

Preschool Children's Environmental Exposures: A Case-Control Epidemiological Study of the Presence of Asthma-Like Symptoms

Dhitinut Ratnapradipa,
MPA, PhD, MCHES
Department of Health Education
and Recreation
Southern Illinois University

Anthony G. Robins, PhD
Director, Program and Research
Center for Black Male
Educational Success
Robert Morris University

Kendra Ratnapradipa, MSW

Abstract The heterogeneity of asthma and asthma-like symptoms results in difficulty defining, diagnosing, and therefore estimating environmental exposures and associations with wheezing or asthma-like symptoms. Determining the disease burden for young children is particularly challenging. In the study described in this article, counter-matched sampling design was used to select participants from the Woman, Infants, and Children (WIC) program for this nested case-control study ($N = 691$, with 412 controls). Data were collected through structured interviews. Exposure to wood or oil smoke, soot, or exhaust was significantly associated with early-life asthma, as was exposure to cockroaches. Multivariate analyses showed that increasing age, male gender, presence of allergies (although not the type of allergies), and the presence of eczema at birth predicted wheezing behaviors in the authors' study. The authors estimated the prevalence of wheezing behavior in a population of low-income preschool children was 31% with prevalence rates higher among African-American children as compared to other races/ethnicities. Fifty-one percent of those children whose caregivers reported wheezing, however, had not received a diagnosis of asthma. Further study is recommended to compare the differences in the wheezing experiences between those diagnosed with asthma and those who are undiagnosed, with the intent of designing primary prevention interventions tailored to parents and caregivers of young children.

Introduction

Popular belief holds that the prevalence of asthma in children is increasing. Does the evidence, however, support this perception? Before this question can be addressed, a definition of asthma is warranted. Although the features of asthma are well documented (Beasley, Crane, Lai, & Pearce, 2000; Ger-

gen, Mullally, & Evans, 1988; Martinez, 2002; Martinez et al., 1995), defining asthma remains a problem (Castro-Rodriguez, Holberg, Martinez, & Wright, 2000; Taylor & Newacheck, 1992). Asthma is characterized by inflammation of the airways linked to hyper-responsiveness (Nowak et al., 1996), meaning that the airways leading to the lungs

can narrow when individuals are exposed to anything to which they are sensitive. Inflammation and bronchial constriction are characterized by wheezing, coughing, and chest tightness (Belanger et al., 2003). Scientists and clinicians have agreed that asthma is not a single disease; it exists in many forms (Bacharier et al., 2004).

The past decade has been characterized by proliferation of expert practice guidelines (Fuhlbrigge et al., 2002; National Asthma Education and Prevention Program, 1997), all with the goals of disseminating scientific knowledge to the practicing clinician and the widespread implementation of anti-inflammatory therapy to improve asthma outcomes (Adams et al., 2001; Diaz et al., 2000; Halterman, Aligne, Auinger, McBridge, & Szilagyi, 2000). To this extent, much emphasis has been on early diagnosis and longitudinal care of patients with asthma, along with ensuring adherence to the recommended therapies (Stempel, McLaughlin, Stanford, & Fuhlbrigge, 2005). Yet, as exciting as changes have been in asthma research and practice, many controversies abound when considering asthma and asthma-like symptoms in children aged five and younger.

Data on asthma in children younger than five years of age are sparse. Establishing a diagnosis of asthma in young wheezing children can be challenging because the type, severity, and frequency of asthma symptoms vary widely among children and sometimes even with an individual child (Martinez, 2002). Also, not all wheezing or coughing is caused by asthma (Martinez et al., 1995). Asthma in children usually has many causes

or triggers that may change as a child ages (Melén, Wickman, Nordvall, van Hage-Hamsten, & Lindfors, 2001). A child's reaction to a trigger may also change with treatment. In children under five years of age, the most common cause of asthma-like symptoms is upper respiratory viral infections such as the common cold (Lemanske et al., 2005).

