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Neighborhood-Level Factors Related to Asthma in Children Living in Urban Areas: An Integrative Literature Review

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Abstract

Asthma disproportionately affects children who are non-White and of low socioeconomic status. One innovative approach to address these health disparities is to investigate the child's neighborhood environment and factors influencing asthma symptoms. The purpose of this integrative review is to critique research investigating the relationships between neighborhood-level factors and asthma morbidity in urban children. Three literature databases were searched using the terms "asthma," "child," "neighborhood," and "urban." The articles included were organized into six themes within the larger domains of prevalence, physical, and social factors. Literature tables provide in-depth analysis of each article and demonstrate a need for strengthening analysis methods. The current research points to the necessity for a multilevel study to analyze neighborhood-level factors that are associated with increased asthma morbidity in urban children. School nurse clinicians, working within children's neighborhoods, are uniquely positioned to assess modifiable neighborhood-level determinants of health in caring for children with asthma.

Keywords

asthma; environmental health/safety; health/wellness; community; parent/family; integrative reviews

Asthma disproportionately affects non-White children living in poverty. The National Health Interview Survey, done by the Center for Disease Control in 2014, demonstrated that the lifetime asthma prevalence for "White non-Hispanic" males and females under 18 years old is 14.1% and 10.1%. When these data were compared with the prevalence for "Black non-Hispanic" males and females (22.7% and 14.8%, respectively) and "Puerto Rican" males and females (35.4% and 28.1%, respectively), the differences are quite obvious (U.S. Department of Health and Human Services, 2014). This survey also demonstrates a higher

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Supplemental Material

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asthma prevalence at lower incomes. Despite a long history of research on asthma, the disparities still exist. Original research focused on the causes and treatments at the individual level. More recent research has begun to investigate family, neighborhood, and societal factors that may influence childhood asthma. This integrative review analyzes research from the year 2010 to 2016 with regard to the quick pace of developments in the field and allows a few years for the 2007 National Asthma Education and Prevention Program (NAEPP) guidelines to be implemented. Neighborhood-level factors are being investigated using sophisticated statistics, accounting for several domains in their modeling.

Neighborhood is defined as a “bundle of spatially based attributes associated with clusters of residences, sometimes in conjunction with other land uses” (Galster, 2001, p. 2112). Neighborhood-level factors include structural characteristics of buildings (i.e., type, scale, materials, state of repair, and density), infrastructural characteristics (i.e., roads, sidewalks, and streetscaping), demographic characteristics of residents, class status characteristics (i.e., income, occupation, and education composition), tax/public service package characteristics (i.e., quality of safety forces, public schools, parks, and recreation), environmental characteristics, proximity characteristics (i.e., proximity to destinations of employment, entertainment, and shopping), political characteristics, social-interactive characteristics, and sentimental characteristics such as how residents identify with their neighborhood (Galster, 2001). Defining neighborhood-level factors demonstrated several areas that might be of interest to school nurses including schools themselves. Both social and physical aspects of neighborhoods affect health. The neighborhood still remains an important area to investigate because it is linked with more severe asthma and greater risk of death. Although there is not one definitive causal factor, it has been proven that residential segregation, both past and present, leads to disparities in socioeconomic status (SES), causing racial health disparities between African Americans and Caucasians (Hill, Graham, & Divgi, 2011). Racial and ethnic minority groups and those living in low-income communities are exposed to multiple physical environmental triggers as well as social stressors related to poverty and inequality (Morello-Frosch, Zuk, Jerrett, Shamasunder, & Kyle, 2011). These physical and social affects have negative health consequences for children with asthma. According to the NAEPP Expert Panel Report 3 (2007), one risk factor for asthma-related death is being an inner-city resident or of low SES. This statement emphasizes how important it is to investigate the impact of neighborhood-level factors on children’s asthma. Analyzing current research in this area will allow scientists to develop interventions to combat asthma at this level. As is mentioned in previous reviews on this topic (Schreier & Chen, 2013; Wright & Subramanian, 2007), a multilevel framework would support and encourage multidisciplinary investigation in asthma-related research. This review also includes neighborhood-level factors that may be important for school nurses to consider when treating students with asthma. The purpose of this integrative review is to analyze and critique research from 2010 to 2016 that investigated the relationships between neighborhood-level factors and asthma in children living in urban areas.

