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The Relationship Between Breastfeeding and the Development of Asthma in Early Childhood

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Title Page
Master of Public Health Research Project

The relationship between breastfeeding and the development of asthma in early childhood.

by

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MPH Research Project: EPID 691

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Master of Public Health
Research Project Agreement Form
Department of Epidemiology and Community Health

Student name: River Ann Pugsley E-mail address: _____

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_____

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Number of semester hours (3-6): 3 Semester: Summer Year: 2005

Please complete the following outline. **Do not exceed 2 pages (A-H).**

A. PROJECT TITLE:
The relationship between breastfeeding and the development of asthma in early childhood.

B. PURPOSE (state hypothesis/research question):
Is breastfeeding, or the duration of breastfeeding, related to the development of asthma and other allergies in early childhood?

C. SPECIFIC OBJECTIVES (list major aims of the study):
1. Determine the prevalence and duration of breastfeeding in the sample population.
2. Determine the prevalence of asthma and other allergies (skin, respiratory, and digestive) among children in the sample population.
3. Determine whether the prevalence of asthma and other allergies is greater among children who were not breastfed compared to those who were.
4. Determine whether there is a dose-response relationship between the length of breastfeeding and the prevalence of asthma and other allergies.
5. Identify any socio-demographic factors that might play a role in the interaction between breastfeeding and allergies (i.e. confounding variables.

D. DESCRIPTION OF METHODS

D.1. Identify source(s) of data (eg, existing data set, data collection plans, etc):
State and Local Area Integrated Telephone Survey (SLAITS): National Survey of Children's Health, 2003.

D.2. State the type of study design (eg, cross-sectional, cohort, case-control, intervention, etc):
SLAITS utilizes a cross-sectional survey design. Data were collected via telephone interviews conducted between January 2003 and July 2004.

D.3. Describe the study population and sample size:
The study population consists of children ages 0 to 17 years old (sampling frame), although breastfeeding questions were only asked for children under 6 years of age. The

total sample size for this survey was 102,353 children. The total number of children under six years of age at the time of the survey was 33,315.

D.4. List variables to be included (If a qualitative study, describe types of information to be

- Breastfeeding (Y/N)
- Age in days when stopped breastfeeding
- Asthma (Y/N)
- Respiratory allergy (Y/N)
- Digestive allergy (Y/N)
- Skin allergy (Y/N)
- *Optional Variables:* severity of asthma, asthma hospitalizations, asthma medications, perceived asthma burden, and perceived overall health of child.

D.5. Describe methods to be used for data analysis

Frequencies, prevalence, and odds ratios will be calculated. A chi-square test of heterogeneity will be conducted to test for differences between breastfeeding exposure groups. The primary outcome variable will be the presence of asthma or any other allergy in early childhood, and subsequent analyses will be conducted by breaking down this composite variable into its component parts. A stratified analysis will be conducted to adjust for socio-demographic variables that are potential confounders. In addition, a student's t-test will be used to analyze any differences in mean duration of breastfeeding based on asthma or allergy outcomes. Finally, a chi-square test for trend will be conducted to evaluate whether a dose-response relationship exists. Either SPSS or SAS statistical software will be used for these analyses.

E. ANTICIPATED RESULTS:

Based on background research and preliminary prevalence analysis, it is believed that the act of breastfeeding exerts a protective effect against the development of asthma and other allergies in early childhood (0 to 6 years of age). It is also hypothesized that the duration of breastfeeding may have a dose-response relationship with the development of such allergies, so that as duration increases, the prevalence of allergies in early childhood decreases.

F. SIGNIFICANCE OF PROJECT TO PUBLIC HEALTH:

The development of allergies in childhood can have significant adverse effects on the health and quality of life of children, and the prevalence of such conditions, asthma in particular, continues to rise among American children.[1] At the same time, breastfeeding has garnered some attention recently in the health fields because of its potential benefits to early childhood growth, development, and health. Research has shown that there is a strong link between breastfeeding and the development of the immune system in children.[2] Currently, however, there is some uncertainty in the scientific field concerning whether any relationship exists between breastfeeding and asthma and other allergies who etiology is not fully understood.[3] The effect that breastfeeding might exert on the development of allergic immune responses is largely unknown. Although preliminary research suggests that exclusive breastfeeding may protect against asthma and allergenic diseases, other studies have failed to find an association.[4-6] By finding a link between breastfeeding and these allergies, this study has the potential to help clarify this relationship and aid public health efforts to prevent the development of allergies in children.

[1] U.S. Dept. of Health and Human Services. Asthma prevalence, health care use, and mortality, 2002. Centers for Disease Control and Prevention, National Center for Health Statistics. Hyattsville, MD.
[2] Hanson LA, Korotkova M, Telemo E. (2003 June). Breast-feeding, infant formulas, and the immune system. Ann Allergy Asthma Immunol. 90(6 Suppl 3):59-63.
[3] Oddy WH. (2004 Sept). A review of the effects of breastfeeding on respiratory infections, atopy, and childhood asthma. J Asthma 41(6):605-621.
[4] Gijsbers B, Mesters I, Andre Knottnerus J, Legtenberg AH, van Schayck CP. (2005 April). Factors influencing breastfeeding practices and postponement of solid food to prevent allergic disease in high-risk children: results from an explorative study. Patient Educ Cons. 57(1):15-21.
[5] Al-Kubaisy W, Ali SH, Al-Thamiri D. (2005 March). Risk factors for asthma among primary school children in Baghdad, Iraq. Saudi Med J. 27(3):460-466.
[6] Becker AB. (2005 Feb). Primary prevention of allergy and asthma is possible. Clin Rev Allergy Immunol. 28(1):5-16.

G. IRB Status:

1) Do you plan to collect data through direct intervention or interaction with human subjects? ___yes __X__no

2) Will you have access to any existing identifiable private information? ___yes __X__no

If you answered "no" to both of the questions above, IRB review is not required.
If you answered "yes" to either one of these questions, your proposed study must be reviewed by the VCU Institutional Review Board (IRB). Please contact Dr. Turf or Dr. Buzzard for assistance with this procedure.

Please indicate your IRB status:
___ to be submitted (targeted date_____)
___ submitted (date of submission _____; VCU IRB # _____)
___ IRB exempt review approved (date_____)
___ IRB expedited review approved (date_____)
___ IRB approval not required

H. PROPOSED SCHEDULE: Start Date: _5/23/05____Anticipated End Date:__7/25/05___

I. INDICATE WHICH OF THE FOLLOWING AREAS OF PUBLIC HEALTH KNOWLEDGE WILL BE DEMONSTRATED:

1. Biostatistics – collection, storage, retrieval, analysis and interpretation of health data; design and analysis of health-related surveys and experiments; and concepts and practice of statistical data analysis. __X_yes ___no (if yes, briefly describe):
   Principles of biostatistics will be utilized to analyze and interpret secondary data from a national health cross-sectional survey.

2. Epidemiology – distributions and determinants of disease, disabilities and death in human populations; the characteristics and dynamics of human populations; and the natural history of disease and the biologic basis of health. __X_yes ___no (if yes, briefly describe):
   Epidemiologic methods will be applied to help evaluate a possible determinant of childhood asthma and other allergies, as well as to describe the demographic characteristics associated with such allergies.

3. Environmental Health Sciences – environmental factors including biological, physical and chemical factors which affect the health of a community. ___yes _X_no (if yes, briefly describe):

4. Health Services Administration – planning, organization, administration, management, evaluation and policy analysis of health programs. ___yes __X_no (if yes, briefly describe):

5. Social/Behavioral Sciences – concepts and methods of social and behavioral sciences relevant to the identification and the solution of public health problems. ___yes __X_no (if yes, briefly describe)

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Acknowledgements

I would like to thank my advisor and preceptor, Dr. Shelley Harris and Dr. Derek Chapman, for all their support and help with this project. Their advice concerning various statistical analyses was invaluable, as was their enthusiasm.

Abstract

Purpose: Asthma can have significant adverse effects on the health and quality of life of children, and the prevalence of this condition continues to rise. Breastfeeding may protect against asthma, but some uncertainty remains. The purpose of this study was to further examine the relationship between breastfeeding and the risk of developing asthma in early childhood.
Methods: Data were collected from the State and Local Area Integrated Telephone Survey: National Survey of Children's Health, 2003. The study population consisted of 33,315 children ages 0 to 5 years. Prevalence rates of asthma and breastfeeding were calculated, as were crude and Mantel-Haenszel summary odds ratios for breastfeeding and other potential confounders including age, race, education, poverty, and tobacco use. Logistic regression models were used to estimate odds ratios and 95% confidence intervals after adjustment for these confounders.
Results: Breastfeeding (never vs. ever) was significantly associated with an increased odds ratio of asthma among the children surveyed (POR = 1.18, 95% CI = 1.04, 1.34). In addition, children with asthma had a slightly lower mean duration of breastfeeding than did children without asthma. However, a significant trend of increasing odds ratios with increasing duration of breastfeeding was not found. It therefore appears that the act of ever breastfeeding, regardless of duration, exerts some protective effect against the development of asthma in early childhood.
Conclusions: Never breastfeeding was found to be significantly associated with the development of asthma in early childhood. Age, race, education, poverty level, and tobacco use were also implicated in this association. While further research is needed to fully determine the effectiveness of breastfeeding in the primary prevention of asthma, public health efforts should focus on promoting breastfeeding as it has the potential improve the overall health of children.