Diagnostic tools and current treatment recommendations do not address adequately the needs of children age five and under (van Schayck, van Der Heijden, van Den Boom, Tirimanna, & van Herwaarden, 2000). Asthma is often difficult to diagnose in infants, but in older children the disease can be diagnosed based on the child's medical history, symptoms, and physical exam (Castro-Rodriguez et al., 2000). The majority of the asthma estimates contained in most reports are dependent on conjecturing diagnoses and documenting these results in patients' records, with the potential of either underestimates or overestimates of cases (Kuehni, Davis, Brooke, & Silverman, 2001; van Schayck et al., 2000). Surveillance will help determine the true disease burden of asthma in children younger than five years of age. Our study was conducted to gather preliminary data regarding the prevalence of asthma-like symptoms in young children and to explore environmental exposure sources that may be impacting symptoms.

Methods

Background and Subject Selection

Our study was approved in accordance with Allegheny County Health Department (ACHD) procedures, with approval granted by the ACHD director rather than an institutional review board. All participants gave written informed consent.

To determine prevalence of asthma in preschool children below the usual age of spirometry (e.g., 5–6 years), subjects for our exploratory case-control study were selected from the Woman, Infants, and Children (WIC) program—a nutrition program that provides food, infant formula, and breastfeeding/nutrition education to income-eligible pregnant, breast-feeding, and bottle-feeding women. The program targets infants, toddlers, and children up to five years of age who meet certain medical or nutritional risk criteria. The WIC program in Allegheny County,

Pennsylvania, serves an average of 15,640 individuals per month, with approximately 50% self-identifying as members of a racial/ethnic minority. To best capture those individuals who would potentially be at greatest risk of reporting asthma-like symptoms, the investigators focused on five WIC program sites. These sites were selected because of their proximity to air monitoring stations and the number of asthma hospitalizations reported by local hospitals. The local health department reported that these geographical areas had potentially poor air quality (Allegheny County Health Department, 2010).

A counter-matched sampling design (Langholz & Goldstein, 2001) was utilized to select subjects for this nested case-control study. The study base consisted of 5% ($n = 810$) of the individuals served by Allegheny County WIC, who were caregivers of children five years of age and younger at the time of the interview and had completed active follow-up of WIC services. Of this study base, 14.7% ($n = 119$) refused participation. From those caregivers of children who chose to participate, all children with histories of wheezing episodes or asthma diagnosis before age five were assigned to the case group ($n = 279$). Matched controls ($n = 412$) were asthma-free children randomly selected from each of the qualifying target sites, with approximately equal numbers of children who were exposed or unexposed to maternal smoking within each sampling stratum.

Inclusion Criteria

Individuals who had appointments to receive WIC services were approached in waiting rooms of WIC providers. Individuals who were WIC participants were eligible for study participation if they were current WIC members with a child five years of age or younger. Because some of the WIC clinics shared office space and waiting room areas with other health agencies, any person coming to these clinics with a child approximately five years of age or younger was also approached. Potential study participants were informed that ACHD was conducting a study on asthma, that the interview would probably take less than five minutes, and that they would receive a grocery store gift card for their participation. Mothers, fathers, grandparents, and foster parents were interviewed. Pregnant women who were pregnant

with their first child, or whose other children were older than five were not included in the sample. For convenience, all participants are referred to as caregivers.

Data Collection

The caregiver of each case and control provided detailed information on demographics, family history of asthma, feeding practices in infancy, day care attendance, and the household environment (cockroaches, pets, herbicides, and pesticides), through a structured interview. When the caregiver did not state the child's racial data, the interviewer inserted this information based on physical appearance.

Exposure Assessment

For the environmental exposures, including exposures to cockroach, pets, and pesticides, mutually exclusive categories of exposure were recorded as “ever exposed” or “never exposed.” To have a surrogate measure of particulate air pollutant exposures at home, caregivers provided a self-report of the child's exposure to wood or oil smoke, soot, dust, or exhaust (specified as referring to home heating sources rather than exposure to auto exhaust in the greater environment). While a subjective measure of air pollution, exposure to wood or oil smoke, soot, dust, or exhaust best captured what respondents understood to be descriptive patterns of air pollution exposure in the home for participating children. It is noteworthy that most participants were not aware of the geographical locations of local air monitoring stations. Although air monitoring data and residential proximity to monitoring stations would have been useful data sources to triangulate reporting, such data collection was beyond the scope of our preliminary study. Maintaining respondent confidentiality and anonymity was a primary concern for this vulnerable population. On the basis of the patterns of exposure in participating children, exposure was defined in three periods: (a) never exposed, (b) exposed since first year of life that continued after one year of age, and (c) exposed only after first year of life.

