services, collaborative, multi-component child maltreatment prevention and health promotion efforts in -historically under-resourced areas may be an effective means to reducing the incidence of child maltreatment and child welfare contact in areas with the greatest need.[1, 21, 46] Evidence on neighborhood processes and variation in the rate of child welfare contact will inform collaboration with other public health and service sectors to meet the needs of vulnerable populations.[27, 31]

Incorporating research methods from spatial epidemiology and concepts from the social determinants of health and health inequities,[21, 47-49] the current study applies a public health framework to ecological research in child welfare.[1] Unlike previous studies, we characterize both small- and large-scale spatial variation in child welfare contact and assess the potential for neighborhood structure to account for spatial autocorrelation in the outcome. This evidence will assist in the assessment of validity for previous studies that did not account for geospatial configuration of the observations in their regression models. Applying spatial regression statistics, we focus on a specific pathway within the Coulton et al. conceptual framework that is particularly suited for small-area ecological research. Using comprehensive observational data on the neighborhood environment, we examine the relationship between neighborhood context (i.e., neighborhood structure and neighborhood processes) and the rate of child welfare contact.[28] Using a modified subset of the Coulton et al framework (See Figure 1, page 109), Figure 2 illustrates the population-level framework applied in the current study.

Figure 2. Neighborhood context and the rate of child welfare contact

Methods

The research protocol described herein was approved by the Maryland Department of Human Resources and the Johns Hopkins Bloomberg School of Public Health Institutional Review Boards.

Study Population

Of the more than 130,000 children and youth under age 18 in Baltimore City, 73% of the population are Black non-Hispanic, 17% are White non-Hispanic, and 6% are Hispanic. One in three children in the city is living below the poverty line, 58% live in female-headed households, and 20% of adults do not have high school diplomas.[50] While Baltimore City has until very recently seen a decline in violent crime over the past twenty years, a long history of violence, drug trafficking, and substance abuse has resulted in considerable social and health needs among the city's most vulnerable populations.[51] While data on maltreatment behaviors are not available, a recent study with a representative sample from Baltimore City can offer insight on other adverse childhood experiences (ACEs), particularly those associated with trauma exposure.[52] Across ACEs assessed in the study, which included divorce/separation and poverty and excluded maltreatment, nearly a third of children and youth in Baltimore City reported at least two ACEs (Maryland overall: 19.4%).[52] National child welfare data suggest children with

child welfare contact have been exposed to substantially more ACEs than the broader population children;[7] these data suggest that victims of child maltreatment in Baltimore City also carry a significantly disproportionate burden of the ACEs described by children and youth in citywide estimates.

Data Sources

Child welfare

The Maryland Department of Human Services provided de-identified data for all children for whom an allegation of maltreatment was investigated by child welfare services in Baltimore City and the case was closed during the three-year observation period (2010-2012). These data provide a unique count of children with child welfare reports during the three-year period. Baltimore City did not use alternative response options during the study period; therefore, the study population comprises all screened in-referrals.

Based on variation in child welfare contact by age group, the study population is limited to children who were ages 0-11 at the time of the referral to child welfare services. Specifically, the rate of child welfare contact is highest at age zero and decreased into adolescence as other social service systems (e.g., juvenile justice, mental health services) become more likely to identify you who have been exposed to maltreatment.[3, 46]

Prior to data de-identification for the current study, each report with an address available was geocoded using the home address of each involved child at the time of the alleged maltreatment by investigators at the University of Maryland. For children subject to multiple investigations during the observation period (10.4%), the home address at the

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time of the first investigation was used. If a child with multiple investigations during the study period was missing the address in the first report, the next available report with an address for that child was used. Following both computer and manual matching efforts, 88% of investigated reports (3,505/3,994) had an address for geocoding and were attributed to a census tract. In turn, 5,731 unique children were subject to an investigated report that had a home address available (82% of children total). Reports without an address were more likely to be unsubstantiated (46.2% vs. 38.5%). No differences in type of maltreatment were found between those with and without an address. Children who did not have an address were more likely to have a single report (96.2% vs. 87.5%) and be older (ages 5-11: 49.2% vs. ages 0-4: 45.1%).

American Community Survey

Small-area population estimates are generated by the United States Census Bureau using data from the American Community Survey (ACS). Annually, more than 2.9 million housing units are sampled from the 3,143 counties and county equivalents in the United States.[53] Stratified random sampling of block groups (i.e., subsets of census tracts), as well as multiphase and multistage strategies of data collection, are used to generate population estimates.[53] Observed data from the population-based sample are then combined with sample weights to generate estimates for the actual population.[53] For small-area estimates, the Census Bureau combines and re-weights data from the preceding five years.[53] In comparison to the decennial census, the Census Bureau reports greater validity and reliability in the ACS five-year estimates.[54, 55] ACS five-year estimates for population size and sociodemographic variables are reported at the census tract level.

Neighborhood Inventory for Environmental Typology

The Neighborhood Inventory for Environmental Typology (NIfETy) is an objective and observational assessment covering seven data domains: physical layout, types of dwellings, adult activity, youth activity, physical order/disorder, social order/disorder, and violence, alcohol, tobacco, and other drug indicators.[56] The current study uses three years of repeated assessments from a stratified, random sample of (1) census block groups and (2) block faces (n = 793) to derive measures of the neighborhood environment. Previous research supports the interrater reliability, test-retest reliability, and internal consistency across domains of the NIfETy tool, with all psychometric properties in the moderate to exemplary range.[56]

Measures

For analysis, all data were aggregated to the level of Community Statistical Areas (CSAs, n = 55). The Baltimore City CSAs are aggregates of socio-demographically similar and adjacent census tracts that are respectful of (but not identical to) residents' conceptions of their own neighborhoods.[57]

Age-adjusted report rate

The unique count of children with maltreatment reports (i.e., screened-in referrals that were investigated by child welfare services) during the observation period were summarized for each CSA. Age standardization was used to adjust for two potential confounders: (1) distribution of child population by age group across Baltimore City CSAs and (2) variation in the rate of child maltreatment and child welfare contact during infancy and early childhood (ages 0-4) compared with school-age children (ages 5-11).

Age-adjusted report rates were derived by calculating the report rate for each age group per 1,000 child-years and averaging rates of child welfare investigation for the two age groups. The *age-adjusted report count* was calculated by multiplying the age-adjusted maltreatment rates (per 1,000) by the number of child-years (0-11) observed and dividing the results by 1,000. Results were rounded to the nearest integer to create a count variable.

Neighborhood disadvantage index

To operationalize the neighborhood structure construct, a composite measure of neighborhood disadvantage that covers four domains of neighborhood structure associated with the rate of child welfare contact was selected.[27, 31] The measure is a composite of four indicators **(Figure 3)**: economic disadvantage (% households living in poverty), wealth/investment in community (% owner-occupied households), social disadvantage (% female-headed households with children under 18), and human capital (% population with at least a bachelor's degree); all data were from the ACS.[55] The neighborhood disadvantage index ranges from -5 and 5, however, scores were centered to generate a possible range 0-10 on the index. To generate a categorical variable, we grouped scores according to low, medium, and high using tertiles of neighborhood disadvantage (low < 4, medium = 4, high > 4).