Introduction

Asthma constitutes a significant public health problem in the United States, especially among children. Rates of asthma have steadily increased over the past 20 years in all age groups, but the most dramatic increases have been observed in children under age 5. Some studies have estimated that this age group has experienced a two and one-half fold increase since the 1980s.[1] Recent estimates rank asthma as the most common cause of chronic illness in children after chronic sinusitis.[2] The overall prevalence of asthma among the United States population is around 11 percent, but the prevalence among children 0 to 17 years of age is 12.2 percent. This is roughly equivalent to 9 million children.[3]

Asthma is a chronic respiratory disease that affects the lungs. It is characterized by episodes or attacks of inflammation. Asthma attacks can vary from mild to life-threatening. During an asthma attack, the sides of airways in the lungs become inflamed and swollen, muscles around the airways tighten, and less air is able to pass in and out of the lungs. Excess mucus may also form in the airways, further blocking the passage of air. Common symptoms of an attack involve shortness of breath, coughing, wheezing, chest pain or tightness, or a combination of these symptoms. Asthma attacks often occur in response to triggers. Such triggers may include various allergens, respiratory infections, exercise, abrupt changes in the weather, and exposure to airway irritants such as tobacco smoke.

Asthma places a significant burden on the health system, as well as on the personal health of those affected. In 2003, it was estimated that 29.8 million people had been diagnosed with asthma during their lifetime.[4] Of these, 19.8 million people were currently diagnosed with asthma, and 11 million people experienced an asthma attack in the previous year. In 2002, asthma accounted for 13.9 million outpatient asthma visits to private physician offices and

hospital outpatient departments. Five million of these patients were children. The visit rate among children was 687 per 10,000 compared to adult rate of 181 per 10,000. Children under 18 also accounted for 727,000 emergency department visits (with rates highest among children aged 0 to 4 years) and 484,000 hospitalizations. Overall, asthma is the third-ranking cause of hospitalization among children under 15.[5] In addition, although deaths among children are rare, approximately 187 children died from asthma in 2002, a rate of 0.3 deaths per 100,000 children.[4]

Although asthma affects people at all socioeconomic levels, poor and minority populations tend to experience a greater asthma burden in terms of chances of dying or being hospitalized. Even after adjustment for common risk factors, asthma is more common in lower than in higher socioeconomic groups.[6] African Americans visit emergency departments, are hospitalized, and die due to asthma at rates up to three times higher than those for white Americans.[5,7] These significant health disparities are a cause for concern. Several other social and demographic factors that increase a child's risk of developing asthma have been identified, such as low parental education, family history of asthma, and smoking.[8]

In addition to the medical burden, asthma is associated with substantial economic costs. In 1998, asthma in the United States accounted for an estimated 12.7 billion dollars annually.[9] Most of these costs are attributable to direct medical expenditures, medications being the largest component of these expenditures. The estimated cost of treating asthma in those under 18 is 3.2 billion dollars per year.[10] Indirect costs also play a large role in overall asthma burden, and can have important social effects. Asthma can have an impact on quality of life and interfere with daily activities, and is one of the leading causes of school absenteeism. In the 2003 National Health Interview Survey, it was found that children aged 5 to 17 years who reported at least one

asthma attack in the previous year, missed approximately 14.7 million school days due to asthma.[11]

With all of this in mind, several organizations have made it their goal to reduce the impact of asthma on society. One the stated goals of *Healthy People 2010* is to reduce the number of deaths, hospitalizations, emergency department visits, school or work days missed, and limitations on activity due to asthma.[12] The CDC's National Asthma Control Program supports these goals and objectives. To this end, the CDC and grantees are currently conducting ongoing asthma tracking and data collection, intervention, partnership, and public health research activities. Priority has been placed on supporting state-based comprehensive asthma control plans and supporting more school-based activities.[7] However, the primary focus of all these efforts is secondary prevention, or the treatment and management of asthma symptoms. According to the CDC, the initial onset of asthma cannot yet be prevented, nor can asthma be cured. Therefore most current efforts focus on controlling asthma and ensuring that people who have asthma can lead quality, productive lives. Only recently have research efforts started to focus more on primary prevention of allergy and allergic diseases like asthma. Many researchers contend that primary prevention of allergy and asthma is possible, and increases in the prevalence of asthma and allergic diseases highlight the need for devising effective preventive strategies.[13]

Asthma symptoms can be controlled by following medical management plans and by avoiding contact with environmental triggers.[7] Focus has been placed on environmental exposures such as house dust mites, environmental tobacco smoke, outdoor air pollution, cockroach allergen, pets, mold, some foods and food additives and drugs that are known to trigger asthma episodes. However, while it is well known that asthma can be triggered by

allergens, it remains unknown why some people develop asthma and others do not. Some scientists believe that ongoing exposure to allergens very early in life may lead to sensitization of the airways, and ultimately asthma. An asthma report issued in January of 2000 by the Institute of Medicine cited sufficient evidence of a causal relationship between exposure to house dust mite allergen and the development of asthma in susceptible children.[14] They also reported an association between exposure to tobacco smoke and the development of asthma in younger children. Their hypothesis is that increases in asthma prevalence might be due to the fact that children are spending more time indoors, thus increasing their exposure to certain allergens and indoor air pollutants.

Other common clinical manifestations of allergy include allergic rhinitis, atopic dermatitis, and food allergy. All of these conditions involve immunological hypersensitivity to specific allergens. In addition to asthma, 12 percent of US children under 18 years of age suffered from respiratory allergies in the past 12 months, 10% from hay fever and 11% from other allergies.[3] As is the case for asthma, the causes and etiology of these allergic diseases remain largely unknown. For example, the causes of food allergy are still unknown, and no particular genes associated particularly with food allergy have been identified.[15] All are likely the result of complex gene-environment interactions. However, research has found that children with atopic dermatitis and allergic rhinitis in later childhood are at increased risk of developing asthma.[16]

It is also known that certain genetic predispositions increase the likelihood of developing asthma. Children with parents diagnosed with asthma are three to six times more likely to develop asthma relative to children who do not have a parent with asthma.[3] However, this only accounts for a small fraction of asthma diagnoses in children, and so the evidence seems to

indicate that certain environmental factors interact with genetics in the development of asthma and other allergies or atopic disorders. Therefore, since genetics cannot be changed, preventive efforts have focused on manipulating environmental risk factors known to play a role in the development of asthma.

A number of intervention studies have focused on reducing one or more environmental exposures in early life that might be modified in families with a strong history of asthma. Some of these environmental interventions have involved indoor aeroallergens and environmental tobacco smoke. In most situations, avoidance of individual risk factors has not been successful in preventing the development of asthma. The large number of potential environmental risk factors, and an inability to accurately predict the development of asthma and allergy, has hindered research efforts, as has conflicting data from different studies concerning the effectiveness of different environmental manipulations. In addition, because primary prevention measures require motivation, effort, and expense, most studies have targeted infants at high risk of allergy to maximize the potential benefit. Family history of allergy is often relied on to identify children at high risk, however the majority of asthmatic children are from families with no history of asthma, and the same is true for atopic dermatitis and allergic rhinitis.[17-18] Therefore, in order to be truly successful, prevention programs must be aimed at the general population, not just those known to be at higher risk.

Since environmental exposure begins during the intrauterine period, it has been proposed that breastfeeding might exert a protective effect against the development of asthma and other allergies in early childhood.[19] There are many known benefits attributable to breastfeeding. Breast milk contains a balance of nutrients that helps infants grow, as well as amino acids that are thought to help infants' brains develop and increase cognitive skills. Perhaps more

importantly, breast milk provides protection against some common childhood illnesses and infections and has been shown to help speed up recovery when infants do become ill.

Research has shown that there is a strong link between breastfeeding and the development of the immune system in children.[20] Lactating mammary glands are part of the integration of the mother's mucosal immune system with the local production of antibodies in the child. Antibodies found in breast milk are highly targeted against infectious agents in the mother's environment. Breastfeeding can reduce the risk of death for infants in the first year of life. A study conducted by the National Institute of Environmental Health Sciences found that children who were breastfed had a 20% lower risk of dying between 28 days and one year than children who were not breastfed, and longer duration of breastfeeding was associated with even lower risk.[21] Epidemiological data suggest that the risk of dying from diarrhea in developing countries could be reduced 14-24 times in breastfed children, and breastfeeding is also helpful in acute lower respiratory infection in the developed world.[22] Studies have found several long-term benefits as well, such as reducing the risk of obesity and hypertension later in life.[23] Breastfeeding also benefits the mother as it helps women to lose weight after pregnancy and releases hormones that cause the uterus to contract.[24]

Despite these benefits, the prevalence of breastfeeding in the United States remains low, and some researchers and agencies feel that this low prevalence is a serious health problem. The American Academy of Pediatrics (AAP) recommends that women should exclusively breastfeed their infants for at least the first six months of life.[25] Furthermore, AAP suggests that women try to breastfeed for the first 12 months of life because of the benefits to both mother and baby. However, according to one national survey, only 70.1% of all mothers breastfed their infants during the early postpartum period, 33.2% breastfed at 6 months, and 19.7% breastfed at 12

months (Mother's Survey, Ross Laboratories, 2002).[26] Rates are even lower among lower-socioeconomic classes and certain ethnic minority groups.[27] Gradual increases in breastfeeding prevalence have been observed for all race and ethnic groups between 1992 and 2001, but the prevalence of infants breastfed remains below the AAP recommendations and the *Healthy People 2010* target.