Outcome Assessment

Asthma status was defined using the response to the question, “Do you have any children four years of age or younger who have ever wheezed when they breathe for any reason?” Wheezing was defined as a high pitched whis-

ling sound during breathing occurring when air flowed through narrowed breathing tubes. Responses to this question were subjective (i.e., self-report) and not based on clinical findings. The age of onset was classified into mutually exclusive categories of early (by three years of age) and late (after three years of age) onset. An asthma case was assigned as having persistent wheezing if the child had (a) one or more episodes of wheezing in the 12 months before study entry, or (b) used prescribed medication for asthma in the 12 months before study entry or after starting preschool. Of the 279 cases, 47 (16.8%) had early transient wheezing, 166 (59.5%) had early persistent asthma, and 166 (59.5%) had late-onset asthma. Children were grouped into two wheezing status categories: those children who “never wheezed” and those children who “wheezed.”

Assessment of Confounders and Effect Modifiers

Maternal smoking during pregnancy was coded as yes (had ever smoked) or no (did not smoke). Secondhand tobacco smoke exposure was defined using the number of household smokers (none, 1, >1) during infancy. Family history of asthma or allergy was defined as any first-degree relative with a diagnosis of asthma or allergy. The yearly family income limits were an annual gross income of \$17,224 for a family of one; \$23,107 for two; \$28,990 for three; \$34,873 for four; \$40,756 for five; \$46,639 for six; \$52,522 for seven; and \$58,405 for eight. Unborn children were counted in determining family size when the woman was pregnant. Maternal or caregiver education at study entry was categorized into five groups: <12th grade education, completed 12th grade, some college, completed college, and some graduate education. Race/ethnicity was grouped into five categories: non-Hispanic Whites, Hispanics, African-Americans, Asians, and others.

Statistical Analysis

Odd ratios (ORs) of physician-diagnosed asthma patients were estimated by fitting conditional likelihood logistic regression models accounting for the counter-matched sampling using the methods described by Langholz and Goldstein (2001). The number of nonparticipants, including those who declined to participate, was considered in the likelihood. Pairwise conditional logistic

TABLE 1

Selected Demographic Characteristics of the Study Sample

Characteristics	Case # (%)	Control # (%)
Gender		
Male	177 (63.4)	234 (56.8)
Female	102 (36.6)	178 (43.2)
Race/ethnicity		
Non-Hispanic white	133 (43)	177 (57)
African-American	220 (58)	160 (42)
Asian and other	3 (1)	3 (1)
Maternal/caregiver education		
<12th grade	82 (29.7)	155 (38.4)
12th grade	137 (49.6)	195 (48.3)
Some college	24 (8.7)	22 (5.4)
College	33 (12.0)	32 (7.9)
Annual family income (\$) for family sizes of two or more children		
<7,500	37 (14.8)	86 (23.6)
7,500–14,999	40 (16.0)	59 (16.2)
15,000–29,999	174 (69.2)	220 (60.2)
Health insurance coverage		
Yes	250 (90.6)	346 (84.8)
No	26 (9.4)	62 (15.2)
Family history of asthma		
Yes	150 (58.1)	296 (79.4)
No	108 (41.9)	77 (20.6)

regression models were used to assess the role of the exposures in different subgroups of levels and intensity of asthma (i.e., early transient wheezing, early persistent, and late-onset asthma) and on age of onset at asthma diagnosis (i.e., asthma diagnosis by age three versus diagnosis after age three). Education, income, race/ethnicity, secondhand smoke, and maternal or family history of asthma confounded the associations between the exposures of interest and asthma. Potential confounding covariate factors were included in final models if their inclusion resulted in a 10% change in the parameter estimate. To investigate whether any of these characteristics modified the associations of the exposures of interest with asthma, conditional logistic regression models were compared with and without appropriate interaction terms using likelihood ratio tests. All tests were two-sided at a 5% significance level.

Results

Table 1 summarizes the demographic characteristics of the study subjects. Most of the

study subjects (55%, $n = 380$) were African-American and male (59%, $n = 411$) and had low socioeconomic status with an annual family income of nearly \$20,000 for a family of two or more. Family history of asthma was more common among cases than among controls. No statistical difference occurred in maternal or caregiver education level, yearly family income, or access to health care measured in terms of health insurance coverage between cases and controls.