Figure 3. Neighborhood disadvantage index

Disadvantage

$$\frac{\text{\% HH, poverty}}{10} + \frac{\text{\% HH, female headed with children}}{10}$$

Advantage

$$\frac{\text{\% adults,} \geq \text{bachelor's degree}}{10} + \frac{\text{\% housing units, owner-occupied}}{10}$$

$$\frac{\text{Disadvantage} - \text{Advantage}}{4} = \textbf{Neighborhood Disadvantage}$$

Neighborhood processes: drug and alcohol index and violence index

We used two indices created by Milam and colleagues to measure neighborhood processes: substance use (drug and alcohol) activity and violence.[58, 59] Twelve dichotomous items are included in the substance use activity index: intoxicated people, people consuming alcohol, people using drugs, signs of drug selling, syringes, baggies, vials, blunt guts/wrappers, marijuana roaches, crack pipes, alcohol bottles, and "other" drug paraphernalia.[59] Seven dichotomous items comprise the violence index: people yelling, people swearing, people fighting, blood in the street, shell casings, police tape, and memorials. Items were summed at the observation level and averaged across the three years; mean scores for each observation were then derived at the neighborhood (CSA) level. Each CSA had more than 20 NIfETy observations dispersed throughout the area (range = 4-32). With regard to psychometric properties of the two indices when transformed into small-area ecological variables, both indices exhibited criterion and construct validity within the context of the social determinants framework.[60] Consistent with the previous CSA-level research, each index was transformed into a categorical variable to maximize sensitivity and specificity for identifying high-risk neighborhoods:

the drug and alcohol index was transformed so that low < 1.0; medium = 1.0-2.0; and high > 2.0; the violence index was transformed so that low = 0; medium = 0.01-0.25; and high > 0.25. Only three CSAs had low violence index scores; as such, we collapsed low and medium categories for comparison with the high violence category in the regression models.

Analytic Strategy

To provide evidence for age adjustment, variation in rates of child maltreatment by age groups are first described with investigation rate ratios to compare the rates of child maltreatment by age group (0-4 vs. 5-11).

Descriptive statistics and global spatial autocorrelation

Neighborhood variation in sociodemographic characteristics are described using the indicators comprising the neighborhood disadvantage indicator (% households living in poverty; % owner-occupied households; % female-headed households with children under 18; % population with at least a bachelor's degree) along with the % population that is African-American, the neighborhood disadvantage index score, the drug and alcohol index score, and the violence index score.[55] Global spatial variation was calculated using Moran's I, with neighbors defined as CSAs that share a boundary.[34] Monte Carlo simulation methods were used to test the null hypothesis that there is no association between neighboring values across the city (i.e., no spatial dependence, Moran's I ≈ 0).[34]

A multistep analysis of spatial variation was used to assess patterns in the distribution of the rate of child welfare investigation across CSAs. To visualize large-scale spatial variation in age-adjusted investigation rates, choropleth maps were created

in ArcGIS® 10.2.2. Small-scale variation, specifically clustering of high or low maltreatment rates within sub-regions of the city, was assessed using Local Indicators of Spatial Association (LISA) and is also presented in map form.[34]

To examine the bivariate relationships between the rate of child welfare investigation and each of the key study variables, we used Spearman's rank correlation to account for the non-normal distribution. To visualize large-scale spatial variation and correlation between key study measures, we present choropleth maps for racial composition, neighborhood disadvantage, drug and alcohol index, and violence index.

Neighborhood disadvantage and the rate of child welfare investigation

The spatial Poisson regression model uses the age-adjusted maltreatment report count and the number of child-years observed to account for the distribution of the outcome variable across CSAs.[34] In the case of overdispersion, a negative binomial model was used to allow for variation in the outcome that extends beyond the assumptions of the Poisson distribution, which requires the variance to be equal to the mean.[34] The first independent variable, neighborhood disadvantage, is a continuous measure (range = 0-10) that was selected with the hypothesis that it may account for the spatial variation in the outcome of interest. To assess residual spatial autocorrelation after accounting for neighborhood disadvantage, the difference between the observed count and expected count will be divided by the number of child-years observed to derive the residual child welfare rate, a measure of variation not explained by the model.

Spatial autocorrelation of the residuals (assessed via Moran's I and Monte Carlo simulation methods to test for significance) indicates the model does NOT explain all spatial variation in the child maltreatment rate.[34] If spatial autocorrelation remains, the

Poisson model would then need to be extended to account for residual spatial autocorrelation, to meet the assumptions of independent observations required, and to obtain valid estimates of the relationship between disadvantage and the rate of maltreatment.[34] Use of a random effects parameter with a predefined distribution is a commonly used method to adjust for residual spatial autocorrelation in the analysis of morbidity and mortality rates across populations and an appropriate method for the current study.[34]

Neighborhood disadvantage, neighborhood processes, and the child welfare investigation rate

Using the model determined appropriate in the previous step, the neighborhood process variables were added to the model in a stepwise fashion, starting with the process variable with the highest correlation with the report rate. The final model included all variables that significantly contributed to the distribution of the maltreatment report rate across Baltimore City neighborhoods. After adjusting for variation in neighborhood disadvantage, we expected both neighborhood process variables (drug and alcohol index and violence index) to be independently associated with rates of child maltreatment. Neighborhood processes were expected to explain most of the variation captured by the neighborhood disadvantage variable; however, we expected disadvantage to continue to be significantly associated with the rate of child maltreatment in the final model, due to variance not captured in the study measures.

Results

Descriptive statistics and global spatial autocorrelation

Variation in the distribution of children by age group was evident with a ratio of

children ages 0-4 to children ages 5-11 ranging from 0.51 to 1.68, respectively; the

investigation rate for children ages 0-4 was higher than the rate for children ages 5-11

(incidence rate ratio: 1.44; 95%CI = 1.36-1.53; data not shown).

In **Table 1**, we present descriptive statistics for the 55 CSAs alongside the

analysis of global spatial autocorrelation for key measures. Population size varied

substantially across CSAs, with a range of 340 in Downton/Seton Hall to 3,862 in

Cedonia.

Table 1. Descriptive statistics and global spatial autocorrelation

Community Statistical Areas (n = 55)	Mean (sd)	Range	Moran's I
Children ages 0-11	1647 (775)	340-3862	--
ages 0-4	754 (356)	213-1602	--
ages 5-11	893 (448)	127-2260	--
Investigations ages 0-11	86 (70)	4-334	--
ages 0-4	47 (39)	1-192	--
ages 5-11	39 (32)	1-142	--
Age-adjusted investigation rate per 1,000 child years	18.3 (13.2)	1.7-77.5	.28***
Percent of population, African American	63.6 (33.2)	2.7-99.1	.46***
Percent of households, living in poverty	19.6 (11.8)	1.0-49.5	.24***
Percent of households, female headed with children	12.9 (7.8)	1.6-35.3	.10
Percent of households, owner-occupied	48.0 (17.5)	6.2-82.3	.38***
Percent of adult population, ≥ bachelor's degree	26.1 (20.8)	3.8-75.4	.38***
Neighborhood disadvantage	4.0 (1.1)	1.4-6.3	.26***
Drug and alcohol index	1.59 (0.70)	0.14-2.79	.24***
Violence index	0.25 (0.24)	0-1.17	.25***

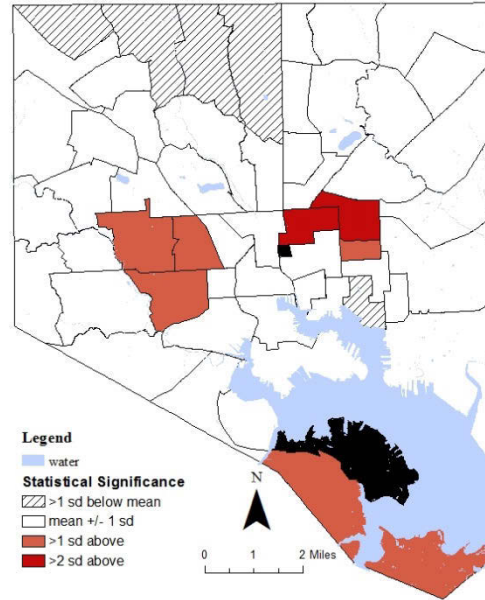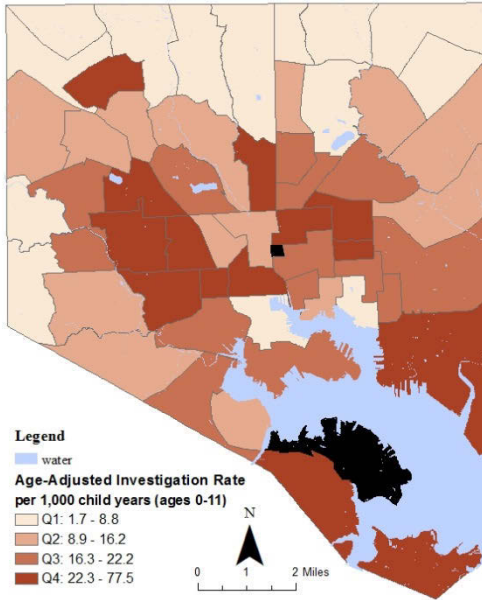$*P \leq .05, **P \leq .01, ***P \leq .001$