These data are concerning as there is evidence that duration of breastfeeding is important. Associations have been found between prolonged breastfeeding and allergic disease. A study of poor urban children in South Africa found that allergic diseases, particularly hay fever, were significantly less frequent in those with prolonged breastfeeding (more than 6 months).[28] This protective effect was most pronounced among children born to nonallergenic parents, and was not found in children with allergic predisposition. Conversely, the Australian Society of Clinical Immunology and Allergy contends that complementary foods should be delayed until a child is aged at least 4-6 months, although the preventive effect from this measure has only been demonstrated in high-risk infants with a family history of allergy and asthma (those with allergenic predisposition).[29]

Such contradictory findings are common in the literature studying the association between breastfeeding and the development of asthma. Therefore the role of breastfeeding in the prevention of allergic disease remains controversial. This controversy has been attributed to methodological differences in studies performed, the immunologic complexity of breast milk itself, and possible genetic differences among patients (especially in mother/infant pairs) that affect whether breast-feeding is protective against the development of allergies or is in fact sensitizing. For example, there is some concern over breastfeeding by mothers with asthma, since their breast milk has been noted to contain higher levels of agents thought to induce

sensitization to allergens in infants.[30] Overall, studies to date have found one of three results: breast feeding decreases the risk of developing atopy/allergy to some degree, increases the risk, or has no effect.[8,31-32]

One large critical review of the literature in 2003 examined 4,323 articles, but excluded 90% of them as being uninformative.[33] Of the remaining 56 articles that were analyzed, the review committee found that exclusive breast-feeding reduced asthma risk, and that any breast-feeding reduced recurrent wheeze for at least the first decade in all children regardless of atopic risk. This protection increased with duration of breastfeeding as long as 4 months, and the protective effect was found to be even greater in children at high risk for atopy. Similarly, a different group of researchers conducted a meta-analysis to examine 12 prospective studies that examined the effect of breast-feeding on the development of atopic dermatitis and asthma.[34] This included more than 8,000 subjects with a mean follow-up of 4.1 years. They found that exclusive breastfeeding for the first 3 months of life offered protection against the development of childhood asthma in those children at high risk for atopy, but not in those at low risk.

While the lack of definitive evidence does not allow specific recommendations concerning breastfeeding for the prevention of allergy and allergic disease, breastfeeding has been hailed as a hallmark in the prevention of allergy in guidelines by some researchers and agencies such as the AAP. In addition, it is not controversial that breastfeeding is the preferred method of infant nutrition in most cases because of its nutritional, immunological, and psychological benefits.

In summation, the development of allergies in childhood can have significant adverse effects on the health and quality of life of children, and the prevalence of such conditions, asthma in particular, continues to rise among American children. At the same time, breastfeeding has

garnered some attention recently in the health fields because of its potential benefits to early childhood growth, development, and health. Research has shown that there is a strong link between breastfeeding and the development of the immune system in children. Currently, however, there is some uncertainty in the scientific field concerning the nature of the relationship that exists between breastfeeding and asthma and other allergies whose etiology is not fully understood.[35] The effect that breastfeeding might exert on the development of allergic immune responses is largely unknown. Although preliminary research suggests that breastfeeding may protect against asthma and allergenic diseases, other studies have failed to find an association. By utilizing a large national dataset, this study has the potential to help clarify this relationship and aid public health efforts to prevent the development of allergies in children.

To further examine the relationship between breastfeeding and risk of developing asthma in early childhood, data from a national cross-sectional survey were analyzed. The data were collected from the State and Local Area Integrated Telephone Survey: National Survey of Children's Health, 2003. The study population consisted of children ages 0 to 17 years (102,353 children), although breastfeeding questions were only asked for children 0 to 5 years of age (33,315 children).

Study Objectives

1. Determine the prevalence of asthma and other allergies (skin, digestive, and respiratory) among children in the sample population.
2. Determine the prevalence and duration of breastfeeding in the sample population.
3. Determine whether the prevalence of asthma and allergies is greater among children who were not breastfed compared to those who were.
4. Determine whether there is a dose-response relationship between the length of breastfeeding and the prevalence of asthma and other allergies.
5. Identify any socio-demographic factors that might play a role in the interaction between breastfeeding and the development of asthma or allergies in early childhood (i.e. confounding variables).

Methods

Study Population and Sampling Methods

The data utilized in this analysis were obtained from the State and Local Area Integrated Telephone Survey (SLAITS): National Survey of Children's Health, 2003. A detailed report of the methodology, design and operation of the National Survey of Children's Health, 2003 has been previously published by the National Center for Health Statistics.[36] The National Survey of Children's Health, a module of the SLAITS, was sponsored by the Maternal and Child Health Bureau of the Health and Human Resources and Services Administration. Additional support was received from the Centers for Disease Control and Prevention's (CDC) National Center for Infectious Diseases. The purpose of the National Survey of Children's Health (NSCH) was to examine the physical and emotional health of children 0 to 17 years of age. This cross-sectional survey was designed to produce national and state-specific prevalence estimates that can be meaningfully compared across states and the nation, for a variety of physical, emotional, and behavioral health indicators and measures of children's health. Special emphasis was placed on factors that may relate to well-being of children, including medical history, family interactions, parental health, school and after-school experiences, and safe neighborhoods. The National Survey of Children's Health is the third SLAITS survey to produce national estimates concerning the health of children.

The SLAITS program is conducted by the CDC's National Center for Health Statistics (NCHS). The SLAITS program is a broad-based, ongoing surveillance system available at the state and local levels for tracking and monitoring the health and well-being of children and adults. The SLAITS survey module uses the same Random-Digit-Dial telephone design approach and sampling frame as the ongoing National Immunization Survey (NIS) conducted by

the CDC.[37] The NIS is a large-scale telephone survey that screens for the presence of young children in selected households and collects immunization history information for eligible children. The NSCH questionnaire was programmed as a module of the NIS, integrating the two surveys into a single interview.

Telephone numbers for the NSCH were initially selected from the telephone numbers randomly generated for the NIS screening effort (see NIS Annual Methodology Report for more information).[38-39] To obtain these telephone numbers, a random sample of telephone numbers was chosen by randomly selecting an area code and prefix combination currently in use, and combining it with a randomly chosen four-digit number between 0000 and 9999. Identified business and nonworking telephone numbers were removed from the sample prior to dialing. All remaining telephone numbers were called by an interviewer. Advance letters were mailed prior to any telephone calls when a mailing address could be identified for a sampled telephone number to increase the study legitimacy and response rates. Letters were mailed for 67.4% of the telephone numbers dialed by the interviewers.

When NIS/NSCH telephone numbers were called, they were initially screened for residential status and for the presence of NIS age-eligible children (children aged between 19 and 35 months). NIS interviews were conducted if NIS age-eligible children lived in the household. If NIS age-eligible children did not live in the household, interviewers asked if there were any children under age 18 living in the household. Households identified as having any children less than 18 years of age were eligible for the NSCH. Then, one such child was randomly sampled from all children in each identified household to be the subject of the NSCH interview. The respondent was the parent or guardian who knew the most about the child's health and health care. In over 95% of the households, the respondent was the child's mother/female guardian or

father/male guardian. A monetary incentive was implemented part-way through the data collection period to increase response, but implementation varied by state.

The primary sampling goal of the National Survey of Children's Heath was to select representative samples of children under 18 years of age from each of the 50 states and the District of Columbia. The target number of interviews was set at 2,000 per state to allow reasonably precise estimates of the characteristics of children in each state. The number of households to be screened was calculated using the expected proportion of households with children in each state. The number of telephone numbers dialed was also increased to compensate for the fact that not all respondents would agree to participate.

Questionnaire

The NSCH questionnaire was designed to immediately follow a completed NIS interview in households with an NIS-eligible child, or the NIS screening questions in households without an NIS-eligible child. The NSCH questionnaire was divided into eleven sections: age eligibility screening and demographic characteristics, health and functional status, health insurance coverage, health care access and utilization, medical home, early childhood (0-5 years), middle childhood and adolescence (6-17 years), family functioning, parental health, neighborhood characteristics, and additional demographic characteristics.

All interviews were conducted by trained interviewers. NSCH interviews were administrated in Spanish as well as English, with a professional team of experienced Spanish-language telephone interviewers providing expertise. The NSCH was conducted using a computer-assisted telephone interviewing (CATI) system. During the telephone interview, the questionnaire was presented on a computer screen to each interviewer. The CATI program guided the interviewer through the questionnaire, automatically routing the interviewer to

appropriate questions based on answers to previous questions. All survey responses were entered directly into the computer during the interview. The CATI program determined whether the selected response was within an allowable range, checked it for consistency against other data collected during the interview, and saved the responses in a survey data file.

Data Collection

Telephone interviewing began on January 29, 2003 and was completed on July 1, 2004. A total of 102,353 interviews were completed during this time period. Of these, 101,306 were cases that completed the entire interview, and 1,047 were partially completed interviews. The weighted overall response rate was 55.3%.

In order to obtain population-based estimates, each interview was assigned a sampling weight. The sampling weight was composed of a base sampling weight, an adjustment for multiple telephone lines within a single household, and various adjustments for non-response. The final adjusted weight was post-stratified so that the sum of the weights for each state equaled the number of children in the state, as determined from the July 2003 Census Bureau estimates and the 5% Public Use Microdata Sample files from Census 2000. The post-stratification process also included an adjustment for the potential bias introduced by the fact that NSCH, as a telephone interview, could not select households without a telephone at the time of the survey. Estimates based on the sampling weights generalize to the non-institutionalized population of children in each state and nationwide.

