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The influence of neighborhood environment on the incidence of childhood asthma: a multilevel approach

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Abstract

Some ecological analyses suggest an influence of neighborhood environment on asthma outcomes. However, no previous study has applied a multilevel approach to assess an ecological effect of neighborhood environment on the incidence of childhood asthma accounting for individual risk factors. This study assessed the influence of neighborhood and individual-level factors on the incidence of childhood asthma among all children born in Rochester, Minnesota, between 1976 and 1979. We identified asthmatics among all children born in Rochester, between 1976 and 1983. We applied a multilevel survival model with the frailty term to assess the effects of neighborhood characteristics, such as mean family income per census tract ($n = 16$) from the 1980 census report and the status of whether a census tract faces intersections with major highways or railroads, on asthma incidence. The relative risks (RR) of neighborhood socioeconomic status (SES), the status of whether census tracts face intersections with highways or railroads and the variance of random effect of census tracts were calculated adjusting individual-level covariates for asthma, including gender, birth weight, mother's age at birth and parental educational level at birth. We found that the RR of developing asthma among children living in census tracts facing intersections with highways or railroads was 1.6 (95% CI: 1.1–2.2) compared to those who lived in census tracts not facing intersections, adjusting individual- and neighborhood-level covariates. The variance of the frailty term attributable to census tracts was small (0.0085) and was modified (from 0.004 to 0.0085, 112% change) by adding neighborhood covariates. The overall effects of individual-level factors on asthma incidence were independent of neighborhood environment. The influence of neighborhood environment on childhood asthma in a non-inner-city setting, like Rochester, Minnesota, was small to modest. Incorporating pertinent neighborhood-level covariates into multilevel models needs to be considered in assessing the random effect of clusters.

Keywords: Neighborhood; Socioeconomic status; Asthma; Multilevel survival; Frailty; USA

Introduction

The prevalence of asthma has been rising dramatically throughout the developed world (Beaglehole, Jackson, Sears, & Rea, 1987; Bousquet, Hatton, Godard, &

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Michel, 1987; Burney, 1987, Juel & Pedersen, 1993; Mannino et al., 1998; Paulozzi, Coleman, & Buist, 1986; Sly, 1989; So, Ng, Ip, & Lam, 1990; Weiss & Wagener, 1990). This rising trend is most noticeable in young children aged 0 to 4 years (from 2.2% in 1980 to 5.8% in 1994, i.e., a 160% increase) (Center for Disease Control and Prevention, 1998). The prevalence of childhood asthma in the US varies substantially (4–17%) depending upon age, ethnic group and geographical region (Beaglehole et al., 1987; Bousquet et al., 1987; Burney, 1987; Gergen, Mullally, & Evans, 1988; Gergen & Weiss, 1990; Juel & Pedersen, 1993; Mannino et al., 1998; Paulozzi et al., 1986; Sly, 1989; So et al., 1990; Weiss & Wagener, 1990; Weitzman, Gortmaker, Sobol, & Perrin, 1992; Yawn, Wollan, Kurland, & Scanlon, 2002). Most epidemiologic research in childhood asthma has focused on identification of risk factors at the individual level (Institute of Medicine, 2001; Pearce, Beasley, Burgess, & Crane, 1998; Wright, 2004). However, there have been sufficient data suggesting the influence of neighborhood environment or the place of residence on health outcomes (Kawachi & Berkman, 2003; Pickett & Pearl, 2001; Adler et al., 1994; Diez–Roux et al., 1997; Haan, Kaplan, & Camacho, 1987; O'Campo, Xue, Wang, & O'Brien Caughy, 1997; Sawicki & Patrice, 1996; Veugelers & Kephart, 2001). Stafford et al. suggest that socioeconomic factors at the individual and area level may influence health by using two models: a collective resources model versus a local inequality model (Stafford & Marmot, 2003). In the collective resource model, people in non-deprived areas have better health than those living in deprived areas because there are more collective resources, including material and social resources. The local inequality model suggests that the disparity between an individual's own socioeconomic status (SES) and the socioeconomic position of those living nearby affects health adversely because of financial, cultural and behavioral barriers. Their study results supported the collective resource model by comparing self-rated health, mental health and waist/hip ratio between least (10th percentile) and most (90th percentile) deprived areas in relation to the neighborhood's Townsend deprivation index. More specifically, Wright suggests possible mechanisms for the influence of neighborhood environment on asthma including: (1) environmental exposures, (2) stress, (3) health behaviors and psychological factors, and (4) access to health care (Kawachi & Berkman, 2003).

However, as Pickett pointed out, previous studies on the influence of neighborhood characteristics on health are limited in testing the causal hypotheses derived from the theorized causal pathways (Pickett & Pearl, 2001). This is in part because most previous studies assessed the role of neighborhood characteristics in relation to a broad and generic health outcome (e.g., self-rated health or mortality rates) rather than a specific health or disease outcome. Because a disease does not necessarily share the same underlying mechanisms with others, and as the contributing factors at individual- or aggregate levels are likely to be different, it may be not realistic to conceptualize the influence of neighborhood environment for different diseases under a conceptual framework. For example, the immunologic concept of T-helper cell 1 (Th1) and T-helper cell 2 (Th2) polarization suggests an inverse relationship between asthma and diabetes and between infectious disease and asthma. For example, individuals who have atopic diseases (Th2 predominant conditions) have been reported to have a lower risk of diabetes (Th1 predominant condition) (Stene & Joner, 2004; The EURODIAB study group, 2000), and children who have increased acquired infections during early childhood are protected from developing asthma later on (Liu & Szefler, 2003; Weiss, 2002). Therefore, to advance our understanding of the role of neighborhood environment on health or disease outcomes, more specific hypotheses derived from a more realistic conceptual model for a specific disease or health outcome need to be tested before generalizing the role of neighborhood environment to broader health or disease outcomes. Thus, in this paper we examine specifically the influence of neighborhood environment on the incidence of childhood asthma based on predetermined asthma criteria.

In regard to the influence of neighborhood environment on childhood asthma, several ecologic studies have previously reported that low neighborhood SES was associated with increased asthma hospitalizations or prevalence of wheezing, although these studies did not take into account individual SES (Lin, Fitgerald, Hwang, Munsie, & Stark, 1999; Wissow, Gittelsohn, Szklo, Starfield, & Mussman, 1988; Ray, Thamer, Fadillioglu, & Gergen, 1998; Duran–Tarleria & Rona, 1999). There are a few studies that have assessed the influence of neighborhood environment on asthma accounting for individual SES (Weitzman, Gortmaker, & Sobol, 1990; Morgan & Chinn, 1983). These studies assessed the influence of the place of residence on childhood asthma by using a standard logistic regression model, which assumes independence among observations sampled in the same cluster (i.e., area of living). However, because the error terms of individuals in the same area are correlated, the standard errors are incorrect, leading to inaccurate statistical inference. Therefore, multilevel models take into account aggregate- and individual-level variables within one model and estimates of the standard errors are corrected (Hedeker, Gibbons, & Flay, 1994) to assess the influence of neighborhood environment on childhood asthma. Multilevel survival models with random effects have been proposed in previous studies (Rodriguez, 1994). Guo and Rodriguez applied a multivariate proportional hazards model with random effect to child survival data