The mean age-adjusted report rate was 18.3 per 1,000 child-years and ranged

from 1.7 to 77.5 per 1,000 child-years; the rate also exhibited significant spatial

autocorrelation (Moran's I = 0.28, p < 0.001). On average, across CSAs, 63.6% of the

population was Black or African-American, 19.6% had income below the federal poverty
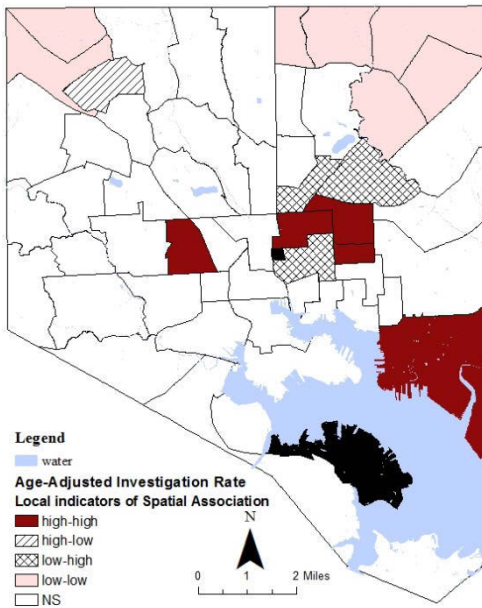
level, 12.9% of households were headed by a single female with children, 48.0% of the homes were occupied by the owners, and 26.1% of adults had earned at least a bachelor's degree.

The largest range among the CSA-level sociodemographic statistics was in the percent of the population that was Black or African-American, which ranged from 2.7% to 99.1% and exhibited the strongest spatial autocorrelation (Moran's $I = 0.46$, $p <$ 0.001). The mean score on the neighborhood disadvantage index was 4.0, with scores ranging from 1.4 to 6.3. Both process indices had a more limited range of scores and are presented with more precision: drug and alcohol index ranged from 0.14 to 2.79 (mean = 1.59) and the violence index ranged from 0 to 1.17 (mean = 0.25). For each of the key indices in the analysis, spatial correlation was evident (Moran's $I = 0.24$-0.26, $p \leq 0.001$). The mean report rate was 18.3 per 1,000 child-years, and only two CSAs were more than two standard deviations away from the mean **(Figure 4)**. Greenmount East and Clifton-Berea both had significantly higher rates of child welfare investigation than the average in the city. Using local indicators of spatial autocorrelation (LISA), we identified areas where the clustering of similar report rates was statistically significant. Areas with high rates of child welfare investigation were clustered in east Baltimore City alongside Greenmount East (54.1 per 1,000 child-years), Clifton-Berea (77.5 per 1,000 child-years), Madison/East End (36.1 per 1,000 child-years), and Orangeville/East Highlandtown (20.4 per 1,000 child-years). CSAs with high rates of child welfare investigation were also clustered around Sandtown-Winchester/Harlem Park (20.4 per 1,000 child-years) in west Baltimore City. CSAs with low rates of child welfare investigation were clustered near the county line in northeast Baltimore City around Glen-Fallstaff and Cross-

Figure 4. Spatial variation in age-adjusted child welfare investigation rate

Community Statistical Areas (n=55)

Legend
water

Age-Adjusted Investigation Rate
per 1,000 child years (ages 0-11)
Q1: 1.7 - 8.8
Q2: 8.9 - 16.2
Q3: 16.3 - 22.2
Q4: 22.3 - 77.5

Community Statistical Areas (n=55)

Legend
water

Statistical Significance
>1 sd below mean
mean +/- 1 sd
>1 sd above
>2 sd above

Community Statistical Areas (n=55)

Legend
water

Age-Adjusted Investigation Rate
Local indicators of Spatial Association
high-high
high-low
low-high
low-low
NS

Community Statistical Areas (n=55)

Legend
water

Local Indicators of Spatial Association
Statistical Significance
p = 0.01
p = 0.05
NS

126
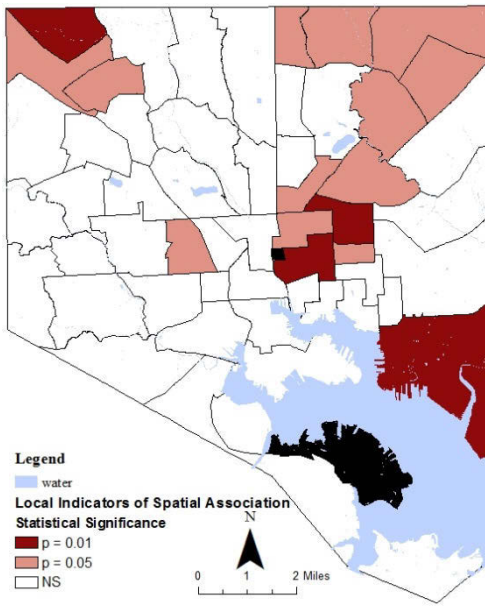
Country/Cheswolde (7.4 and 2.2 per 1,000 child-years, respectively) and in northwest

Baltimore City around Chinquapin Park/Belvedere (8.7 per 1,000 child-years), Loch

Raven (8.0 per 1,000 child-years), Harford/Echodale (6.3 per 1,000 child-years),

Hamilton (8.6 per 1,000 child-years), and Lauraville (10.5 per 1,000 child-years). LISA

also identified four CSAs that had rates of child welfare investigation that were

significantly different from nearby CSAs. Three CSAs had rates of child welfare

investigation that were significantly lower than the CSAs around them:

Midway/Coldstream (17.0 per 1,000 child-years), Belair-Edison (18.1 per 1,000 child-

years), and Oldtown/Middle East (16.6 per 1,000 child-years). One CSA,

Pimlico/Arlington/Hilltop (23.1 per 1,000 child-years), had a report rate that was

significantly higher than nearby CSAs.

Spearman's rank correlation was used to assess the strength of association

between variables considered for the analysis, all of which were statistically significant

(Table 2) with a single exception – the correlation between racial composition of the

population and the rate of child welfare investigation was not statistically significant. The

strongest correlation between measures was found for the drug and alcohol score with the

violence score (rho = 0.81, p < 0.001).

Table 2. Correlation between key variables

		1	2	3	4
1.	Age-adjusted investigation rate				
2.	% Black/African-American	0.33			
3.	Neighborhood disadvantage	0.55***	0.67***		
4.	Drug and alcohol score	0.55***	0.77***	0.72***	
5.	Violence score	0.65***	0.60***	0.73***	0.81***

Spearman's rho, Bonferroni adjusted *p* value: * $p \leq .05$, ** $p < .01$, *** $p < .001$
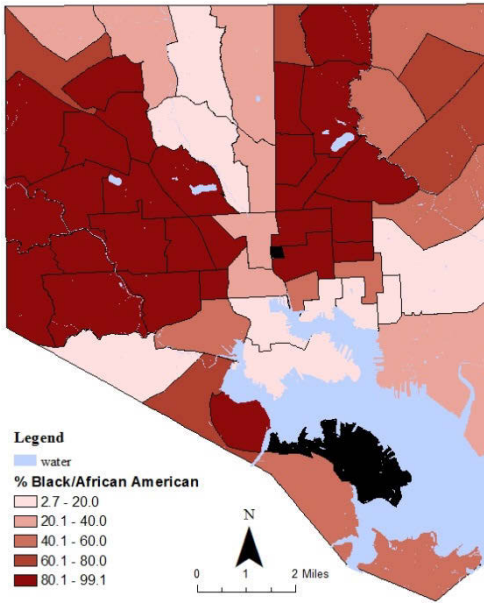
In **Figure 5**, we present maps illustrating the spatial distribution of the neighborhood structure and process measures considered for the regression analysis: % Black or African-American, neighborhood disadvantage index, drug and index, and violence score index.