Sample Subset

During the NSCH survey, breastfeeding questions were only asked for children under 6 years of age. Therefore, although the total sample size for the NSCH survey was 102,353 children, only 33,315 children, the total number of children under six years of age at the time of

the survey, were included in this analysis. In addition, this study only considered a subset of the original NSCH variables. The abbreviated variable list and corresponding interview questions used in this analysis is included in Appendix A, and the variable coding dictionary for these variables can be found in Appendix B.

Measures

The primary exposure of interest was whether or not the child was ever breastfed. This exposure was assessed both as a dichotomous and a continuous measure. For the dichotomous measure, breastfeeding was assessed by whether or not the child had ever been breastfed or fed breast milk (yes/no response). For those who answered affirmatively, this was followed by a question asking the age of the child, in days, when he/she completely stopped breastfeeding or being fed breast milk. For some analyses, this continuous response was broken down into a categorical variable. The categories were broken down as follows: less than one week, one week to 6 weeks, 6 weeks to 6 months, 6 months to one year, one year to 2 years, and 2 or more years. These divisions were chosen because they correspond to common markers and current recommendations for the duration of breastfeeding. For example, most workplaces allow mothers six weeks of maternity leave, while some allow up to three months. However, the American Academy of Pediatrics recommends that women should exclusively breastfeed their infants for at least the first six months of life, and *Healthy People 2010* has set breastfeeding goals based on rates at early postpartum, 6 months, and 12 months intervals.[12,25]

The primary outcome measure for this analysis was the development of asthma in early childhood, where early childhood was defined as 0 to 6 years of age. The presence of asthma was assessed by asking whether or not a doctor or health care professional had ever diagnosed the child with asthma. Three additional secondary outcomes measures were analyzed in this

study, as well as a composite measure. These secondary measures related to the presence of hay fever or any kind of respiratory allergy (not including asthma diagnosis), any food or digestive allergy, and eczema or any skin allergy. Each was assessed in a similar fashion as asthma, by asking whether a doctor or health care professional had ever informed the respondent of such a condition in the child. From these three allergy measures, a composite variable was created to assess whether the child had ever been diagnosed with any type of allergy excluding asthma.

In studying the relation between breastfeeding and the development of asthma and other allergies, several other variables were assessed as potential confounders. Socio-demographic and socio-economic variables are known to play an important role in maternal behavior, including breastfeeding, as well as in the development of allergies and asthma.[27] For example, the prevalence of ever breastfeeding is lowest among black or African Americans, mothers with lower educational attainment, and those living below the 100% poverty level, while the prevalence of asthma is generally higher among these same groups.[3, 40] Socio-demographic variables considered in this analysis included: gender, age, race (white, black, other, multiracial), Hispanic or Latino origin, primary language spoken in the household (English or other), and highest level of education obtained by anyone in the household (less than high school, high school, and more than high school). Socio-economic variables included: poverty level of household based on DHHS guidelines and whether or not anyone in the household received cash assistance from a state or county welfare program in the last 12 months. All of these factors have been implicated in the prevalence of asthma and other allergies. For example, the prevalence of asthma has been shown to increase with increasing age among children.[3] In addition, many of these variables co-vary, such as race and education, and both have been linked to variations in allergic diseases.[3] Finally, respondents were asked whether or not anyone in the

household used cigarettes, cigars, or pipe tobacco, as environmental tobacco smoke is known to contribute to the development of asthma and other respiratory allergies.[41,42-43]

An additional set of variables relating to asthma burden and severity was also included in this analysis for descriptive purposes. These measures included whether or not the child still had asthma at the time of the survey, the level of health difficulties caused by asthma (minor, moderate, or severe), perceived asthma burden on the family (ranging from "a great deal" to "not at all"), time since last took asthma medication, asthma episode or attack in the last 12 months, and overnight hospital admission because of asthma in the last 12 months.

Statistical Analysis

Analyses were conducted using SPSS 13.0 for Windows (2004 SPSS Inc. Chicago, IL). All variables of interest were left in their original categorical scales for analysis, with the exception of duration of breastfeeding, which was analyzed as both a continuous and categorical variable. The unweighted and weighted percentages for all variable categories were calculated. The prevalence per 100 children of asthma by all of the adjustment variable categories was calculated, as were the corresponding 95% confidence intervals (CI). Confidence intervals for variable categories with less than 100 cases were calculated using Poisson distribution 95% confidence limits. Summary statistics (numbers and percentages) for variables measuring the impact of asthma and asthma burden on families were also calculated. The prevalence and 95% CI of breastfeeding among all exposure and adjustment variables was calculated similarly.

The weighted and un-weighted percentages and prevalence per 100 children of hay fever or respiratory allergies, food or digestive allergies, and eczema or skin allergies were also calculated. Respiratory, digestive and skin allergies were then compiled into a single composite variable, and percentages calculated. However, preliminary analyses indicated that neither food

or digestive allergies nor eczema or skin allergies were significantly associated with breastfeeding, and in fact were likely reducing the power of the study to detect associations in the data. In addition, it was decided that the hay fever or respiratory allergy variable was too heterogeneous, and probably included a large percentage of undiagnosed asthma cases, thus confounding any statistical analysis. This decision was supported by the finding that 28.7 percent of all children with hay fever or respiratory allergies also had asthma. Therefore, while analyses were run similarly for all outcome variables (see Appendix C), only analyses for the asthma variables are reported here.

Crude prevalence odds ratios (POR) and 95% confidence intervals were calculated, using univariate logistic regression, to measure the effect of breastfeeding on asthma risk. An asthma diagnosis was selected as the outcome variable and the other variables of interest were independent variables entered into separate regression models. These variables included: child's gender, age, race, Hispanic or Latino origin, primary language in household, highest education level attained by anyone in the household, poverty level, state or county welfare assistance, and tobacco use in household. These odds ratios were used to compare differences in asthma prevalence within each categorical variable and to estimate the associated risk. The unadjusted prevalence odds ratios and 95% CI of ever breastfeeding by each of these same demographic and risk variables were also calculated to better understand the determinants of ever breastfeeding among the study population.

Univariate logistic regression was then used to estimate the crude prevalence odds ratio of asthma among children never vs. ever breastfed, and by the categorical duration of breastfeeding variable. A formal test for trend was not conducted because no trend was observed in the crude data. Mean duration of breastfeeding was calculated by excluding the "still

breastfeeding" and "more than 1095 days" of breastfeeding categories to obtain a continuous variable. These categories were excluded from the analysis because there was no reasonable method available to incorporate them into a continuous measure. Because the distribution was skewed, this variable was log-transformed to approximate a normal distribution (Figure 1). Analysis of variance was used to test for differences in mean duration of breastfeeding based on asthma outcome.

Finally, the effect of the child's age, race, household education level, poverty level, and tobacco use among ever-breastfed and never-breastfed children was assessed by comparing crude and Mantel-Haenszel summary odds ratios. The results from these analyses were used to conduct a multiple logistic regression to assess associations between breastfeeding and asthma. Only the following potential confounders, which were related to both asthma and breastfeeding and showed an impact on the observed crude odds ratios, were included in the final regression model: age, race, education, poverty level, and tobacco use. Adjusted prevalence odds ratios were obtained from this analysis. Additional logistic regression models were run using backwards regression and then by stratifying the population into black and white children and running separate logistic regression analyses for each group. Statistical significance for all analyses was $p < 0.05$.

Results

A total of 33,315 children between the ages of 0 and 5 were included in the subset of data used in this analysis. Descriptive statistics for all variables considered in this analysis are shown in Table 1. Percentages by variable category were calculated as both un-weighted percentages and percentages weighted to national population characteristics. Only valid percentages were reported. The total prevalence of ever having an asthma diagnosis among children in the study population was 2518 out of 33,315, or 7.6% (weighted prevalence 8.8%). The total prevalence of ever being breastfed or fed breast milk was 72.9% (weighted prevalence 71.8%).

Table 2 includes summary statistics describing the characteristics of asthma among children who had ever been diagnosed with asthma, as well as the burden asthma places on such children's families. Approximately 74% of all children ever diagnosed with asthma still had asthma at the time of this study, and 5.3% of these children experienced severe health difficulties caused by asthma. Fifty-three percent had experienced an asthma episode or attack in the last 12 months, and 10.2 % of these children had stayed overnight in a hospital because of asthma in the last year.

Descriptive statistics for asthma prevalence by socio-demographic and risk variables are presented in Table 3. In the sample population, the children were fairly evenly distributed with respect to age and gender. However, the prevalence of asthma appeared to increase with increasing age, from 2.2% (95% CI = 1.8, 2.6) among children less than one year old, to 11.2% (95% CI = 10.4, 12.1) among children aged 5 years. Also, the prevalence of asthma among males was 9.3% (95% CI = 8.8, 9.7), while the prevalence among females was 5.8% (95% CI = 5.4, 6.1). The prevalence of asthma also varied between race and poverty level categories.

Univariate logistic regression was used to estimate the risk of asthma by each variable category, using the prevalence odds ratio (POR) as the estimate of risk. Based on Table 3, male children had a significantly higher risk of developing asthma. This higher risk was such that the odds of a male child developing asthma were 1.67 (95% CI = 1.54, 1.82) times greater than the odds for females. The prevalence odds ratios were also significant across all variable categories except for Hispanic or Latino origin. For example, black children had a significantly higher risk of being diagnosed with asthma compared to white children (POR = 2.59, 95% CI = 2.32, 2.90).