Table 2 summarizes the associations between various risk factors that were examined. Exposure to wood or oil smoke, soot, or exhaust was significantly associated with early-life asthma. Children exposed to wood or oil smoke, soot, or exhaust were at a 1.6-fold higher risk of asthma than those who were never exposed ($OR = 1.61$; 95% confidence interval [CI], 1.03–2.51). This association appeared stronger when exposure occurred in the first year of life ($OR = 1.74$; 95% CI, 1.02–2.96). In subgroup analysis, exposure to wood or oil smoke, soot, or exhaust was positively associated with both early- and late-onset

TABLE 2

Associations Between Any Asthma, Early Transient Wheezing, Early-Onset Persistent Asthma, and Late-Onset Asthma and Selected Environmental Exposures

Exposure	Control #	Any Asthma		Early Transient Wheezing		Early-Onset Persistent Asthma		Late-Onset Asthma	
		#	OR ^a (95% CI) ^a	#	OR ^a (95% CI)	#	OR ^a (95% CI)	#	OR ^a (95% CI)
Wood/oil smoke, soot, or exhaust									
Never	310	201	1.0	32	1.0	122	1.0	47	1.0
Ever	102	78	1.61 (1.03–2.51)	15	4.32 (1.80–10.38)	44	1.59 (0.94–2.70)	19	1.12 (0.52–2.43)
In first year and later	60	46	1.74 (1.02–2.96)	10	5.65 (1.97–16.20)	22	1.62 (0.84–3.10)	14	1.35 (0.58–3.16)
Not in first year	42	32	1.44 (0.77–2.68)	5	2.99 (0.86–10.41)	22	1.57 (0.77–3.21)	5	0.73 (0.22–2.42)
Cockroaches									
Never	364	240	1.0	38	1.0	143	1.0	59	1.0
Ever	102	78	1.61 (1.03–2.51)	15	4.32 (1.80–10.38)	44	1.59 (0.94–2.70)	19	1.12 (0.52–2.43)
In first year and later	60	46	1.74 (1.02–2.96)	10	5.65 (1.97–16.20)	22	1.62 (0.84–3.10)	14	1.35 (0.58–3.16)
Not in first year	42	32	1.44 (0.77–2.68)	5	2.99 (0.86–10.41)	22	1.57 (0.77–3.21)	5	0.73 (0.22–2.42)
Pets									
Never	82	58	1.0	9	1.0	34	1.0	15	1.0
Ever	330	221	1.42 (0.88–2.29)	38	2.61 (0.89–7.71)	132	1.41 (0.80–2.47)	51	0.73 (0.32–1.64)
In first year and later	224	146	1.48 (0.88–2.47)	23	2.34 (0.72–7.55)	90	1.47 (0.80–2.68)	33	0.78 (0.32–1.90)
Not in the first year	106	75	1.35 (0.78–2.33)	15	2.90 (0.91–9.25)	42	1.32 (0.69–2.53)	18	0.67 (0.27–1.67)
Aerosols/indoor pesticides									
Never	387	257	1.0	46	1.0	151	1.0	60	1.0
Ever	25	22	1.20 (0.58–2.47)	1	0.26 (0.02–4.36)	15	1.36 (0.61–3.01)	6	1.21 (0.40–3.68)
In first year and later	5	11	4.58 (1.36–15.43)	0	–	10	10.08 (2.46–41.33)	1	2.26 (0.19–27.43)
Not in the first year	20	11	0.58 (0.24–1.39)	1	0.26 (0.02–4.36)	5	0.36 (0.12–1.11)	5	1.09 (0.33–3.58)
Exclusive breast-feeding									
<4 months	280	163	1.0	32	1.0	100	1.0	31	1.0
≥4 months	121	111	1.34 (0.88–2.04)	14	1.34 (0.54–3.33)	62	1.27 (0.77–2.11)	35	1.98 (0.96–4.07)

^a OR = odds ratio; CI = confidence interval. ORs are matched on age, sex, and community of residence (i.e., proximity to air monitoring station), counter-matched on in utero maternal smoking and adjusted for race/ethnicity.

asthma. The ORs were statistically significant for early transient wheezing, for which exposure since the first year of life was associated with a more than five-fold increased risk (OR = 5.65; 95% CI, 1.97–16.20).