Neighborhood disadvantage and the rate of child welfare investigation

The null model, including only the age-adjusted count of child welfare investigations offset by the log of the number child-years observed, indicated statistically significant overdispersion ($\alpha = 0.44$, $p < 0.001$), suggesting negative binomial regression models were most appropriate for the analysis. For each unit increase in the disadvantage score, there was a 50% increase in the investigation rate (IRR = 1.49; 95% CI = 1.29-1.74). In the first regression model with categorical variables, the medium and high neighborhood disadvantage groups had investigation rates that were more than two and three times (respectively) the rate of the CSAs in the low disadvantage group (**Table 3**). Residuals of regression models using only the neighborhood disadvantage variables exhibited no spatial autocorrelation (continuous measure Moran's I= -0.02, $p = 0.97$; categorical measure Moran's I = 0.04, $p = 0.39$); thus, no adjustment for spatial autocorrelation was necessary for the remaining models in the current study.

Figure 5. Thematic mapping of neighborhood structure and process indicators

Community Statistical Areas (n=55)

Legend
water
% Black/African American
2.7 - 20.0
20.1 - 40.0
40.1 - 60.0
60.1 - 80.0
80.1 - 99.1

N
0   1   2 Miles

Community Statistical Areas (n=55)

Legend
water
Neighborhood Disadvantage
Low <4 (16)
Medium 4 (22)
High >4 (17)

N
0   1   2 Miles

Community Statistical Areas (n=55)

Legend
water
Drugs and Alcohol
low <1 (11)
medium >1 and <2 (25)
high >2 (19)

N
0   1   2 Miles

Community Statistical Areas (n=55)

Legend
water
Violence
low 0 (3)
medium 0.01-0.25 (32)
high >0.25 (20)

N
0   1   2 Miles
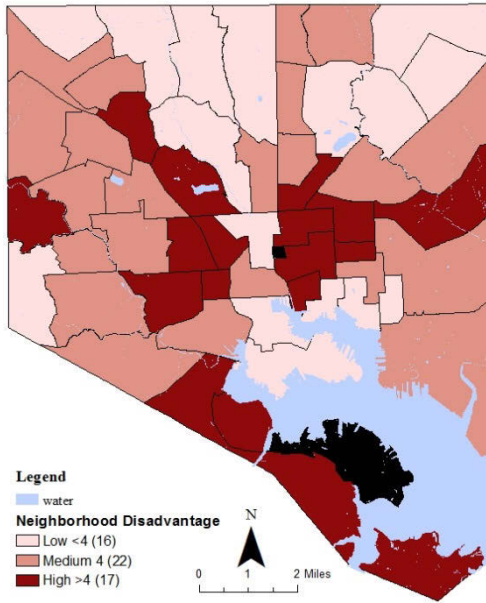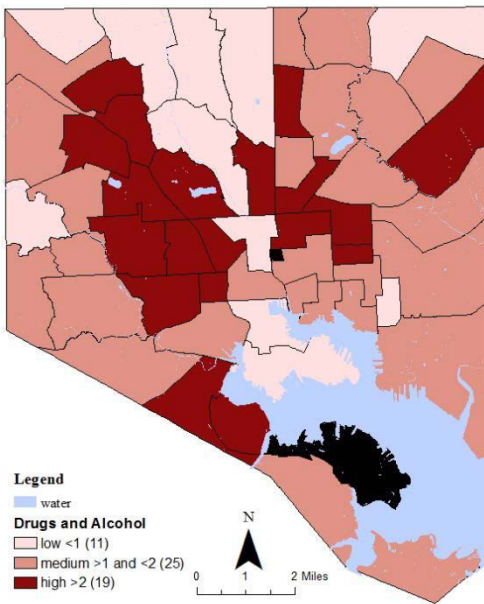
Table 3. Neighborhood structure, processes, and the rate of child welfare investigation

	Model 1 IRR (95% CI)	Model 2 IRR (95% CI)	Model 3 IRR (95% CI)
Neighborhood Structure			
Neighborhood disadvantage			
Moderate	**2.08 (1.46-2.97)**	**1.65 (1.03-2.65)**	**1.72 (1.21-2.44)**
High	**3.02 (2.07-4.40)**	**1.84 (1.07-3.15)**	**1.93 (1.23-3.05)**
Neighborhood Processes			
Violence index			
High	--	**1.55 (1.00-2.41)**	**1.71 (1.19-2.45)**
Drug and alcohol index			
Medium	--	1.03 (0.63-1.69)	--
High		1.20 (0.63-2.27)	

IRR Incidence Rate Ratio, CI Confidence Interval

Bold $P \leq .05$

Neighborhood disadvantage, neighborhood processes, and the rate of child welfare investigation

In the next step of the analysis **(Model 2, Table 3)**, we added both categorical neighborhood process variables (drug and alcohol index: low/medium, high; violence index: low/medium, high)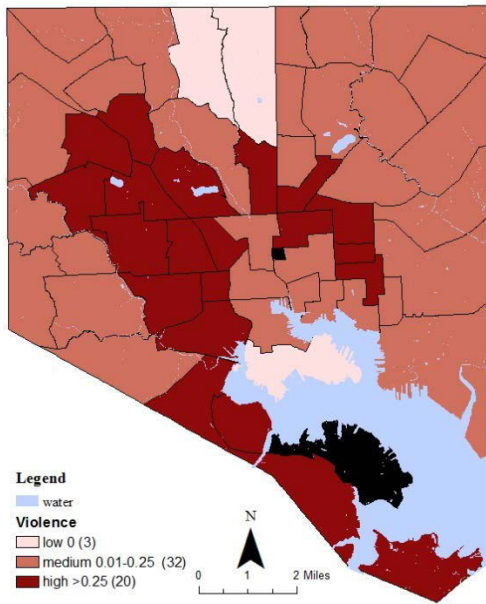 to the negative binomial model with the categorical variable for neighborhood disadvantage (low-medium-high). The drug and alcohol indicator was not statistically significant and thus removed from the final model. In the final analysis (Model 3), medium and high disadvantage were associated with a 72% and 93% higher report rate, respectively, than CSAs with low disadvantage, and high violence was associated with 71% increase in the investigation rate (IRR = 1.71; 95% CI = 1.19-2.45) in comparison to areas with low-medium violence.

Discussion

Consistent with previous research, spatial autocorrelation in the child welfare report rate was statistically significant in the current study. Two adjacent areas in east Baltimore City had child welfare rates of child welfare investigation significantly higher than the mean and were clustered with other neighborhoods with high rates of child

welfare investigation. While previous studies describe spatial autocorrelation at the global scale, the current study extends the literature by assessing spatial variation at the local level and through the assessment of a single, composite, neighborhood structure indicator (neighborhood disadvantage index) to explain spatial autocorrelation in the rate of child welfare investigation. Combining indicators often used in previous child welfare studies, the current study illustrated how a composite variable for the neighborhood structure (social and economic disadvantage, home ownership, and education) is not only very strongly associated with the report rate but also explains the spatial variation in the outcome. Evidence from the current analysis provides support for the validity of previous studies of neighborhood variation in the rate of child welfare contact that did not evaluate spatial autocorrelation but did include adequate measures of neighborhood structure in their regression models.

In bivariate analyses, the rate of child welfare contact was strongly associated with the neighborhood disadvantage, violence, and drug and alcohol indices, but not the racial composition of the neighborhood. Historical patterns of redlining and racial discrimination have resulted in extreme patterns of residential segregation in Baltimore City, influencing the strong association between racial composition and neighborhood disadvantage. In contrast to previous small-area ecological studies in child welfare, we chose not to include racial composition in the final model. Instead, we included a single composite measure of neighborhood disadvantage, which was selected based on a more precise alignment with a social determinants of health framework.