The prevalence of breastfeeding by demographic and other risk variables is presented in Table 4. The prevalence of breastfeeding was 75.3% (95% CI = 74.7, 75.8) among white children compared to 52.5% (95% CI = 50.7, 54.2) among black children. The prevalence appeared to decrease with older age, possibly an indication of recall bias. In terms of educational attainment, children from families with less than high school education had a 65.6% (95%CI = 63.4, 67.8) prevalence of breastfeeding, whereas the prevalence among children from families with more than high school education was 77.3% (95% CI = 76.8, 77.9). Notably, the prevalence of breastfeeding was lower among households with high school education (58.5%, 95% CI = 57.3, 59.7) compared to either less than high school or more than high school educations. The prevalence of breastfeeding appeared to increase with increasing income, and was higher among households without tobacco use. The odds of having ever been breastfed was lower among children from households with tobacco use (POR = 0.48, 95% CI = 0.45, 0.52). When crude prevalence odds ratios were calculated, all of the variables exhibited significance except for the multiple race and other categories of the race variable. Black children were significantly less likely to have ever been breastfed compared to white children (POR = 0.36, 95% CI = 0.34, 0.39).

Table 5 summarizes the prevalence of breastfeeding by asthma diagnosis. The prevalence of asthma among children who had ever been breastfed was 6.6% (95% CI = 6.2, 6.9), compared to 10.3% (95% CI = 9.6, 10.9) among children who had never been breastfed. Univariate logistic regression was again used to estimate the risk of asthma in never breastfed relative to ever breastfed children, using the POR as the estimate of risk. We found that children who were never breastfed had a significantly higher risk of developing asthma. This higher risk was such that the odds of a never-breastfed child developing asthma were 1.63 (95% CI = 1.50, 1.78) times greater than the odds for ever-breastfed. The prevalence of asthma by duration of breastfeeding varied from 6.6% (95% CI = 4.8, 9.1) for children breastfed less than one week, to 8.1% (95% CI = 5.4, 11.9) among those breastfed for more than two years. However, while there appeared to be a trend of decreasing odds ratios with increasing duration, the prevalence odds ratios for the categories of duration of breastfeeding were not significant. Therefore, no further analyses were reported for this categorical breastfeeding duration variable.

The geometric mean duration of breastfeeding among the overall population was 122.9 days (95% CI = 120.88, 124.87). The mean duration of breastfeeding among children diagnosed with asthma was 115.5 (95% CI = 108.82, 122.67), compared to a mean of 123.4 (95% CI = 121.38, 125.55) among children without asthma. This relationship is illustrated in Figure 2. The ANOVA test indicated that these two geometric means were significantly different ($F(1, 21478) = 4.21$, p-value = 0.04). Therefore, children with asthma had a slightly lower mean duration of breastfeeding than did children without asthma, however the significance of this relationship was marginal, and probably not clinically significant.

Table 6a presents the crude and adjusted prevalence odds ratios of asthma by breastfeeding and child's age. All age groups exhibited a significant age-specific prevalence

odds ratio. For example, the odds of having asthma among children aged 0 to one year were 2.80 (95% CI = 1.92, 4.06) times higher for children who were never breastfed relative to children who were ever breastfed. It appeared that there was an upward trend in POR with increasing age. The combined crude odds ratio for all age categories was calculated to be 1.63 (95% CI = 1.49, 1.78). When the Mantel-Haenszel summary odds ratio was calculated to adjust for the effect of age, the odds of asthma among children who were never breastfed dropped slightly to 1.50 (95% = 1.38, 1.65) times greater than those who were ever breastfed. Adjusting for age made only a small difference in the odds ratio, although there appears to be effect modification by age such that the odds of a higher prevalence of asthma decrease with increasing age. This may indicate that never breastfeeding might be associated with an earlier onset of asthma.

The effect of children's race on asthma prevalence odds ratio between never and ever breastfed children is shown in Table 6b. Groups that exhibited a significant race-specific POR included whites, blacks, and children of multiple race. The combined crude POR for all race categories was 1.62 (95% CI = 1.49, 1.77). The Mantel-Haenszel summary POR was 1.53 (95% CI = 1.41, 1.68). Again, when adjusted for the effect of race, the POR for the relationship between never and ever breastfed dropped slightly, indicating that there may be some effect modification. Similarly, Table 6c presents the effect of the household's highest education on asthma by breastfeeding history. All of the crude education-specific POR values were significant. The crude summary POR was 1.62 (95% CI = 1.49, 1.77), while the Mantel-Haenszel summary POR was slightly lower at 1.53 (95% CI = 1.41, 1.68), possibly an indication of confounding.

Table 6d shows the prevalence odds ratios of asthma by breastfeeding and household poverty level. Significant odds ratios were found for five out of the eight poverty levels. The three non-significant poverty levels included: 133% to below 150%, 185% to below 200%, and 300% to below 400%. Based on the crude prevalence odds ratio for all poverty levels, the odds of asthma were 1.55 (95% CI = 1.41, 1.70) times higher for never-breastfed relative to ever-breastfed children. The adjusted, Mantel-Haenszel summary prevalence odds ratio was 1.43 (95% CI = 1.30, 1.57), slightly lower than the crude odds ratio. This difference might indicate that there is confounding present, and the odds of asthma might vary with poverty level.

Finally, the effect of tobacco use on asthma POR between never and ever breastfed children is presented in Table 6e. Both category-specific POR values were significant, as was the crude POR of 1.59 (95% CI = 1.43, 1.78). The Mantel-Haenszel summary POR was again slightly lower than this crude value (POR = 1.53, 95% CI = 1.37, 1.71).

Adjusted prevalence odds ratios for asthma were calculated from multiple logistic regression (see Table 7). The following variables were entered into the model: age, race, education, poverty level, tobacco use, and ever breastfed. The sample size for the regression analyses was 17,317 after cases with missing or unknown values were excluded. These variables were entered into the model because of previously demonstrated relationships with both asthma and breastfeeding. Multivariable logistic regression adjusting for all covariates showed that the odds of asthma among children who were never breastfed remained significant (adjusted POR = 1.18, 95% CI = 1.04, 1.34). This adjusted POR was lower than the crude value. The following predictors of asthma and breastfeeding also remained significant after adjusted for the other variables: age, race, education, and tobacco use. In the education category, high school education was not significantly associated with asthma after adjustment, but less than high

school and college education was significantly associated. In addition, only four out of the seven poverty levels remained significant after adjustment. Conducting backwards logistic regression showed that the removal of any of the individual variables did not significantly change the model.

The crude PORs of asthma by never- compared to ever-breastfed children did vary when stratified by race (Table 8). The PORs for the white only, black only, and multiple race categories were all significant. However, only the white and multiple race categories remained significant after adjustment for age, household's highest education, poverty level, and tobacco use.

Discussion

Findings and Possible Explanatory Mechanisms

We found that never breastfeeding, when measured as a dichotomous variable, was associated with a significant increase in asthma prevalence among the children surveyed in the National Survey of Children's Health, 2003 (POR = 1.18, 95% CI = 1.04, 1.34). That is, the act of ever breastfeeding exerts a protective effect against the development of asthma in early childhood. The odds of developing asthma at a younger age were greater for children who were not breastfed compared to those who were. In addition, children with asthma had a slightly lower mean duration of breastfeeding than did children without asthma. Therefore, a longer duration of breastfeeding might be protective against the development of asthma, although it is unlikely that the slight difference found in this study is clinically significant. However, we failed to find a significant trend of increasing odds ratios with increasing duration of breastfeeding. It appears that the act of ever breastfeeding, regardless of duration, exerts some protective effect against the development of asthma in early childhood.

There are several plausible biological explanations for these findings. Research has shown that there is a strong link between breastfeeding and the development of the immune system in children.[20] Antibodies found in breast milk are highly targeted against infectious agents in the mother's environment. Some studies have shown that early infection with respiratory syncytial virus and other viruses predispose susceptible infants to wheezing episodes, and toddlers and grade school children to higher rates of asthma and wheezing illness.[44] Breast milk may provide antiviral antibodies and other factors that reduce the incidence of these infections, and thus subsequent wheezing episodes.[35] Conversely, exposure to certain infectious agents in early childhood may actually protect against allergy development by stimulating the

T_H1 immune pathway.[45-46] Therefore, although breastfeeding is advantageous to the general health of children by decreasing some respiratory infection rates, the effect this might have on the development of subsequent allergies such as asthma is most likely mediated by complex immunological pathways.[47]

It is also possible that various chemicals and compounds found in breast milk impact the development of asthma more directly. Several factors in breast milk are currently being evaluated as either inducing or protecting against various allergies. For example, factors protecting against food allergies are though to include: antigens (tolerizing allergens); cytokines such as TGF-B and soluble CD14; immunoglobulins; n-3 polyunsaturated fatty acids; and some polyamines.[48] Such factors might aid in the proper development of the child's immune system, and thus help prevent later allergic diseases such as asthma.

Supporting/Contradicting Research

The overall prevalence of asthma among the children (0 to 5 years) surveyed was 7.6% (weighted prevalence 8.8%), which is slightly higher than the nationally reported prevalence of 5.9 among 0-4 year olds or 8.5 among the 0-17 age group.[49] This higher prevalence may reflect the continuing increases in asthma prevalence among children. The prevalence of breastfeeding among the study population was similar to recent national estimates, although both fall short of recommended goals.[26] The *Healthy People 2010* target breastfeeding prevalence for the general population is 75% during the early postpartum period.[12] Our study reported the overall prevalence of ever breastfeeding to be only 72.9% (weighted prevalence 71.8%).