Literature Search Method

Integrative reviews present the state of the science by compiling recent empirical or theoretical literature to provide a comprehensive view of a health topic (Whittemore &

Knafl, 2005). The purpose of this integrative review was to critique and summarize research examining the relationship between neighborhood-level factors and asthma in children living in urban areas. A literature search of CINAHL, Pubmed, and PsycINFO databases was conducted in March 2016 with the assistance of a university librarian. Search terms included the Medical Subject Headings (MeSHs) terms “neighborhood,” “asthma,” “child,” and “urban.” See Figure 1 for a screenshot of the search strategy. The search was performed for the years 2010 through March 2016. Articles were found from this search as well as a hand search after speaking with experts in the field and reviewing reference lists to identify relevant articles. There were no restrictions on primary author discipline, location of the study, or methodological orientations. Due to the nature of neighborhood-level factors being relatively difficult to manipulate, all of the studies included were nonexperimental.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (Figure 2) illustrates the search process. The inclusion criteria were full text, published, peer-reviewed, and English language. Studies based on adult asthma, trialing interventions, dissertations, reviews, opinion articles, and articles published prior to 2010 were excluded, leaving 26 studies after 3 additional studies were added from a hand search. The presentation of results is organized conceptually discussing research on prevalence as well as physical and social neighborhood-level factors that are associated with asthma. The next section is a critique followed by implications for future research.

Results

Articles were analyzed by the type of study; method; results; asthma measurement; inclusion of sex, race, and ethnicity; and SES. See Supplementary Tables 1–6 for a detailed analysis of each individual article. During analysis, articles were evaluated critically regarding theoretical and methodological features. After analysis of all articles, six themes emerged organically from the data. The results are presented according to the theme below, beginning with research of asthma prevalence followed by physical then social neighborhood-level factors.

Prevalence

Several recent studies demonstrate that asthma prevalence varies by race as well as SES. Two large national studies ($N = 1,784$ and $23,065$) demonstrated that asthma rates are significantly higher for children who are African American or Puerto Rican (Holt, Theall, & Rabito, 2013; Keet et al., 2015). These studies also analyzed data by SES and one demonstrated that a one-unit decrease in the household income to poverty ratio was associated with a 7% increase in the odds of prevalent asthma (95% confidence interval [CI] = [1.05, 1.10]; Keet et al., 2015). A similar study was done with data from the Latin American International Study of Asthma and Allergies in Childhood to analyze multiple factors relating to asthma prevalence (Fattore, Santos, & Barreto, 2014). This study also found that the Gini index, which is a measure of income distribution similar to SES, along with crowding, sanitation, infant mortality rate, and homicide rate, explains 75% of the variability in asthma prevalence between 31 Latin American urban centers (Fattore et al.,

2014). This study, along with the two discussed earlier, utilized a cross-sectional design that prevents any causal inferences to be drawn.

Fattore, Santos, and Barreto (2014) measured socioeconomic and environmental determinants of wheezing in children in Latin America as described above. Similarly, Holt, Theall, and Rabito (2013) and Keet et al. (2015) analyzed data on the sociodemographic, neighborhood, familial, and individual level. Holt et al. (2013) found that the mother's race and ethnicity, child's insurance coverage, child's sex, allergies, the physical condition of the exterior of the home, and the percentage of the population with a bachelor's degree were significantly associated with an asthma diagnosis by age 5 in children ($N = 1,784$ mothers). The variables were significant ($p < .05$) when analyzed in a multivariable model including individual-level sociodemographic, housing characteristics, interviewer observed/participant-reported neighborhood characteristics, and census tract-level neighborhood variables. Keet et al. (2015) sampled children ($N = 23,065$ children) living in various census tracts ($N = 5,853$ tracts) around the United States and found that race and ethnicity were strongly associated with asthma prevalence, but in a multivariate analysis they found that neighborhood poverty and urban/rural status were not risk factors. In a similar study, Ownby et al. (2015) demonstrated that asthma prevalence, when controlling for SES, is similar among rural and urban African American teens. These data also included asthma symptoms and demonstrated that the teens living in urban Detroit ($N = 1,047$ teens) reported more symptoms and hospitalizations in the past 30 days compared to the teens living in rural Georgia ($N = 208$ teens). The cross-sectional data were from self-report questionnaires that were sent out to students through public schools in each area during the years 2007–2008 in Detroit and 2009–2010 in Georgia. These two samples were taken 2 years apart and had differing sample sizes which weaken the strength of the authors' argument. Although there have been unique findings as demonstrated by Ownby et al. (2015), methodologically stronger research should be done to support the evidence that urban versus rural location are not associated with asthma prevalence. Taken together, this body of research demonstrates that asthma disproportionately affects African American and Puerto Rican children in the United States, and it seems to correlate with SES nationally and internationally. There is a discrepancy as to whether or not one's neighborhood is associated with increased asthma prevalence, however, being an "inner-city resident" is cited as a risk factor for asthma mortality, and it is important to continue to investigate the elements of this environment that are related to asthma prevalence and control.