Children exposed to cockroaches were also at significantly higher risk for childhood asthma. Children exposed to cockroaches in their infancy had a nearly two-fold higher risk of asthma than those not exposed (OR = 1.74, 95% CI, 1.02–2.96). Any cockroach exposure was associated with early transient wheezing (OR = 5.65; 95% CI, 1.97–16.20). This association derived from exposure to

cockroaches after the first year, which was associated with increased risk for early transient wheezing. Exposure to pets was not associated with asthma in our data. Furthermore, specific types of pets (e.g., dogs, cats, birds, and other furry animals) were not associated with asthma (results not shown).

Children exposed to aerosols and indoor pesticides in the first year of life were significantly at higher risk of asthma (OR = 4.58, 95% CI, 1.36–15.43) although exposure beginning after the first year of life was not associated with increased risk of asthma. When aerosols and indoor pesticide expo-

sure were considered together, children exposed to any aerosol or pesticide in the first year of life were at a 2.53-fold higher risk of asthma compared with children who were never exposed (OR = 2.53; 95% CI, 1.25–5.09). The ORs for the association of exposure to aerosols and indoor pesticide and early persistent asthma were largest for exposure beginning in the first year of life (OR = 3.78, 95% CI, 1.70–8.41).

No association was found between exclusive breast-feeding and any asthma outcome. Family or maternal history of asthma, secondhand tobacco exposure, maternal smok-

ing during pregnancy, gestational age, yearly family income, health insurance coverage, and maternal education level did not confound the association between any of the early-life exposures and asthma outcomes. Therefore, these variables were not included in the final models. Furthermore, none of the associations between the exposures and early-life asthma varied by family or maternal history of asthma or allergy.

In our study, the estimate of prevalence of wheezing behavior in a population of low-income preschool children was found to be 31%; however, 51% of those children with wheezing, as reported by caregivers, had not received a diagnosis of asthma.

Multivariate analyses showed that increasing age, male gender, presence of allergies (although not the type of allergies), and the presence of eczema at birth predicted wheezing behaviors in children in the WIC population. The data showed gender as a predictor of wheezing. For example, males were 1.6 times more likely to wheeze than females. When breathing problems after physical activity or after exposure to cigarette smoke were considered, the presence of eczema at birth and breathing problems after exposure to cigarette smoke were significantly associated with wheezing behaviors.

Discussion

The diagnosis of asthma in young children may well be more challenging than previously appreciated. The difficulty of accurate diagnosis is often underestimated by clinicians who may link it to a passing cold or other nonserious condition rather than relating it to asthma, a chronic and potentially serious disease. What accounts for the widespread perception that the prevalence of asthma is increasing in children, particularly in those younger than five years of age?

Being diagnosed as having asthma is closely related to receiving specific treatment for the condition (Kuehni et al., 2001; van Schayck et al., 2000) and good reason already exists to suppose that pediatricians are seeing more children whom they recognize as having asthma-like symptoms. Increases in hospital admissions and general practice consultations for asthma have been reported (Homer et al., 1996; Ordonez, Phelan, Olin-sky, & Robertson, 1998). Such increases may reflect changes in diagnosis and treatment

of asthma-like symptoms rather than an increase in the prevalence of the disease.

The percentages of wheezing children ranged from 1% of Hispanic children to more than 59% of African-American children. Most children had mild to moderate degrees of severity. Atopy, environmental triggers, and tobacco smoke exposure were common risk factors.

Our study found that older children, males, those with allergies, and those with eczema at birth were at increased risk for wheezing behavior that is common to asthma. The greatest proportional increase among the boys, and a substantial increase among the girls, was in those with persistent symptoms but no diagnosis of asthma or asthma-like disease. In view of the close association that is believed to exist between diagnostic labels and treatment, this is particularly troubling. It may indicate an increasing number of untreated cases with moderately severe disease.