In general, our findings agree with previous studies that have found that breastfeeding exerts a protective effect against the development of asthma in early childhood.[20,50] After conducting a review of the epidemiological literature, Oddy and Peat recommended breast

feeding as a preventive measure of asthma,[51] Similarly, infants fed formulas of intact cow's milk or soy protein compared with breast milk had a higher incidence of atopic dermatitis and wheezing illnesses in early childhood.[30] However, as mentioned previously, other researchers have failed to detect such a difference. For example, a study conducted by Sears *et al.* found that breastfeeding does not protect children against atopy and asthma, and may actually increase the risk.[52] In their study, a greater number of children who were breastfed reported current asthma at each assessment between age 9 and 26 years compared to those who were not breastfed. The odds ratio for this association was 1.83 (95% CI = 1.35, 2.47) for current asthma at 9-26 years by repeated-measures analysis.

The only truly unexpected result of our study was that we failed to observe a trend of decreasing asthma risk with increasing breastfeeding duration. We hypothesized that the duration of breastfeeding may have a dose-response relationship with the development of asthma, so that as duration increased, the prevalence of asthma in early childhood would decrease. While the mean duration of breastfeeding was significantly lower among those children diagnosed with asthma, this difference was very slight in terms of clinical significance. However, when duration of breastfeeding was analyzed as a categorical variable, no significant difference in odds ratios was found between children breastfed for less than one week compared to any longer duration. For example, the odds ratio for asthma was not significant for children breastfed less than one week compared to those breastfed for six to twelve months.

These results differ from previous findings by other researchers. Several studies have implied that duration of breastfeeding does play a role in the later development of asthma and other allergies. A Swedish prospective birth cohort study demonstrated a significant decrease in asthma diagnosis by two years of age in infants breastfed for more than four months as opposed

to infants breastfed for a shorter period (OR = 0.66, 95%CI = 0.51, 0.87).[53] It is possible that we failed to find such an association because some potentially confounding factors, such as family history of asthma and exclusive breastfeeding, were not accounted for in our analysis.

Other Risk Variables

Of interest, although not directly related to our study objectives, we confirmed the association between asthma and other previously described risk factors such as gender, age, race, education, poverty level, and tobacco use. According to the CDC, among children 0 to 17 years of age, males are more likely than females to have ever been diagnosed with asthma, although this relationship is opposite for adults.[4] Our study found that the prevalence of asthma was indeed higher among males relative to females (9.3% vs. 5.8%). Similarly, the proportion of children ever diagnosed with asthma is known to increase with age, which also corresponds to our findings.[3] The prevalence of asthma increased from 2.2% among those 0 years of age to 11.3% among those 5 years of age. The finding that the odds of developing asthma at a younger age were greater for children who were not breastfed (Table 6a) is supported by the literature. In an Australian birth cohort study, investigators found that age of asthma diagnosis was lower if exclusive breastfeeding was continued for less than four months compared with four or more months.[54] In another study, researchers found that breast-feeding reduces the risk of asthma during the first 4 years of life.[50]

Our findings concerning the relationship between race, breastfeeding, and asthma are also borne out in the literature. For example, children of Hispanic or Latino origin had the highest prevalence of ever being breastfed at 76.6%. National estimates concur, but place the prevalence closer to 62.7% in 2001.[27] Similarly, black children had significantly higher odds ratios of developing asthma, and were less likely to have ever been breastfed relative to white children, an

association that has been well-documented and is a cause for concern.[4,5] However, when the association between breastfeeding and asthma (adjusted for potential confounders) was stratified by race, this relationship reversed. Significant associations were only found for children in the white and multiple race categories. It is therefore likely that the higher prevalence of asthma observed among black children is primarily due to confounding covariates. This finding is supported by studies that have shown higher rates of respiratory allergies in white and higher income children.

The highest education achieved by anyone in the household was significantly associated with asthma prevalence. This association was such that children from families with lower educational attainment had higher prevalence and crude odds of asthma. However, this association did not hold true for breastfeeding, or asthma after adjustment. Children from households with high school education were actually significantly less likely to breastfeed compared to households with less or more than high school education. It is possible that this association can be explained by the fact that people with more than high school education can afford to take time off work to breastfed, while those with high school education cannot afford to do the same, and those with less than high school education cannot afford not to breastfed. Conversely, it is possible that measuring the household's highest education did not capture the mother's highest education, nor the mother's implied job class and knowledge of breastfeeding. It may be that mother's education is more relevant than overall household education. After adjustment, children from households with high school educations had significantly higher odds of being diagnosed with asthma relative to those from households with more than high school education, but the same did not hold true for less than high school education.

Some studies have proposed childhood asthma to be more common in families with low socioeconomic status, and breastfeeding is usually lowest among this population as well. For example, a study by Almqvist *et al.* found a decreasing risk of asthma and rhinitis with increasing socioeconomic status comparing the highest and lowest socioeconomic groups (RR = 0.33, 95% CI = 0.17, 0.66).[6] Overall, they found that after adjustment for common risk factors, asthma, rhinitis, and sensitization was more common in lower than higher socioeconomic groups. Our study found that low socioeconomic status, as measured by poverty level, was a risk factor for asthma and never breastfeeding, although some of the lower poverty levels lost significance after adjustment. This finding is partially supported by Hancox *et al*, who found that socioeconomic status in childhood had no significant impact on the prevalence of asthma among a New Zealand cohort, and that previously reported associations were most likely due to confounding.[55] Tobacco use was also significantly associated with asthma, as has been indicated by previous research.[56-57] We found that children from households with tobacco use had odds of developing asthma 1.21 (95% CI = 1.07, 1.38) times greater than children form households without tobacco use.

Generalizability and Limitations

Our study's findings are primarily applicable to children, between the ages of 0 and 5, who reside in the United States. The generalizability of our analyses is greatly augmented by the fact that our study population was very large. Conversely, the generalizability of our findings is slightly hindered by the fact that the data were not weighted to the national population characteristics for most analyses. However, as SLAITS, and thus the National Survey of Children's Health, utilizes a random-digit-dial telephone sampling method, the sample population should still be representative of the general U.S. population of children who reside in

households with telephones. Considering the great care that went into crafting a sampling frame that captures the characteristics of the entire United States population, sampling bias was unlikely. Generalizability is also limited by the fact that since the NSCH is a telephone survey, the sampling frame was limited to children who live in households with telephones, but this is a common problem with any telephone-based survey. The overall response rate for the NSCH was relatively low (55.3%), possibly an indication of non-response bias.[36] Similarly, the interview completion rate, a measure of the proportion of completed interview among known households with children, was 68.8%. These low rates may have been a result of the fact that the average length of the interview was close to half an hour, a long period of time for respondents to remain on the line. If in fact the non-responders were not randomly distributed with regard to the variables under study, it is possible that response bias might influence the results of any analysis. Such bias could either under- or over-estimate the role of breastfeeding in the development of asthma, and it cannot be completely ruled out.

It is important to note that although our study failed to find a significant association between duration of breastfeeding and asthma, this does not necessarily indicate that such an association does not exist. Our analysis was hindered by several limitations. There may have been differences between survey respondents. While survey administrators asked to speak to the parent or guardian in each household who knew the most about the health and health care of the surveyed child, these responders could have varied considerably in their knowledge. For example, while 78.6% of the respondents were the child's mother or female guardian, birth-mothers may have been able to respond more accurately to questions concerning duration of breastfeeding.[36] Recall bias may have also influenced responses. Mothers who recently stopped breastfeeding their child would be more likely to accurately recall the child's age when

breastfeeding was stopped compared to mothers of older children who had stopped breastfeeding years before. Therefore, the duration of breastfeeding measure is most likely more accurate for younger children. Additionally, distinct peaks corresponding to significant markers, such as six and twelve months, were seen in the data. These peaks may have been a reflection of parents adhering to breastfeeding recommendations, or may have been a result of the respondents estimating or rounding the actual length in days to months. Therefore, the use of duration of breastfeeding as a continuous variable may have been unjustified.

Perhaps most importantly, the NSCH questionnaire was not designed specifically to answer research questions about asthma or to analyze associations between asthma, breastfeeding, and various risk factors. Therefore, this analysis had limited data. Not all of the potentially relevant questions pertaining to asthma and breastfeeding were included in the survey. For example, several studies have found that family history contributes to asthma susceptibility.[6] Many polymorphic genetic markers have been linked to an atopic phenotype.[58] It has been estimated that if a person has a parent with asthma, he or she is three to six times more likely to develop asthma than is a person who does not have a parent with asthma. The NSCH questionnaire did not ask about family history of asthma, and so this potentially important factor was not included in our analysis. There is some debate, however, as to the effect of family history on the breastfeeding-asthma interaction. A study by Sears *et al.* found that breastfeeding effects were not affected by parental history of asthma or hay fever,[52] while other studies have indicated that they are.[50,59]

The degree of exclusive breastfeeding among the study population was also unknown. Some studies have shown that supplemented diets are associated with increased risk of food allergies and asthma.[60] The effect of breastfeeding on asthma may be modified by the extent of

exclusive breastfeeding.[61] A meta-analysis based on longitudinal studies reported that exclusive breast feeding was associated with a lower rate of asthma.[34] Our study did not show a beneficial effect of duration of breastfeeding in relation to asthma, but we did not have information as to whether the children were exclusively breastfed or if their diets were supplemented with other foods. A dose-response relationship between length of breastfeeding and decreasing asthma risk might only exist for children who are exclusively breastfed.