Physical—Outdoor Air

Research of outdoor air-quality ranges from analyzing pollen exposure related to asthma emergency department (ED) visits (Jariwala et al., 2011) to the impact of weather (Wanka et al., 2014) and particular air pollutants (Buonanno, Marks, & Morawska, 2013; Glad et al., 2012; Nishimura et al., 2013; Svendsen et al., 2012; Vieira et al., 2012) on asthma and respiratory health. Some of the research has mixed results. Jariwala et al. (2011) found a correlation between pollen exposure and asthma ED visits ($r = .9$, $p = .0374$) but could not demonstrate a relationship between nitrogen oxides (NO_x) or ozone (O₃) peaks and peak visits for asthma to the ED.

Glad et al. (2012) utilized a case-crossover design to demonstrate a 2.5% increase in asthma ED visits for every 10 parts per billion (ppb) increase in O₃ level (odds ratio [OR] = 1.025, $p < .05$). The case-crossover design may have strengthened the method, but the pollution data were obtained from a limited number of monitors and therefore did not capture variability across regions. Through a retrospective case-control study, Nishimura et al. (2013) demonstrated a 5 ppb increase in average nitrogen dioxide (NO₂) during the first year of life was associated with an OR of 1.17 for asthma (95% CI [1.04, 1.31]). This study also demonstrated that Chicago and New York had the highest level of NO₂, considered to be a traffic-related pollutant. The study design also addressed the temporality of air pollution, but the data were analyzed as large areas rather than particular homes of the study participants. Svendsen et al. (2012) demonstrated in Texas that a 10 ppb increment increase in NO₂ levels was associated with current asthma (OR = 1.65, 95% CI [1.08, 1.65]) for children (mean age = 10.1 years) in public schools at elevations above 1,170 m. In valley schools of lower elevation, the relationship was not significant. The environmental data were collected in 1999 and the questionnaires from the schools were obtained in 2001. The final analyses focused on children who had lived in their current residence for over 1 year. These analyses controlled for indoor sources of exposure including gas stoves and secondhand smoke.

Buonanno, Marks, and Morawska (2013) and Vieira et al. (2012) were able to measure individual pollutant exposure, thereby strengthening their inferences. In Italy, Buonanno et al. (2013) demonstrated that children in urban areas are exposed to particle concentrations 25% higher than the overall mean exposure ($p < .01$). The author also demonstrated that home was a major contributor (57%) to daily dose of airborne particles and that there is an association between personal dose and respiratory health effects. Vieira et al. (2012) demonstrated a low-cost method to measure NO₂ and O₃ exposure among children by using small air filters in their homes, balconies, and hooked onto their backpacks. Although the sample size was small ($N = 64$), the study found that the NO₂ in indoor air and personal exposure to O₃ were independently associated with asthma ($p = .02$ for both) and wheezing at any time ($p < .01$). These data support research that air pollution in the form of NO₂ and O₃ do relate to asthma, and their exposure early in life may increase the odds of an asthma diagnosis. Overall there appears to be strong evidence supporting an association with NO₂ and asthma, although not as much information on O₃, and limited research on the association between pollen and asthma. More research should be done on individual-level exposures possibly by the methods used by Vieira et al. (2012) to measure outdoor, indoor, and personal exposure.