Several studies have assessed the relationship between neighborhood processes and variation in child welfare contact. The majority of these studies focused on aspects of

the built environment, which were found to be either detrimental (e.g., alcohol outlets)[36-38, 40] or beneficial (e.g., access to early childhood care and preschool, substance abuse treatment)[40, 61] to the rate of child welfare contact in the neighborhood. While the built environment is an indicator of access to potentially positive and negative places, it tells us little about the social environment of the neighborhood. The current study fills a previous gap in the literature on neighborhood social processes with compelling evidence of a strong association between neighborhood violence and the rate child welfare contact.[27, 31]

Similar to previous studies that examined drug arrests, when drug and alcohol activity was measured objectively in the current study via observations of human activity and behavior, it was associated with the rate of child welfare contact.[41, 42] While strongly associated with the rate of child welfare contact, the categorical measure derived from the drug and alcohol index was not independently associated with the outcome in the current study. The correlation between the violence index and the drug and alcohol index was the highest among study variables, making it difficult to tease apart these two constructs in the regression models, considering the small sample size for the study. The strong correlation between these two social process indicators and the rate of child welfare contact is sufficient evidence to illustrate the co-morbidity of multiple forms of social disorder requiring public services.

In neighborhoods with heavy concentration of violence, drug, and alcohol activity, surveillance of residents and visitors alike is generally more intensive as public service agencies like child protective services, police departments, and health departments monitor the area in hopes of improving the well-being of the population.

However, collaboration between public service agencies can be limited. The work of different human service departments often takes place without agencies communicating about the individuals being served. With expanded funding for community-focused interventions with a place-based framework for service provision, opportunity for collaboration between public service agencies is at an all-time high. Partnerships between agencies on a coherent, cross-disciplinary, and comprehensive plan to improve population health at the local level is in line with the World Health Organization's recommendations for addressing social and health inequalities.[49]

The application of public health methods brought several strengths to the current research, most notably in improvements of measurement. For the outcome, we selected the person-centered indicator "children subject to investigation" over "child welfare reports" to shift the focus to child welfare exposure for unique children rather than concentration of reports. Incorporating person-years and use of multiple years of observation improves the validity and stability of the measurement from an epidemiologic perspective.[34] Further, in the current study, the evaluation of the geographic distribution of the population by age strongly supports the consideration of age-adjusted measures of exposure and using geographic areas larger than census tracts for small-area ecological research. This confounder may be of particular importance in urban areas like Baltimore City, where the spatial distribution of children by age group is strongly associated with race and poverty status. Other strengths in measurement include the analysis and presentation of spatial variation and the use of observational indicators for neighborhood social processes, both addressing previous gaps in the research literature.[27, 31, 35]

Cross-sectional studies are limited within the context of traditional etiological research because inferences of causality cannot be drawn without assessments over time. However, the research in this study is a population-level assessment of health determinants which are already evident in individual-based research literature and is therefore not intended to be etiologic in nature. The current research is not able to disentangle actual maltreatment risk (i.e., parental behavior) from child welfare contact risk, but future research is needed to understand how the neighborhood context may be differentially associated with the risk of maltreatment and child welfare contact. It is plausible that while violence is associated with maltreatment, areas with heavy concentrations of police surveillance may have a rate of child welfare contact disproportionate with actual maltreatment behaviors. To study how the rate of maltreatment behaviors and child welfare contact vary, an assessment of parental behaviors summarized at the neighborhood level is needed for comparison.

Another notable limitations in the study is the small number of CSAs which limited the power for statistical analysis. By using composite variables for each construct studied, we aimed for a parsimonious regression model. Inclusion of additional constructs (e.g physical disorder, social cohesion) may provide evidence for relationships not captured in the current study.

When interpreting the results, it is important to consider how local practices in child welfare may affect the external validity of study results. In Baltimore City, at the time of this study, there was no alternative response program in practice. Generalizability of the results to areas that do use alternative response may be limited due to the large number of children and families who are identified as lower risk and deferred from

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further investigation in lieu of parent training and treatment for behavioral health issues. Relationships identified in the current study might be stronger in areas with alternative response, as the population in contact with child welfare would be identified as higher risk.

Conclusion

In Baltimore City, child welfare services may benefit from further coordinating their prevention efforts with other public sectors serving child populations that are at risk of maltreatment. Place-based strategies have considerable momentum in the city and provide an opportunity for collaboration to improve population health.[49] Examples of current place-based strategies that are consistent with needs identified in the current study include violence prevention interventions, home visiting for parents of young children, community health worker programs, and efforts to amend zoning laws associated with alcohol outlets.[62-65] Co-location or collaborative provision of public services and preventive efforts targeting similar population health problems may be a means for increasing the effectiveness of place-based intervention efforts and improving efficiency in resource allocation within local child welfare service agencies in Baltimore City.

Supplemental Table 1. Child welfare terms and definitions from the Administration of Children and Families, United States Department of Health and Human Services

Term	Definition
Maltreatment	Any recent act or failure to act on the part of a parent or care-taker which results in death, serious physical or emotional harm, sexual abuse or exploitation; or an act or failure to act, which presents an imminent risk of serious harm
Referral	Notification to child protective services of suspected maltreatment
Report	Screened in referrals that received a response in the form of an investigation response or an alternative response
Unsubstantiated maltreatment	An investigation disposition that concludes there was not sufficient evidence under state law to conclude or suspect that the child was maltreated or at-risk of being maltreated
Indicated maltreatment	An investigation disposition that concludes maltreatment could not be substantiated under state law or policy, but there was a reason to suspect that at least one child may have been maltreated or was at-risk of maltreatment. This is applicable only to states that distinguish between substantiated and indicated dispositions.
Substantiated maltreatment	An investigation disposition that concludes the allegation of maltreatment or risk of maltreatment was supported or founded by state law or policy.
Unique count of children	Counting a child once, regardless of the number of reports concerning that child, who received a CPS response
Duplicate count of children	Counting a child each time he or she was the subject of a report. This count also is called a report-child pair

Terms used to describe the disposition for child welfare investigations (unsubstantiated, indicated, and substantiated maltreatment) are consistent with definitions used by Federal government. Maryland uses these terms differently within the state but reports to the Federal government using the Federal terms. To ease both interpretation and dissemination outside of the state of Maryland, all child welfare terms used in the proposal are used according to the Federal definitions.

Supplemental Table 2. Descriptive statistics – child welfare investigations, 2010-2012

	All	No address	Address	*P* value
	n=3994	n=489	n=3505	
N children (mean, se)	1.84 (0.01)	1.53 (0.04)	1.34 (0.01)	
Maltreatment type	%			
Neglect	66.5	66.5	66.5	.826
Physical abuse	23.8	24.3	23.7	
Sexual abuse	9.7	9.2	9.7	
Outcome				
Indicated	61.5	53.8	61.5	.001
Unsubstantiated	38.5	46.2	38.5	

Supplemental Table 3. Descriptive statistics – unique children identified, 2010-2012

	All	Not Geocoded	Geocoded	*P* value
	n=5731	n=1019	n=4712	
Referrals per child				
Only 1	89.1%	96.2%	87.5%	<.001
Age				
Age 0	23.9%	18.4%	25.1%	<.001
Ages 1-4	30.2%	32.5%	29.8%	
Ages 5-11	45.9%	49.2%	45.1%	
Sex				
Female	48.8%	48.8%	49.0%	
Male	51.0%	51.0%	50.9%	
Race				
Black	76.5%	80.9%	77.1%	.373
White	16.0%	14.2%	15.6%	
Ethnicity				
Hispanic	2.8%	1.1%	3.2%	.003

<1% sex unknown

Supplemental Figure 1. Baltimore City, Community Statistical Areas

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DISCUSSION OF RESULTS AND POLICY IMPLICATIONS

Summary of key findings

Through a systematic review of small-area ecological research on neighborhood effects (Aim 1), we reframed the literature on neighborhood characteristics that regulate the risk for child welfare contract. Using existing observational data, we developed area-level indicators for multiple, specific constructs within the context of neighborhood processes (Aim 2). Addressing gaps identified in the literature, we assessed the relationship between neighborhood disadvantage, violence, drug and alcohol activity and the rate of child welfare contact (Aim 3). The next section summarizes key findings for each of the three aims, as well as contributions to the research literature on neighborhood structure, neighborhood processes, and the rate of child welfare contact. This chapter concludes with a description of public health and child welfare policy implications and areas for future research.