Our study had several limitations. It examined children participating in the Allegheny County, Pennsylvania, WIC program, which serves families of low socioeconomic status, so the findings do not represent the general population. This sample was also not representative of the racial distribution, or of the access to health care and health-related products and practices of the general population. Other limitations of our study include the extremely limited ability to draw causal inferences due to the cross-sectional nature of the study, as well as the recall bias associated with asking questions about events and conditions that may have occurred up to five years ago for some participants.

Other study limitations relate to operational definitions. Our study was designed to explore a wide range of environmental exposures that may impact asthma-like symptoms. Case definitions of asthma-like symptoms were broadly defined in an effort to capture the widest possible range of asthma and asthma-like symptoms, whether or not a participant had ever received a formal diagnosis of asthma. Likewise, exposure status was defined using mutually exclusive categories of occurring or not occurring in an effort to capture the widest possible range of exposure factors. Detailed exposure data such as frequency, duration, or magnitude of exposure were not collected, thus limiting statistical analysis capabilities. Although reported air

quality and the number of asthma hospitalizations were used to select interview sites, our study was based solely on subjective caregiver self-report. Residential addresses would have provided the ability to triangulate empirical air quality data, but protecting participant anonymity was an overriding concern for our study, so no personally identifying information was collected.

Conclusion

The results from this exploratory study suggest that nearly 30% of the low-income preschool population may be at risk for asthma or asthma-like symptoms, and that African-American children may be at higher risk for wheezing behavior than other racial groups. Of those at risk, approximately half reported no diagnosis of asthma. Despite a greater awareness and better understanding of asthma, the problem of definition and diagnosis remains unresolved. Further research is necessary to improve understanding of the differences between children who wheeze and those who do not, as well as comparing the experiences of children who have been diagnosed with asthma and those who have not. Such studies would benefit from an examination of medical records, particularly regarding diagnosis of asthma or repeated doctor or hospital visits for breathing problems.

Future studies will also benefit from inclusion of empirically based indicators of environmental exposures, such as air monitoring data and the frequency, duration, and magnitude of exposures. This line of research is important for designers of primary prevention efforts in this population. Because environmental exposures may increase risk for development of asthma-like symptoms, educational outreach to parents and caregivers of young children about environmental exposures may be one such prevention method. ■■■

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Corresponding Author: Anthony G. Robins, Director, Program and Research, Center for Black Male Educational Success, Robert Morris University, Wheatley Center Room 301, 6001 University Blvd., Moon Township, PA 15108. E-mail: robins@rmu.edu.