Physical—Outdoor Air—Traffic

In analyzing traffic-related pollution, Cook, deVos, Pereira, Jardin, and Weinstein (2011) and Li et al. (2011) used proximity of houses to major roads and estimated traffic counts to analyze asthma. They both used case-control studies to demonstrate increased risk of asthma-related events such as ED visits. Cook et al. (2011) demonstrated that in Perth, Australia, there was a 24% increase in the risk of experiencing multiple emergency contacts for asthma for every log unit of traffic exposure (95% CI [1.00, 1.52]). Li et al. (2011) demonstrated that in Detroit, MI, for every 1-km increase in distance away from a primary road, the OR of an asthma event is 0.97 (95% CI [0.94, 0.99]). Although they used large

sample sizes, $N = 434$ (Cook, deVos, Pereira, Jardin, & Weinstein, 2011), and $N = 14,646$ (Li et al., 2011), neither study took into account SES, sex, or ethnicity, which might explain some of the variation in asthma events. These data did not account for other exposures such as secondhand smoke, family history, or indoor air pollutants and allergens because they were deidentified from hospital records in Australia and Medicaid data in Detroit. Although this information does not demonstrate causation, these data about specific pollutants appear to have an association between outdoor air quality and asthma.

Physical—Indoor Air—Triggers and Housing

Research investigating indoor variables and asthma includes types of housing (Northridge, Ramirez, Stingone, & Claudio, 2010), specific triggers (Butz et al., 2011; Olmedo et al., 2011), and behaviors aimed at decreasing triggers (Martin et al., 2013; Yinusa-Nyahkoon, Cohn, Cortes, & Bokhour, 2010). Northridge, Ramirez, Stingone, and Claudio (2010) determined that there is a high prevalence of asthma in public housing (21.8%; 95% CI [17.3, 26.3]) in New York City after adjusting for community-level demographic and economic factors. Of those sampled, those in public housing were more likely to report the presence of cockroaches (68.7% vs. 21%) compared to other types of housing. This finding demonstrates differential exposure to asthma triggers by housing type. The researchers analyzed questionnaires from 4,853 children representative of the 5- to 12-year-old population of children attending New York City public schools.

Olmedo et al. (2011) used a case-control design to analyze high asthma prevalence neighborhoods (HAPNs) compared to low asthma prevalence neighborhoods (LAPNs). Bed dust was tested for allergens, and in HAPNs there were more cockroach (22 ng/g vs. 37 ng/g), mouse (41 ng/g vs. 93 ng/g), and cat allergens (30 ng/g vs. 56 ng/g) and lower dust mite allergens (10 ng/g vs. 5.3 ng/g). The author theorized that air conditioning was less common in HAPNs, and therefore, the dry air was less conducive to dust mites. This idea was supported by Northridge et al. (2010) who found that public housing residents, who had higher asthma prevalence, were less likely to report the use of an air conditioner (50.6% vs. 70.1%) compared to the residents of family dwellings.

Another asthma trigger analyzed by Butz et al. (2011) is exposure to secondhand tobacco smoke measured through urine cotinine levels. Although no significant associations were found, it should be noted that children with a greater number of symptom days had the highest cotinine concentrations. Data also indicated a twofold increase in urine cotinine concentrations, when the child's caregiver smoked as compared to other people living in the house. The sample consisted of children with uncontrolled asthma, so the lack of variability may have led to the lack of statistical significance. The study also demonstrated that urine cotinine, as opposed to passive nicotine sampling badges in the environment, should be considered the gold standard for measuring secondhand smoke exposure in children.

Martin et al. (2013) also utilized cotinine data in saliva to analyze asthma trigger behaviors for Puerto Ricans in Chicago ($N = 101$ families). Caregivers of children with asthma were scored through questionnaire, home assessment, and cotinine levels to determine their trigger behavior summary score. Each item was coded as 1 for *affirmative* and 0 for *negative*, and they included dust in the bedroom; dust in the home; lack of an air cleaner;

lack of allergen covers; pets in the bedroom; pets in the home; presence of roaches, rodents, cracks/holes; strong cleaning smells; smoke exposure; fragrance; and/or mold. The average trigger score was 6.0 ($SD = 1.7$). All items on the trigger behavior summary score represent modifiable behaviors, so these data have identified areas for future environmental interventions. Fragrance use was the most common behavior (71%) followed by presence of mold (41% of homes).

Although the study by Martin et al. (2013) identified triggers, Yinusa-Nyahkoon, Cohn, Cortes, and Bokhour (2010) analyzed qualitative data to address family routines and asthma management in African American families ($N = 19$) in Boston, MA. Two of the four main themes were that caregivers worked to manage the air quality in their home and frequently cleaned the home to remove triggers. Over half of the study sample lived above the poverty line, almost half lived in two-parent houses, and all had health insurance and a regular source of ambulatory care. Although this study may not be transferable to “inner-city” populations, it would be interesting to interview families of lower SES to understand how their family routines and asthma management differ.