Aim 1: Systematically review evidence from small-area ecological research on the relationship between the neighborhood context (i.e., structure and processes) and the rate of child welfare contact.

We identified 17 studies (described in 28 articles and/or doctoral theses) on the relationship between neighborhood context and variation in child welfare contact. Only four studies provided evidence of the spatial autocorrelation observed in the child welfare outcome studied. All studies included structural aspects of the neighborhood, most often indicators of socioeconomic disadvantage and residential stability, but few studies included measures of neighborhood processes. For those studies in which neighborhood processes were assessed (n = 8), evidence sufficient to draw a conclusion was limited to

the density of alcohol outlets and drug-based arrests. To reduce the potential for bias, future small-area ecological research on the rate of child welfare contact should incorporate concepts from epidemiology, including person-years of observation and age-adjusted rates of child welfare contact. To inform place-based intervention efforts in child welfare, objective evidence on specific constructs within neighborhood processes, such as physical disorder, violence, and social disorganization, is necessary.

Aim 2: Extend application of the Neighborhood Inventory for Environmental Typology through an assessment of the psychometric properties of area-level measures consistent with the concept of risk regulators.

Using data from 793 block-face observations collected once a year during a 3-year period of observation (2010-2012) in Baltimore City, we generated six area-level indices of neighborhood processes (i.e., risk regulators): (1) drug and alcohol index (2) violence index, (3) physical disorder index, (4) hub index, (5) youth activity index, and (6) improvements/beautification index. Three risk regulator indices (physical disorder, drug and alcohol, and violence) performed well on statistical tests for both criterion and content validity; evidence from this study most strongly supports the utilization of these three measures in small-area ecological research.

Aim 3: Assess neighborhood processes as possible explanatory variables for the cross-sectional association between neighborhood structure and variation in the rate of child welfare contact for children across neighborhoods in Baltimore City.

In order to focus on the population most often in contact with child welfare services, we limited the study population to ages 0-11. To account for variation in the rate of child welfare contact and variation in the distribution of the population by age, we

used an age-adjusted rate of child welfare investigation for the current analysis. Through a detailed analysis of spatial autocorrelation and local indicators of spatial association, the study provides the first comprehensive analysis of geographic variation in child welfare contact. Use of a single measure for neighborhood structure, an index of neighborhood disadvantage, was sufficient to explain spatial autocorrelation of the outcome in the current study. Both indices measuring neighborhood processes (drug and alcohol index and violence index) were strongly associated with the outcome in bivariate analyses. In the final negative binomial regression model, high scores on the violence index were associated with a nearly twofold increase in the rate of child welfare investigation; this relationship did fully not explain the associations between moderate and high disadvantage and the child welfare report rate. With violence co-occurring in areas with high rates of child welfare contact, there is the potential for child welfare services to collaborate with other public service agencies working to reduce violence in high-risk neighborhoods. Place-based efforts to strengthen parenting skills and caregiving assets may be an effective model for targeting child welfare resources for the most vulnerable populations of children in Baltimore City.

Overall Strengths and Limitations

This work is framed by a cross-disciplinary perspective, incorporating concepts and methods from the sciences of child development, social work, sociology, criminology, and social epidemiology. While the concept of health geography is rapidly gaining favor in the behavioral sciences,[1, 2] the research methods have not yet been broadly applied to problems generally addressed by the field of social work, including child abuse and neglect. In their seminal work, Glass and McAtee urged public health

researchers to use small-area ecological research to (1) understand the determinants of disease rates among populations and (2) inform place-based interventions efforts.[1]

The greatest contribution of the work described herein is the application of methods and concepts from epidemiology to improve measurement and interpretation of small-area ecological research on the rate of child welfare contact. Through critical assessment of the existing literature, we identified several areas for improvement, including the use of multiple years of data, person-years of observation, and age-adjusted rates of child welfare contact. We were able to apply these concepts and present a detailed assessment of spatial variation in child welfare contact in an urban area, evidence that can both inform future research efforts as well as aid in the interpretation of previous research findings in this field. In contrast to previous research in the field, we utilized negative binomial regression models to assess the relationship between neighborhood context and the rate of child welfare contact. Replication of the small-area ecological research methods used in this study will improve the validity of neighborhood research in child welfare.

Though this body of work has notable strengths in innovation and methodological rigor, some limitations are notable. Small-area ecological research is particularly useful for understanding how *known* individual-level risk factors may be operating at the population-level; however, it is imperative that conclusions for population-based research remain within the non-causal framework of neighborhood-level risk regulators to avoid an ecological fallacy in the interpretation of the evidence.

Implications for child welfare and public health policy

Focusing child maltreatment prevention interventions in areas with the greatest density of child welfare contact is an avenue by which interventions can reduce both the incidence of child maltreatment and the rate of child welfare involvement. Public health and child welfare experts agree programs targeted at the individual-level alone are inadequate for promoting community health or preventing child maltreatment.[3, 4] Using place-based interventions to target efforts in the most disadvantaged neighborhoods is among the leading approaches described by the World Health Organization for addressing social and health inequities.[5-8]

Greater accountability for community health in the areas surrounding anchor institutions and hospitals has further sparked efforts for coordinating the efforts across service agencies to serve the most vulnerable populations of children and families. With evidence supporting the co-occurrence of violence and areas of high rates of child welfare contact, neighborhood-level child maltreatment prevention efforts may benefit from collaboration with other service agencies (e.g., public health department, police department) focused on addressing similar public health issues, including violence prevention and maternal and child health, using place-based initiatives. Collaborative efforts between hospitals, public service sectors, and community-based resources to address the needs in the most disadvantaged and social disordered areas are likely to be both effective and efficient methods for targeting resources to the most vulnerable children and families in the city.

Future directions for neighborhood research in child welfare

While the current research sheds light on the relationship between violence, substance use activity, and the rate of child welfare contact, further evidence on neighborhood processes is needed. Evidence from individual-level research indicates that neighborhood processes describing social interaction among residents may be particularly important in understanding pathways to both child maltreatment and child welfare contact at the neighborhood level. Small-area ecological research on other neighborhood processes, such as social cohesion and collective efficacy, is imperative to informing place-based efforts in child welfare.

With the literature now framed through a population health lens, future research should focus on differentiating the pathways by which neighborhood context is associated with *maltreatment behavior* versus *contact with child welfare services*. To assess whether variation in child welfare contact is consistent with variation in the actual risk of child maltreatment behaviors, objective measurement of parental behaviors is necessary alongside the analysis of administrative data from child welfare. Comparing these two interconnected but potentially varied outcomes will be instrumental in the understanding of how systemic bias in child welfare contact may operate at the neighborhood level.

Public health significance – Baltimore City

Considering the high rate of child welfare contract in Baltimore City, the need to reduce the burden on the child welfare system, and growing attention for the need to prevent child maltreatment in high risk neighborhoods, child welfare services may benefit

from further coordinating their prevention efforts with other public health sectors serving children at risk of maltreatment. The momentum for place-based interventions is currently strong in Baltimore City, presenting a significant opportunity to promote optimal health among disadvantaged populations. Examples of current place-based strategies to promote the health and well-being of children, youth, and families in Baltimore City include home visiting for parents of young children, community health worker programs, violence prevention interventions (e.g. Safe Streets), and efforts to amend zoning laws to promote healthy communities.[9-12] Momentum for place-based strategies is further driven by the state of Maryland's legislated Health Enterprise Zones (HEZ) Initiative.[13, 14] By focusing resources into small geographic areas with significant health burdens, Maryland's HEZ Initiative is in line with the efforts to shift to a population health promotion framework driven by the Affordable Care Act and recommendations put forth by the World Health Organization for action to address health inequities.[6, 8]

The description of spatial variation in the rates of child maltreatment in Baltimore City will provide local decision makers with actionable health intelligence about areas with the highest rates of child welfare contact. Data owners at the state level are now able to compare the rate of child welfare contact with other indicators of health and well-being for children in Baltimore City. Evidence on neighborhood processes defined in this study can inform place-based interventions by identifying specific characteristics of the neighborhood environment that regulate population health across outcomes. Specifically, comparing neighborhood-level data from multiple sources (e.g., juvenile services, public health) will enable stakeholders to identify areas with consistently high rates of service

use across provider types and throughout childhood and adolescence. These geographic areas would be well suited for cross-agency collaboration. Additional research efforts using child welfare data disaggregated by maltreatment type and mode of identification may be useful for generating hypotheses on how the environment may contribute to both the risk for child maltreatment and an overburdened child welfare system.