References

- Adams, R.J., Fuhlbrigge, A., Finklestein, J.A., Lazano, P., Livingston, J.M., Weiss, K.B., & Weiss, S.T. (2001). Impact of inhaled anti-inflammatory therapy on hospitalization and emergency department visits for children with asthma. *Pediatrics*, 107(4), 706–711.
- Allegheny County Health Department. (2010). *Air quality annual data summary: Criteria pollutants and selected other pollutants for 2010*. Pittsburgh, PA: Author.
- Bacharier, L.B., Strunk, R.C., Mauger, D., White, D., Lemanske, R.F., Jr., & Sorkness, C.A. (2004). Classifying asthma severity in children: Mismatch between symptoms, medication use, and lung function. *American Journal of Respiratory Critical Care Medicine*, 170(4), 426–432.
- Beasley, R., Crane, J., Lai, C.K., & Pearce, N. (2000). Prevalence and etiology of asthma. *Journal of Allergy and Clinical Immunology*, 105(2 Pt. 2), S466–472.
- Belanger, K., Beckett, W., Triche, E., Bracken, M.B., Holford, T., Ren, P., McSharry, J.E., Gold, D.R., Platts-Mills, T.A., & Leaderer, B.P. (2003). Symptoms of wheeze and persistent cough in the first year of life: Associations with indoor allergens, air contaminants, and maternal history of asthma. *American Journal of Epidemiology*, 158(3), 195–202.
- Castro-Rodriguez, J.A., Holberg, C.J., Martinez, F.D., & Wright, A.L. (2000). A clinical index to define risk of asthma in young children with recurrent wheezing. *American Journal of Respiratory Critical Care Medicine*, 162(4), 1403–1406.
- Diaz, T., Sturum, T., Matte, T., Bindra, M., Lawler, K., Findley, S., & Maylahn, C. (2000). Medication use among children with asthma in East Harlem. *Pediatrics*, 105(6), 1188–1193.
- Fuhlbrigge, A.L., Adams, R.J., Guilbert, T.W., Grant, E., Lozano, P., Janson, S.L., Martinez, F., Weiss, K.B., & Weiss, S.T. (2002). The burden of asthma in the United States: Level and distribution are dependent on interpretation of the national asthma education and prevention program guidelines. *American Journal of Respiratory Critical Care Medicine*, 166(8), 1044–1049.
- Gergen, P.J., Mullally, D.I., & Evans, R., III. (1988). National survey of prevalence of asthma among children in the United States, 1976 to 1980. *Pediatrics*, 81(1), 1–7.
- Halterman, J.S., Aligne, C.A., Auinger, P., McBride, J.T., & Szilagyi, P.G. (2000). Inadequate therapy for asthma among children in the United States. *Pediatrics*, 105(S2), 272–276.
- Homer, C.J., Szilagyi, P., Rodewald, L., Bloom, S.R., Greenspan, P., Yazderki, S., Leventhal, J.M., Finkelstein, D., & Perrin, J.M. (1996). Does quality of care affect rates of hospitalization for childhood asthma? *Pediatrics*, 98(1), 18–23.
- Kuehni, C.E., Davis, A., Brooke, A.M., & Silverman, M. (2001). Are all wheezing disorders in very young (preschool) children increasing in prevalence? *Lancet*, 357, 1821–1825.
- Langholz, B., & Goldstein, L. (2001). Conditional logistic analysis of case-control studies with complex sampling. *Biostatistics*, 2(1), 63–84.
- Lemanske, R.F., Jackson, D.J., Gangnon, R.E., Evans, M.D., Li, Z., Shult, P.A., Kirk, C.J., Reisdorf, E., Roberg, K.A., Anderson, E.L., Carlson-Dakes, K.T., Adler, K.J., Gilbertson-White, S., Pappas, T.E., DaSilva, D.F., Tisler, C.J., & Gern, J.E. (2005). Rhinovirus illnesses during infancy predict subsequent childhood wheezing. *Journal of Allergy and Clinical Immunology*, 116(3), 571–577.
- Martinez, F.D. (2002). Development of wheezing disorders and asthma in preschool children. *Pediatrics*, 109(2 Supp.), 362–367.
- Martinez, F.D., Wright, A.L., Taussig, L.M., Holberg, C.J., Halonen, M., Morgan, W.J., & the Group Health Medical Associates. (1995). Asthma and wheezing in the first six years of life. *New England Journal of Medicine*, 332(3), 133–138.
- Melén, E., Wickman, M., Nordvall, S.L., van Hage-Hamsten, M., & Lindfors, A. (2001). Influence of early and current environmental exposure factors on sensitization and outcome of asthma in preschool children. *Allergy*, 56(7), 646–652.
- National Asthma Education and Prevention Program. (1997). *Expert panel report 2: Guidelines for the diagnosis and management of asthma* (Publication No. 97-4051). Bethesda, MD: National Institute of Health.
- Nowak, D., Heinrich, J., Jorres, R., Wassmer, G., Berger, J., Beck, E., Boczor, S., Claussen, M., Wichmann, H.E., & Magnussen, M. (1996). Prevalence of respiratory symptoms, bronchial hyperresponsiveness and atopy among adults: West and East Germany. *European Respiratory Journal*, 9(12), 2541–2552.
- Ordonez, G.A., Phelan, P.D., Olinsky, A., & Robertson, C.F. (1998). Preventable factors in hospital admission for asthma. *Archives of Diseases in Childhood*, 78(2), 143–147.
- Stempel, D.A., McLaughlin, T.P., Stanford, R.H., & Fuhlbrigge, A.L. (2005). Patterns of asthma control: A 3-year analysis of patient claims. *Journal of Allergy Clinical Immunology*, 115(5), 935–939.
- Taylor, W.R., & Newacheck, P.W. (1992). Impact of childhood asthma on health. *Pediatrics*, 90(5), 657–662.
- van Schayck, C.P., van der Heijden, F.M., van den Boom, G., Tirmann, P.R., & Van Herwaarden, C.L. (2000). Underdiagnosis of asthma: Is the doctor or the patient to blame? The DIMCA project. *Thorax*, 55(7), 562–565.

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