Social—Outdoor—Safety

Measuring safety was done both directly by looking at crime data (Gupta et al., 2010) and indirectly by measuring the perception of safety (Coutinho, McQuaid, & Koinis-Mitchell, 2013; Koinis-Mitchell et al., 2012; Vangeepuram, Galvez, Teitelbaum, Brenner, & Wolff, 2012). Gupta et al. (2010) utilized surveys of children from kindergarten through eighth grade ($N = 45,371$). The surveys asked the child’s caregiver about demographic information as well as whether the child had been diagnosed with asthma, age at diagnosis if applicable, current asthma status, and presence of a family history of asthma. In total, 5,908 children (13% of the sample) reported an asthma diagnosis. After geocoding all addresses into 247 Chicago neighborhoods, they were divided into quartiles based on asthma prevalence. These data were analyzed with crime data from the Chicago Police Department. Criminal activity was significantly ($p < .001$) higher in neighborhoods with high asthma prevalence. After adjusting for community-level race and ethnicity, violent crime continued to explain 15% of the variation in childhood asthma ($p < .05$). These data only account for reported crime, so prevalence of asthma may be underestimated. This study demonstrated the utility of directly measuring crime, while Coutinho, McQuaid, and Koinis-Mitchell (2013) and Vangeepuram, Galvez, Teitelbaum, Brenner, and Wolff (2012) measured perceived safety.

Coutinho et al. (2013) utilized mixed methods to analyze caregiver/child dyads ($N = 147$), and their perception of safety related to family asthma management. There were significant ethnic group differences in poverty status, $F(2, 120) = 6.49, p < .01$, with Latino and African American dyads reporting greater poverty than the non-Latino White dyads. There were also differences in perceived safety by ethnicity, $F(2, 124) = 6.29, p < .01$, with non-Latino White dyads reporting higher perceived home and neighborhood safety compared to the Latino and African American dyads. Ratings of effective family management positively correlated with home and neighborhood safety ($r = .36, p < .01$) and negatively correlated with perceived discrimination ($r = -.19, p < .05$) and acculturative stress ($r = -.21, p < .05$). Vangeepuram et al. (2012) used cross-sectional data from parents ($N = 504$) of 6- to 8-year-olds with asthma,

in New York City. They found that parents who reported feeling unsafe walking in the neighborhood were more likely to have a child diagnosed with asthma ($OR = 1.89$, 95% CI [1.13, 1.34]). An interesting finding in these data is that the neighborhoods sampled were relatively similar, but it was the variation in parent perception of safety that related to asthma prevalence. All three of these studies demonstrate that the direct and indirect measures of safety may be correlated with asthma.

Koinis-Mitchell, Kopel, Salcedo, McCue, and McQuaid (2014) used a mixed methods exploratory study with cross-sectional data from two separate studies ($N = 208$ total) to analyze children's stress perception related to their asthma. Children with poorly controlled asthma reported a higher rate of neighborhood stress compared to children with well-controlled asthma, $F(1, 145) = 4.5$, $p = .04$. The family moving was most frequently mentioned (43%) as a stressor for respondents. Children with poorly controlled asthma reported higher levels of stress related to being afraid to go outside compared to children with well-controlled asthma, $F(1, 145) = 6.1$, $p = .02$. The study authors reported that a limitation was that there was not a parent instrument to corroborate children's perceptions of concepts, but the mixed methods nature of the study allowed the children to explain their answers.

Social—Indoor—Family Stress

Family stress is analyzed in several different ways, taking into account the family (Koinis-Mitchell et al., 2012; Sampson et al., 2013) and the parent (Mathilda-Chiu, Coull, Wooley, & Wright, 2012; Otsuki et al., 2010; Quinn, Kaufman, Siddiqi, & Yeats, 2010). Family-level data were obtained by Koinis-Mitchell et al. (2012) and Sampson et al. (2013) using mixed methods. The data Sampson et al. (2012) presented demonstrated that caregivers ($N = 40$) of children with asthma from low-income families in Detroit, MI, do not see caring for an asthmatic child as a source of stress. Rather, they reported high stress with regard to asthma-related change, uncertainty, control, and anxiety.