The age of the children in the study may also have limited our findings. We only looked at children under 6 years of age, because those were the only ages for which data on breastfeeding were obtained. It is possible that the relationship between breastfeeding and reduced risk of asthma dissipates as children age.[62] Breastfeeding may simply delay the onset of asthma, but not prevent it entirely. Conversely, asthma can be difficult to diagnose, especially in children under 5 years old.[63] Consequently, a large number of undiagnosed children may have obscured the association between breastfeeding and asthma.

Conclusion

In conclusion, the risk of developing asthma in early childhood was found to be significantly associated with never breastfeeding among a large sample of children in the United States. Age, race, education, poverty level, and tobacco use were also implicated in this association. This indicates that breastfeeding should be encouraged, even if it is only possible for a short duration of time. Our findings add to the growing body of evidence supporting the role of breastfeeding in the primary prevention of asthma. Despite decades of research and the fact that several large organizations, such as the American Academy of Pediatrics and the European Society for Paediatric Allergology and Clinical Immunology, recommend breastfeeding as part of an allergy prevention program, it is still impossible to make a definitive statement that breastfeeding will help prevent sensitization to allergens in infants or later respiratory illnesses such as asthma.[64-65] Additional research is still needed to conclusively describe the association between breastfeeding and the development of asthma. Future research should focus on describing in more detail the influence of other risk factors on the development of asthma, and how they interact both with breastfeeding and each other.

To aid in this endeavor, in 2003 and 2004 SLAITS fielded the National Asthma Survey, which was developed to help understand the health, socioeconomic, behavioral, and environmental factors that relate to better control of asthma.[36] This survey also aims to determine detailed prevalence rates by various demographic characteristics on a national level. Data from the National Asthma Survey will be publicly released in 2005, and this data can be used to help clarify risk factors for asthma, as well as identify additional preventive measures.

Furthermore, recent studies have indicated that multifaceted interventions show promise in the primary prevention of allergy and allergic diseases like asthma.[32] Such diseases are the

result of complex gene-environment interactions, and might best be prevented by targeting several environmental factors simultaneously. Some contend that as a primary prevention strategy, only a multi-faceted intervention program has thus far proven successful.[32] Avoidance of any one of the individual risk factors associated with childhood asthma has not been successful in preventing its development. Several studies have recently been conducted, or are currently underway, in this field.[66] The focus is often on high-risk infants, and attempts to decrease the occurrence of severe asthma. Chan-Yeung *et al.* recently analyzed the effectiveness of a multifaceted intervention program for the primary prevention of asthma in high-risk infants. They identified 545 high-risk infants with immediate family history of asthma and prospectively randomized them to intervention or control groups. The intervention program involved reduction of exposure to common indoor allergens, avoidance of environmental tobacco smoke, encouragement of breast-feeding, and delayed introduction of other foods during the first 12 months of life. At seven years of age, the prevalence of pediatric allergist-diagnosed asthma was significantly lower in the intervention group than in the control group (14.9% vs. 23%, adjusted RR = 0.44, 95% CI = 0.25, 0.79).[67] In light of early successes, it is likely that much of the forthcoming research will focus on such multifaceted approaches.

In the meantime, cumulative advice strongly suggests that breastfeeding should be encouraged for a myriad of reasons, and there is a definite need for more widespread breastfeeding promotion and support. It is the responsibility of the public health and health care system to encourage more mothers to breastfeed. Broader health policy issues also need to be addressed; for example, encouraging workplace environments that enable mothers to continue breastfeeding for a reasonable length of time. Promoting community and family support is also

crucial. Encouraging breastfeeding promotes the health of both mothers and their children, and also has the potential to help reduce the prevalence of asthma and other allergies later in life.

Tables

Table 1. General demographic and risk characteristics of 33,315 children, aged 0 - 5 years, in NSCH, 2003

Variable	Total		
	N	%†	%‡
gender			
male	17050	51.2	51.4
female	16250	48.8	48.6
don't know	1	0.0	0.0
refused	14	0.0	0.0
age			
0	5843	17.5	15.9
1	6254	18.8	16.8
2	4867	14.6	14.3
3	5692	17.1	17.6
4	5429	16.3	18.2
5	5230	15.7	17.1
race classification			
white only	24307	79.0	74.4
black only	3084	10.0	15.6
multiple race	1732	5.6	4.4
other	1642	5.3	5.6
Hispanic or Latino origin			
yes	5434	16.4	20.6
no	27561	83.3	79.1
don't know	41	0.1	0.2
refused	33	0.1	0.1
primary language in home			
English	29773	89.4	84.2
any other language	3523	10.6	15.7
don't know	17	0.1	0.0
refused	2	0.0	0.0
household's highest education			
less than high school	1762	5.3	8.6
high school graduate	6715	20.2	25.6
more than high school	24645	74.0	65.1
don't know	159	0.5	0.6
refused	33	0.1	0.1
poverty level			
less than 100% poverty level	4416	14.6	20.2
100% to below 133% poverty level	2209	7.3	8.2
133% to below 150% poverty level	1065	3.5	4.1
150% to below 185% poverty level	2165	7.2	7.7
185% to below 200% poverty level	1123	3.7	3.5
200% to below 300% poverty level	5684	18.8	16.9
300% to below 400% poverty level	4661	15.5	13.6
at or above 400% poverty level	8831	29.3	25.8
state or county welfare			
yes	1855	11.2	12.4
no	14699	88.6	87.4
don't know	36	0.2	0.1
refused	3	0.0	0.1
tobacco use in household			
yes	5540	27.0	26.3
no	14986	73.0	73.7
don't know	4	0.0	0.0
refused	6	0.0	0.0
asthma diagnosis (ever)			
yes	2518	7.6	8.8
no	30685	92.1	90.8
don't know	110	0.3	0.3
refused	2	0.0	0.0
child ever breastfed or fed breast milk			
yes	24285	72.9	71.8
no	8836	26.5	27.5
don't know	187	0.6	0.7
refused	7	0.0	0.0
duration of breastfeeding			
less than one week (0-6 days)	587	2.4	2.1
one week to 6 weeks (7-42 days)	3655	15.1	14.1
6 weeks to 3 months (43-90 days)	3761	15.5	15.4
3 months to 6 months (91-180 days	4852	20.0	20.9
6 months to one year (181-365 days	5901	24.3	24.9
one to two years (366-730 days)	2697	11.1	11.8
more than two years (>731 days)	297	1.2	12.0
still breastfeeding	2307	9.5	8.6
don't know	204	0.8	0.8
refused	19	0.1	0.1

† unweighted percentages

‡ percentages weighted to national population characteristics

Table 2. Summary statistics of asthma burden for 2,518 children ever diagnosed with asthma in NSCH, 2003

Variable	N	%†	%‡
still has asthma			
yes	1870	74.3	75.0
no	548	21.8	21.6
don't know	100	4.0	3.4
refused	0	0.0	0.0
health difficulties caused by asthma			
minor difficulties	1195	63.9	60.4
moderate difficulties	567	30.3	33.9
severe difficulties	100	5.3	5.0
don't know	8	0.4	0.7
refused	0	0.0	0.0
perceived asthma burden on family			
a great deal	77	4.1	3.6
a medium amount	278	14.9	15.2
a little	587	31.4	30.2
not at all	924	49.4	50.8
don't know	3	0.2	0.2
refused	1	0.1	0.0
time since last took asthma medication			
< 1 day ago	752	29.9	26.1
1-6 days ago	159	6.3	6.1
1 week to less than 3 months ago	586	23.3	27.8
3 months ago to less than 1 year ago	563	22.4	22.0
1 year ago to less than 3 years ago	345	13.7	12.6
3 years to 5 years ago	43	1.7	1.8
more than 5 years ago	2	0.1	0.1
has never used medicaiton	61	2.4	3.0
don't know	7	0.3	0.5
refused	0	0.0	0.0
asthma episode or attack in last 12 months			
yes	1341	53.3	54.2
no	1165	46.3	45.5
don't know	11	0.4	0.3
refused	1	0.0	0.0
overnight hospital b/c asthma in last 12 months			
yes	257	10.2	9.8
no	2257	89.6	89.8
don't know	3	0.1	0.3
refused	1	0.0	0.0

† unweighted percentages

‡ percentages weighted to national population characteristics

Table 3. Prevalence of asthma by demographic and risk characteristics of 33,315 children, aged 0 - 5 years, in NSCH, 2003