Conclusion

A cross-disciplinary perspective is necessary to inform child maltreatment prevention and health promotion efforts. The current study illustrates the application of methods from spatial epidemiology and small-area ecological research to guide place-based, family health promotion in urban areas. In this study, we described the population-level evidence on risk regulators and child welfare contact, aligning the research with a newly emerging paradigm of population health research. As evidence from the field of small-area ecological research grows, future research on neighborhood effects and child welfare will benefit by aligning efforts through this public health framework. Population-level inferences drawn from this evidence base can inform the design of place-based interventions for child welfare and aid with the coordination of other population health efforts across public service sectors.

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Doctor of Philosophy, Mental Health   2017
Johns Hopkins University Bloomberg School of Public Health, Baltimore, MD
Thesis: Neighborhood variation in the rate of child welfare contact
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Master of Public Health, Maternal & Child Health   2008
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Thesis: The role of public schools in HIV prevention: perspectives from African Americans in the rural south
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Bachelor of Science, Sociology (minor, Family Studies) 2004
James Madison University, Harrisonburg, VA
Thesis: An Ethnographic Study of Rave Culture
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Honors and Awards

Brown Community Health Scholarship Johns Hopkins Bloomberg School of Public Health (2012-2017)
1st place in Maltreatment Prevention Poster Contest Moore Center for the Prevention of Child Sexual Abuse (2016)
Travel Scholarship Johns Hopkins Urban Health Institute (2014)
Emerging Scholar Administration for Children and Families, Office of Planning, Research and Evaluation, United States Department of Health and Human Services (2014)
Highly Published Author RTI International (2012)
Early Career Preventionist Network Scholarship Society of Prevention Research (2009)
Maternal & Child Health Section Student Fellow American Public Health Association (2008 -2009)
Health Sciences Scholarship Danville Memorial Hospital, Danville, VA (2000-2001)
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Professional Experience

2014 to present	**Independent Public Health Consultant**
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	Johns Hopkins School of Public Health – Baltimore, MD
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| 2009 to 2010 | **Project Manager** |
| | Pediatrics, University of North Carolina – Chapel Hill, NC |

2008 to 2009	**Research Associate**
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| | Battelle, Center for Public Health Research and Evaluation– Durham, NC |

| 2005 to 2006 | **Residential Treatment Counselor** |
| | Concern of Durham, Inc., Greenhouse for Girls – Durham, NC |

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Teaching Experience

Johns Hopkins University, School of Arts and Science
Spring 2015   Health and Wellbeing in Baltimore: A Public Health Perspective
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Fall 2015   Mental Health/Biostatistics: Statistics for Psychosocial Research: Measurement Models
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Spring 2004   Social Work: Acting Outreach (service-based learning)

Peer-Reviewed Journal Articles

Lloyd, S.W., Davey-Rothwell, M. A., Tobin, K.E., & Latkin, C.A. (in press) People who inject drugs and have a history of mood disorder – a brief assessment of health risk behaviors. *Substance Use and Misuse.*

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Manuscripts in Progress

Lloyd, S. W., Connolly, F., Milam, A.J., Olson, L., & Leaf, P. Preparing students for success: Expansion of public preschool programming and elementary school outcomes in Baltimore City, Maryland. In preparation for *TBD*

Lloyd, S. W., Milam, A.J., Leaf, P. & Castillo-Salgado, C. Measurement of neighborhood risk regulators in Baltimore City, new metrics for population health. In preparation for *Journal of Epidemiology and Community Health*

Lloyd, S.W., Pollack, K., Daniels, M., Feder, K. Greenblatt, A. & Leaf, P. Neighborhood context and the rate of child welfare contact: an evaluation and synthesis of population-based research. In preparation for *Child and Youth Services Review*

Lloyd, S.W., Latimore, A., Castillo-Salgado, C., Milam, A.J., Iyer, S.D. and Leaf, P.J. Variation in Mortality Rates across Youth Populations in Baltimore City – a Snapshot of Health Inequities. In preparation for *American Journal of Public Health*

Lloyd, S. W., Leaf, P. & Castillo-Salgado, C. Neighborhood structure and spatial variation in the rate of child welfare investigation. In preparation for *Journal of Urban Health*

Lloyd, S.W., Nguyen, A. The contribution of child maltreatment exposure to poor mental health functioning in adulthood, looking beyond diagnostic criteria. In preparation for *TBD*

Lloyd, S. W., Leaf, P. & Castillo-Salgado, C. Neighborhood structure, processes, and the rate of child welfare investigation. In preparation for *Journal of Urban Health*

Presentations (*invited)

Lloyd, S.W., Pollack, K., Daniels, M., Feder, K. Greenblatt, A. & Leaf, P. (November, 2016) Neighborhood context and the rate of child welfare contact: an evaluation and synthesis of population-based research. In *American Public Health Association 144th Annual Meeting* (No. 4076), Denver, CO.

Edelin, T. M., Nadison, M., **Lloyd, S. W.**, Finkle, J., & Ramjohn, D.S. (October, 2016) Stepping outside the walls: Exploring the role of intergrated healthcare systems in creating healthy communities. In *American Evaluation Association: Evaluation 2016 Conference* (Session No. 2673), Atlanta, GA.

Edelin, T. M., Ramjohn, D.S., Nadison, M. & **Lloyd, S. W.** Moving from Contribution to Accountability – Leveraging the Assets of Anchor Institutions.

Nadison, M., Ramjohn, D.S., **Lloyd, S. W,** & Finkle, J.Capitalizing on existing population health data through standard, theory-driven assessment.

Lloyd, S. W. Ramjohn, D.S., Nadison, M., & Finkle, J. Working towards authentic community engagement through primary data collection

Ramjohn, D.S., Nadison, M., **Lloyd, S. W,** & Finkle, J. Responding to community identified health needs with strategic investments.

Salazar, L. **Lloyd, S.W.,** & Leaf, P (2016, July) Geographic Variation of Arrests in Baltimore and Neighborhoods' Social Determinants of Health. In *Hopkins Career Academic and Research Experiences for Students Poster Session*, Baltimore, MD.

Lloyd, S.W., Pollack, K., Daniels, M., Feder, K. Greenblatt, A. & Leaf, P. (2016, November). Neighborhood context and the rate of child welfare contact: an evaluation and synthesis of population-based research. In *Moore Center for the Prevention of Child Sex Abuse Student Poster Contest*, Baltimore, MD.

Lloyd, S.W., Nguyen, A. (2016, April). The contribution of child maltreatment exposure to poor mental health functioning in adulthood, looking beyond diagnostic criteria. In *Moore Center for the Prevention of Child Sex Abuse Student Poster Contest*, Baltimore, MD. (1st place in poster contest)

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 Viswanathan, M., **Lloyd, S. W.**, Yuen, A. N., Swinson Evans, T. M., Morgan, L. C., Lux, L. J., & Lohr, K. N. (2010, October). Training materials for systematic reviews for the RTI-UNC Evidence-based Practice Center. In *RTI Innovations Showcase, Research Triangle Park*, NC.