Koinis-Mitchell et al. (2012) calculated a cumulative risk index (CRI) to quantify the risk factors for asthma. The CRI score was formulated by adding a 1 for the presence of six risk factors including neighborhood stress, poverty, acculturative stress, discrimination, asthma severity, and asthma triggers within the home. The study showed that cumulative risks were associated with increased functional limitation ($r = .25$, $p < .01$) and risk for an ED visits in the past 12 months ($r = .15$, $p < .05$). Quinn, Kaufman, Siddiqi, and Yeats (2010) analyzed both parent perceptions of collective efficacy and neighborhood order for a sample of low-income Chicago families with a child who has asthma. Collective efficacy is the mutual trust between neighbors and the willingness to intervene on behalf of the public good (Sampson, 2006). Neighborhood order was defined as observable physical and social decay operationalized as presence of litter/trash, graffiti, vacant houses, and asking about trust between businesses and residents. Parent health was associated with collective efficacy (risk difference low vs. high = 20.9, 95% CI [7.8, 33.9]). General health outcomes of the family, including parents, were associated with collective efficacy, but child respiratory health outcomes were associated with neighborhood order. No biological or behavioral risk factors were accounted for in the statistical analysis, and the authors note that reverse causality may

be a limitation since asthma may cause stress. Due to the cross-sectional design of this study, causality cannot be demonstrated.

Both Mathilda-Chiu, Coull, Wooley, and Wright (2012) and Otsuki et al. (2010) utilized prospective designs to demonstrate temporality between maternal stress and depressive symptoms and wheeze and asthma morbidity. Mathilda-Chiu et al. (2012) analyzed maternal stress during the prenatal and postnatal period and then subsequent wheeze as reported by predominantly Latina (55%) and African American (29%) mothers in Boston, MA. Analysis of 989 mothers revealed that children born to mothers with high stress in both pregnancy and the postpartum period were significantly more likely to have repeated wheeze (adjusted *OR* 3.04, 95% CI [1.67, 5.53]) compared with children of mothers reporting low stress in both periods. The study followed children up to 2 years old and assumed that wheeze was a proxy for those that may be more likely to develop asthma or have compromised lung function. Otsuki et al. (2010) analyzed data at baseline and 6 months regarding maternal depressive symptoms and child asthma morbidity. This large sample ($N = 262$) of African American mothers of children with asthma demonstrated that maternal depressive symptoms at baseline predicted children's asthma symptoms 6 months later ($B = .15, p < .01$). It was shown that maternal depressive symptoms at baseline did not predict asthma ED visits at 6 months, but the sample was recruited from the ED during high morbidity, so these data may not be the best outcome measure.

Discussion

SES, Race and Ethnicity, and Sex

In general, most international articles did not identify the race and ethnicity of their samples. Two of the four international articles did mention the SES of their sample because they were looking at social inequity as the main variable related to asthma (Fattore et al., 2014; Vieira et al. 2012). The data from the United States also frequently accounted for SES. It was operationalized in different ways; Northridge et al. (2010), Holt et al. (2013), and Keet et al. (2015) used census data as a proxy for neighborhood SES, some discussed if sample participants lived above or below the poverty line (Sampson et al., 2013; Yinusa-Nyahkoon et al., 2010), one was not able to get SES information due to the type of data they were using (Li et al., 2011), and several mentioned "controlling for SES" in analysis (Coutinho et al., 2013; Gupta et al., 2010; Mathilda-Chiu et al., 2012; Ownby et al., 2015; Vangeepuram et al., 2012). More than half of the studies from the United States sampled specifically African American and/or Puerto Rican children due to the high prevalence of disease among this race and ethnicity. Several of the studies analyzed sex as it related to the outcome variable. A few of them had small sample sizes, so this stratification was not possible. Several of the stress studies sampling caregivers ended up with predominantly female caregivers as their sample. Because there was always a high percentage of caregivers who were female it was noted but data were never analyzed separately depending on the sex of the caregiver. When analyzing neighborhood-level factors related to asthma in children, it is important to account for unique contextual variables in analysis. As mentioned above, some of the reviewed articles did not address these key variables, thus adding complexity to the interpretation of their variables.

Method

As mentioned in Results section, a common research design for these studies is cross sectional. Data were frequently obtained from baseline questionnaires of intervention studies or other types of secondary data. These data can demonstrate correlations, but the design prevents an inference of causation between variables. They were also frequently gathered retrospectively and missing measurement of important variables. The few prospective studies were helpful to analyze maternal mental health and wheezing (Mathilda-Chiu et al., 2012) and asthma morbidity (Otsuki et al., 2010). Prospective data add temporality to relationships thus strengthening the evidence, but without an experimental study, causation cannot be inferred.

The article by Otsuki et al. (2010) was also the only article to use path analysis to model complex relationships between several variables over time. Another frequent analytic technique was logarithmic regression, which is appropriate, given binary outcome data. Although logarithmic regression can test for confounding or effect modification, it does not allow for modeling complex relationships like path analysis or mixed effects modeling. Another statistical trend was to dichotomize or group data originally gathered continuously. This change in the level of statistical analysis from parametric to nonparametric weakens the strength of the evidence. Some authors noted this as a limitation, but others accepted it as a requirement of their study due to non-normal distributions of results.

Sample selection also varied across studies as shown in the studies that sampled from medical records such as ED data, primary care clinics, Medicaid data, and urgent care call centers. Each type of medical data lends itself to a different sample and therefore results should be interpreted within that sample and are not generalizable to other samples. Several studies also sampled from schools that have implications depending on whether they are public versus private, and the specific demographics of their students. A few of the studies were explicit in their reasoning for sampling at a specific school, but others neglected to present this information in their article. The sampling methods differed depending on the purpose and pragmatic challenges of the study.

A critique of the methods for most of the air-quality studies, aside from the study by Vieira et al., was the lack of individualized data for each study participant. The authors mentioned that using generalized air pollution data could inaccurately estimate the amount of exposure for an individual. Vieira et al. (2012) used a unique and inexpensive method for attaching air filters to children's backpacks and placing them around their homes for a more precise estimate of exposure.

Asthma Operationalization

Supplementary Tables 1–6 also present how asthma is operationalized in each study. Some studies utilized health-care data and International Classification of Diseases, Ninth Revision (ICD-9) or ICD-10 diagnosis of asthma or “status asthmaticus.” Several studies asked for parents to report whether or not their child had physician-diagnosed asthma and their symptom frequency. Self-report can be limiting if the caregiver cannot recall this diagnosis or frequency of symptoms. This might happen if the child is in day care, if the parent works

long hours, or if more than one child has asthma. Of note, other health-care providers, nurse practitioners for example, also frequently diagnose asthma. Some further stratified type of asthma by analyzing parent report of control, severity, and functional limitation. Another common theme was to look at ED visits for exacerbation. Several studies cited the NAEPP Expert Panel Guidelines (2007) for how they measured asthma. This resource from the National Heart Lung and Blood Institute of National Institutes of Health (NIH) provides details on how to diagnose asthma severity, assess persistence and control, and provides a good universal method to operationalize this concept.

Limitations

This review has some limiting factors. One possible limitation of the inclusion criteria is that articles were from 2010 to March 2016. Although this time frame was justified considering frequent advances in the field, some important articles might have been excluded. Research from 2010 to March 2016 appeared to build on previous research and allowed examination of results after dissemination of the NAEPP guidelines. Thus, expanding the search time frame might not have added any significant articles. There is also a chance that search terms related to neighborhood-level factors were not included in the search. For this reason, a university librarian was consulted to help design the search. MeSH terms as well as search terms were used to attempt to capture all of the required terms without being too specific, but there is a chance that an important term was excluded. Another possible limitation was the use of the term “urban” in the inclusion criteria. Some of the articles in the review demonstrated that urban versus rural status may not be an important factor in asthma prevalence. Although this may be true, the focus on this review was urban children, and therefore it was a critical search term to be included.

Implications for Future Research

There are specific as well as general suggestions for future research in the above areas. Research into prevalence should be clear about what is being measured. Evidence presented argued that SES, and not place, drives asthma disparities. However, as the connection between SES and asthma was not the specific focus of this review, analyzing more research in this area would help support or refute these findings. Fattore et al. (2014) recommended continuing prevalence studies discriminating between phenotypes of asthma, addressing the geographic and individual level, and incorporating variables related to socioeconomic and urbanization. On that note, as it was suggested several times, outdoor air pollution data need to use more individualized methods (Buonanno et al., 2013; Vieira et al., 2012). If these small-scale studies are done frequently in differing populations, climates, and geographic areas, then a meta-analysis would help to draw conclusions about the overall risk for humans (Glad et al., 2012).