Lloyd, S. W., & McRee, A. (2009, November). Mental health of same sex attracted adolescents: is religion protective? In *American Public Health Association 137th Annual Meeting* (No. 206073), Philadelphia, PA.

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Gaynes, B. N., Lux, L. J., **Lloyd, S. W.**, Hansen, R. A., Gartlehner, G., Keener, P., Brode, S., Swinson-Evans, T., Jonas, D., Crotty, K., Viswanathan, M., Lohr, K.(2011). *Nonpharmacologic Interventions for Treatment-Resistant Depression in Adults.* (Report No. 33). Agency for Healthcare Research and Quality. Available at http://www.ncbi.nlm.nih.gov/books/NBK65315/

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Donahue, K., Gartlehner, G., Jonas, D., Lux, L., Thieda, P., Jonas, B., Hansen, R., Morgan L., **Williams [Lloyd], S**., & Lohr, K. N. (2007). *Comparative Effectiveness of Drug Therapy for Rheumatoid Arthritis and Psoriatic Arthritis in Adults*. (Report No. 11) Agency for Healthcare Research and Quality. Available at http://www.ncbi.nlm.nih.gov/books/NBK43126/

Other Publications

Lloyd, S.W., Latimore, A., Castillo-Salgado, C., Milam, A.J., Iyer, S.D. and Leaf, P.J. (2015) *The Health and Wellbeing of Children, Youth, and Families in Baltimore City: Child and Youth Mortality.* Johns Hopkins Urban Health Institute. Available at: http://urbanhealth.jhu.edu/media/reports/UHI_Child_Youth_Mortality_ Report_2015.pdf

Lloyd, S.W., Latimore, A., Castillo-Salgado, C., Milam, A.J., Iyer, S.D. and Leaf, P.J. (2015) *Trends in Child and Youth Mortality, 2001-2012.* Available at: http://urbanhealth.jhu.edu/media/reports/Youth_Mortality_- _Brief_1_Trends.pdf

Lloyd, S.W., Latimore, A., Castillo-Salgado, C., Milam, A.J., Iyer, S.D. and Leaf, P.J. (2015) *Neighborhood variation in child and youth mortality rates, 2001-2012.* Available at: http://urbanhealth.jhu.edu/ media/reports/Youth_Mortality_- _ Brief_2_Neighborhoods.pdf

Lambert, M. C., **Lloyd, S. W**., Spann, L., Greenblatt, A., Thomas, A. 2012. *Celebrating the Strengths of Black Youth*. SELMedia. Cary, NC. Available at: https://csbyprogram.com/

Research Projects

Current Projects

KPMAS Implementation Strategy   **Investigator 2016- present**
Kaiser Permanente of the Mid-Atlantic States   PI: Ramjohn
Lead the development of a community-driven plan to address health needs in KP-MAS service areas. Manage planning and implementation of a Social Innovation Challenge to Address Health Disparities in Baltimore City

Health and Wellbeing of Children, Youth, and Families in Baltimore   **Investigator 2013-2016**
Urban Health Institute, Johns Hopkins University   PI: Leaf
Lead analysis and production of a series of reports for the Baltimore City Health Department to inform responsive interventions to promote the health and wellbeing of children youth and families in the city

Completed Projects

KPMAS Community Health Needs Assessment   **Investigator 2015-2016**
Kaiser Permanente of the Mid-Atlantic States   PI: Ramjohn
Supported the population health assessment for three services areas: Northern Virginia, Washington-DC/Suburban Maryland, and Baltimore

A network and Dyad HIV prevention intervention for drug users   **Co-Investigator 2013-2016**
National Institutes of Drug Abuse/JHU Center for AIDS Research   PI: Latkin
Used data from RCT in Baltimore to assess risk behaviors for injection drug users with affective disorders

Qualitative Research for Gender, Equity, and Human Rights   **Investigator 2014-2015**
World Health Organization   PI: Castillo-Salgado
Supported the development of toolbox for qualitative analysis for Health Situation Analysis and Response

National Child Traumatic Stress Network   **Co-Investigator 2013-2015**
Substance Abuse and Mental Health Services Administration   PI: Belcher
Analyzed data collected from children exposed to trauma through JHU-Duke NCTSN collaboration

National Survey of Child and Adolescent Wellbeing, Wave II   **Analyst 2012**
Administration for Children and Families   PI: Casanueva
Prepared summaries of population-based research for comparison with Wave II participants at baseline

Interventions for Children Exposed to Trauma   **Associate 2011-12**
Agency for Healthcare Research and Quality   PIs: Forman Hoffman/Viswanathan
Contributed to comparative effectiveness review on interventions for children exposed to trauma other than maltreatment and family violence

Interventions for Children Exposed to Maltreatment   **Co-I/Coordinator 2010-12**
Agency for Healthcare Research and Quality   PIs: Goldman Fraser/Viswanathan
Produced comparative effectiveness review on interventions for maltreated children

Title X Family Planning Annual Report Compilation Project   **Associate 2009-2012**
Office of Population Affairs   PI: Fowler
Validated, analyzed, and disseminated Title X data; develop/implement national data collection website

Training materials for systematic reviews   **Associate 2009-2010**
RTI International   PI: Viswanathan
Contributed to the development of a manual to guide the process of completing a systematic review

2nd Generation Antidepressants in Treatment of Depression, Update   **Associate 2009-11**
Agency for Healthcare Research and Quality   PIs: Gartlehner/Viswanathan
Assisted with update comparative effectiveness review of antidepressants for Major Depressive Disorder

Nonpharmacologic Interventions for Treatment-resistant Depression   **Co-Investigator 2009-11**
Agency for Healthcare Research and Quality   PIs: Gaynes/Viswanathan
Produced a comparative effectiveness review of nonpharmacologic interventions for patients with Major Depressive Disorder who were not responsive to antidepressant medications

Promotion of HPV vaccine among parents and young men   **Coordinator 2009-2010**
MERCK/ North Carolina Translational and Clinical Sciences Institute   PI: Coyne-Beasley
Trained data collectors and analysts, coordinated data collection, moderated focus groups

Celebrating the Strengths of Black Youth   **Author/Coordinator 2008-09**
National Institute of Child Health and Human Development   PI: Lambert/DeRosier
Coordinated and contributed to the development and evaluation of a strengths-based to promote positive psychosocial development

Social and Emotional Skills Training, Early Childhood   **Intern/Associate 2008-09**
National Institute of Mental Health   PI: McMillen
Assisted with efficacy testing of an emotional literacy curriculum for children in K-2nd grade

Web Tool to Disseminate Empirically Based Interventions to Schools   **Coordinator 2008-09**
National Institute of Mental Health   PI: DeRosier
Supported the development and feasibility testing of a Web-based tool to disseminate evidence-based interventions in the school setting

Social Skills Training for Children through Interactive Technology   **Coordinator 2008**
National Institute of Mental Health   PI: DeRosier
Coordinated feasibility testing for computer-based interactive social training system

Project GRACE: A Participatory Approach to Address Health Disparities **Assistant 2006-08**
National Center on Minority Health Disparities   PI: Corbie-Smith
UNC Center for AIDS Research
Assisted with collection and analysis of qualitative data; contributed to development of HIV prevention intervention

Learning About Research in North Carolina   **Assistant 2006-08**
NIH National Human Genome Research Institute   PI: Corbie-Smith
NIH National Center for Research Resources
Managed qualitative and quantitative data; analyzed participant perceptions of genetic variation research and the causes of colorectal cancer

Effectiveness and Safety of Pharmacologic Treatment for Depression   **Assistant 2006**
Agency for Healthcare Research and Quality   PI: Gartlehner
Assisted with comparative effectiveness review of antidepressants for major depressive disorder

Technical Skills

Statistics Software Packages (Advanced)
STATA, MPLUS, R, SAS, SPSS
ArcGIS, Atlas.ti, GeoDa

Online Course and Meeting Management (Proficient)
Blackboard, CoursePlus, Adobe Connect, WebEx

Social Media Platforms (Proficient-Advanced)
Twitter, LinkedIn, Facebook, Instagram, Snapchat