Nishimura et al. (2013) also reported that increased exposure to NO₂ in the first year of life statistically significantly increased the odds of being diagnosed with asthma, but the regions where study participants lived had NO₂ levels lower than required by the Environmental Protection Agency (EPA) air-quality standard. This suggests the need for further research to specifically test NO₂ levels. Current EPA requirements may not be sufficient to protect the health of children, and the EPA standards might need to be increased. The studies relating

proximity to traffic and asthma also represent areas where public health indicated the requirement for changes in policy. Some policy changes are already underway. Currently, the EPA (2016) has a Clean School Bus program to reduce diesel exhaust from school buses. They have developed tougher emission standards for new school buses and fund projects that reduce emissions from existing diesel engines. One of the simplest ways to decrease emissions is to reduce idling in school parking lots where children are exposed (EPA, 2016). This environmental health issue should be investigated further particularly in the school environment where school buses park emitting exhaust while waiting to load children. School nurses should lead the charge to implement policies to reduce the exhaust exposure among school children.

Several of the studies (Martin et al., 2013; Northridge et al., 2010; Yinusa-Nyahkoon et al., 2010) discussing indoor air suggest a multipronged approach to reducing home triggers. There should be more research and interventions targeting the individual level whether that is smoking cessation (Butz et al., 2011) or discussion of how to eliminate other triggers such as cockroaches and mold, using integrated pest management practices as well as policy changes around housing, pollution control, and tobacco legislation. Northridge et al. (2010) noted that because many of the houses are multiunit dwellings, the families living inside them have limited control over the maintenance of the spaces and therefore limited ability to control triggers that affect their children. Therefore, policy changes around housing for those on government assistance should take into account the health of children in determining what type of building meets their requirements.

The safety research demonstrated correlations between actual crime in neighborhoods (Gupta et al., 2010), perceived safety (Coutinho et al., 2013; Vangeepuram et al., 2012), and asthma. All three studies recommend additional research in this area to investigate the mechanisms behind the associations (Coutinho et al., 2013), specific psychological measures related to violence exposure (Vangeepuram et al., 2012), and control for potential confounders in the built environment (Gupta et al., 2010). More data are needed in this area to develop interventions to treat this problem. Regarding other sources of stress, future research should continue to investigate the mechanisms of how chronic stress affects children over time. The range of studies recommended looking at maternal depression starting in pregnancy, evaluating interventions to treat the depression, and further investigating the relationship between prenatal depression and future wheeze. Stress studies need to analyze psychological and physiological effects of stress while taking into account the other variables noted to affect asthma including the physical environment.

Analyzing the current research in neighborhood-level factors affecting asthma clearly shows that the next step is multilevel research into factors associated with asthma. As mentioned earlier, mixed effects modeling would be the optimal statistical analysis due to complex relationships between many differing levels of variables. SES, for example, is related to asthma and demonstrated by research in this review and previous research, but it acts through different mediators such as housing. To appropriately measure the relationship between SES and asthma, several pathways need to be included in the model to examine multiple associations between these variables, and therefore mixed effects modeling is the best statistical analysis to use with these types of data. This review has analyzed the latest

research on neighborhood-level factors that affect asthma in children living in urban environments. The current research has demonstrated a gap in studies analyzing multiple levels of influence through advanced statistical methods. These data can be used to better understand relationships of multiple factors as well as to influence health policy to improve the neighborhood environment for those children most affected by asthma.

Implications for School Nurse Clinicians

This review directly applies to school nurse clinicians who frequently monitor and care for children with asthma. As health-care providers, working in the community where high-risk children reside, they should be informed of the physical and social neighborhood-level factors that contribute to childhood asthma. They have a unique opportunity to target educational and behavioral interventions as well as policy decisions toward these determinants of health. This review also serves as a reminder to assess children with asthma holistically, within the context of their physical and social neighborhood environment.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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((("Environment"[Mesh]) OR "Social Environment"[Mesh]) OR (neighborhood* [tw] OR neighbourhood* [tw] OR residence [tw] OR residential [tw] OR residence characteristics [mh]) AND (asthma [mh] OR asthma [tw] OR wheez* OR "reactive airway disease" OR "reactive airway diseases" OR "reactive airway disorders" OR "allergic airway disease" OR "allergic airway diseases")) AND (child [mh] OR infant* [tw] OR toddler* [tw] OR child* [tw] OR youth [tw] OR teen* [tw] OR adolescen* [tw]) AND ("Urban Health"[Mesh]) OR "Urban Population"[Mesh])

Figure 1.
Screenshot of search strategy for Pubmed database.

Figure 2. PRISMA flow diagram for literature search process

Note. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.