Variable	Total (N)	Asthma (N)	Prevalence %	(95% CI)	Crude POR	(95% CI)
gender						
male	16986	1580	9.3	(8.9, 9.8)	1.67	(1.54, 1.82) *
female	16202	935	5.8	(5.4, 6.1)	1.00	
don't know	1	0	0.0			
refused	14	3	21.4	(4.4, 62.6)		
age						
0	5822	126	2.2	(1.8, 2.6)	1.00	
1	6230	327	5.2	(4.7, 5.8)	2.50	(2.03, 3.09) *
2	4848	370	7.6	(6.9, 8.4)	3.74	(3.04, 4.59) *
3	5673	529	9.3	(8.6, 10.1)	4.65	(3.81, 5.67) *
4	5418	578	10.7	(9.9, 11.5)	5.40	(4.44, 6.57) *
5	5212	588	11.3	(10.4, 12.2)	5.75	(4.72, 7.00) *
race classification						
white only	24234	1538	6.3	(6.0, 6.7)	1.00	
black only	3070	459	15.0	(13.7, 16.3)	2.59	(2.32, 2.90) *
multiple race	1721	182	10.6	(9.2, 12.1)	1.75	(1.48, 2.05) *
other	1635	157	9.6	(8.2, 11.2)	1.57	(1.32, 1.86) *
Hispanic or Latino origin						
yes	5414	414	7.6	(7.0, 8.4)	1.01	(0.91, 1.13)
no	27471	2080	7.6	(7.3, 7.9)	1.00	
don't know	39	5	12.8	(4.2, 29.9)		
refused	33	1	3.0	(0.1, 16.9)		
primary language in home						
English	29675	2320	7.8	(7.5, 8.1)	1.43	(1.23, 1.67) *
any other language	3509	196	5.6	(4.8, 6.3)	1.00	
don't know	17	2	11.8	(1.4, 42.5)		
refused	2	0				
household's highest education						
less than high school	1756	161	9.1	(7.8, 10.5)	1.37	(1.16, 1.63) *
high school graduate	6691	663	9.9	(9.2, 10.6)	1.50	(1.36, 1.64) *
more than high school	24564	1683	6.8	(6.5, 7.2)	1.00	
don't know	158	10	6.3	(3.0, 11.6)		
refused	33	1	3.0	(0.1, 16.9)		
poverty level						
less than 100% poverty level	4399	494	11.2	(10.3, 12.2)	2.16	(1.89, 2.46) *
100% to below 133% poverty level	2206	192	8.7	(7.5, 9.9)	1.62	(1.37, 1.93) *
133% to below 150% poverty level	1056	96	9.0	(7.4, 11.1)	1.70	(1.36, 2.14) *
150% to below 185% poverty level	2156	189	8.7	(7.6, 10.0)	1.64	(1.37, 1.95) *
185% to below 200% poverty level	1121	99	8.8	(7.2, 10.8)	1.65	(1.32, 2.07) *
200% to below 300% poverty level	5672	403	7.1	(6.4, 7.8)	1.30	(1.14, 1.49) *
300% to below 400% poverty level	4644	328	7.0	(6.3, 7.8)	1.30	(1.12, 1.50) *
at or above 400% poverty level	8801	488	5.5	(5.1, 6.0)	1.00	
state or county welfare						
yes	1845	258	13.9	(12.4, 15.6)	1.82	(1.57, 2.10) *
no	14657	1203	8.2	(7.8, 8.7)	1.00	
don't know	36	1	2.8	(0.1, 15.5)		
refused	3	1				
tobacco use in household						
yes	5518	513	9.3	(8.5, 10.1)	1.38	(1.23, 1.54) *
no	14928	1035	6.9	(6.5, 7.4)	1.00	
don't know	4	1				
refused	6	0				

* indicates significance at the $p < 0.05$ level

Table 4. Prevalence of breastfeeding by demographic and risk characteristics of 33,315 children, aged 0 - 5 years, in NSCH, 2003

Variable	Total N	Ever Breastfed N	Prevalence %	(95% CI)	Crude POR	(95% CI)
gender						
male	16970	12512	73.7	(73.1, 74.4)	1.04	(0.99, 1.10)
female	16137	11763	72.9	(72.2, 73.6)	1.00	
don't know	0	0				
refused	14	10	71.4	(34.3, 131.4)		
age						
0	5837	4604	78.9	(77.8, 79.9)	1.00	
1	6238	4736	75.9	(74.8, 77.0)	0.84	(0.78, 0.92) *
2	4849	3644	75.1	(73.9, 76.4)	0.81	(0.74, 0.89) *
3	5649	4033	71.4	(70.2, 72.6)	0.67	(0.61, 0.73) *
4	5371	3731	69.5	(68.2, 70.7)	0.61	(0.56, 0.66) *
5	5177	3537	68.3	(67.0, 69.6)	0.58	(0.53, 0.63) *
race classification						
white only	24212	18298	75.6	(75.0, 76.1)	1.00	
black only	3057	1618	52.9	(51.1, 54.7)	0.36	(0.34, 0.39) *
multiple race	1718	1297	75.5	(73.4, 77.5)	1.00	(0.89, 1.12)
other	1594	1196	75.0	(72.8, 77.1)	0.97	(0.86, 1.09)
Hispanic or Latino origin						
yes	5418	4148	76.6	(75.4, 77.7)	1.00	
no	27386	19943	72.8	(72.3, 73.3)	0.82	(0.77, 0.88) *
don't know	40	24	60.0	(38.4, 89.3)		
refused	32	21	65.6	(40.6, 100.3)		
primary language in home						
English	29586	21412	72.4	(71.9, 72.9)	0.60	(0.55, 0.66) *
any other language	3516	2861	81.4	(80.1, 82.7)	1.00	
don't know	17	10	58.8	(28.2, 108.2)		
refused	2	2				
household's highest education						
less than high school	1756	1156	65.8	(63.6, 68.0)	1.00	
high school graduate	6685	3928	58.8	(57.6, 59.9)	0.74	(0.66, 0.83) *
more than high school	24488	19059	77.8	(77.3, 78.4)	1.82	(1.64, 2.02) *
don't know	158	116	73.4	(66.5, 80.3)		
refused	33	25	75.8	(49.0, 111.8)		
poverty level						
less than 100% poverty level	4402	2749	62.4	(61.0, 63.9)	0.39	(0.36, 0.42) *
100% to below 133% poverty level	2203	1473	66.9	(64.9, 68.8)	0.47	(0.43, 0.52) *
133% to below 150% poverty level	1058	709	67.0	(64.2, 69.8)	0.48	(0.41, 0.55) *
150% to below 185% poverty level	2154	1523	70.7	(68.8, 72.6)	0.57	(0.51, 0.63) *
185% to below 200% poverty level	1120	801	71.5	(68.9, 74.2)	0.59	(0.51, 0.68) *
200% to below 300% poverty level	5653	4165	73.7	(72.5, 74.8)	0.66	(0.61, 0.71) *
300% to below 400% poverty level	4637	3526	76.0	(74.8, 77.3)	0.74	(0.68, 0.81) *
at or above 400% poverty level	8757	7097	81.0	(80.2, 81.9)	1.00	
state or county welfare						
yes	1846	1118	60.6	(58.3, 62.8)	0.66	(0.60, 0.73) *
no	14637	10225	69.9	(69.1, 70.6)	1.00	
don't know	35	23	65.7	(41.7, 98.6)		
refused	3	3				
tobacco use in household						
yes	5505	3410	61.9	(60.6, 63.2)	0.48	(0.45, 0.52) *
no	14897	11496	77.2	(76.5, 77.8)	1.00	
don't know	4	3	75.0	(15.5. 219.2)		
refused	6	5	83.3	(27.1, 194.5)		

* indicates significance at the $p < 0.05$ level

Table 5. Asthma prevalence by breastfeeding for 33,315 children, aged 0 - 5 years, in NSCH, 2003

Variable	Total N	Asthma N	Prevalence (95% CI)	Crude POR (95% CI)
child ever breastfed or fed breast milk				
yes	24204	1591	6.6 (6.3, 6.9)	1.00
no	8809	906	10.3 (9.7, 10.9)	1.63 (1.50, 1.78) *
don't know	184	20	10.9 (6.6, 16.8)	
refused	6	1	16.7 (0.4, 92.9)	
duration of breastfeeding				
less than one week (0-6 days)	584	39	6.7 (4.7, 9.1)	1.00
one week to 6 weeks (7-42 days)	3637	290	8.0 (7.1, 8.9)	1.21 (0.86, 1.71)
6 weeks to 3 months (43-90 days)	3744	282	7.5 (6.7, 8.4)	1.14 (0.81, 1.61)
3 months to 6 months (91-180 days)	4835	360	7.4 (6.7, 8.2)	1.12 (0.80, 1.58)
6 months to one year (181-365 days)	5889	386	6.6 (5.9, 7.2)	0.98 (0.70, 1.38)
one to two years (366-730 days)	2688	172	6.4 (5.5, 7.4)	0.96 (0.67, 1.37)
more than two years (>731 days)	296	24	8.1 (5.2, 12.1)	1.23 (0.73, 2.09)
still breastfeeding	2304	25	1.1 (0.7, 1.6)	
don't know	203	12	5.9 (3.1, 10.3)	
refused	19	0		

* indicates significance at the $p < 0.05$ level

Table 6a. Effect of child's age on asthma prevalence odds ratio between 33,315 non-breastfed and breastfed children from the NSCH, 2003†

	not breastfed		breastfed		
age	asthma	no asthma	asthma	no asthma	POR (95 % CI)
0	53	1173	73	4517	2.80 (1.92, 4.06) *
1	114	1381	211	4508	1.76 (1.38, 2.25) *
2	129	1072	239	3390	1.71 (1.35, 2.15) *
3	185	1429	339	3680	1.41 (1.16, 1.71) *
4	211	1427	360	3362	1.38 (1.15, 1.66) *
5	214	1421	369	3156	1.29 (1.07, 1.55) *
Crude POR	1.63 (1.49, 1.78)				
M-H Summary POR	1.50 (1.38, 1.65)**				

Table 6b. Effect of child's race on asthma prevalence odds ratio between 33,315 non-breastfed and breastfed children from the NSCH, 2003†

	not breastfed		breastfed		
race	asthma	no asthma	asthma	no asthma	POR (95 % CI)
white only	496	5400	1029	17215	1.54 (1.37, 1.72) *
black only	246	1189	212	1398	1.36 (1.11, 1.67) *
multiple race	60	358	121	1169	1.62 (1.15, 2.28) *
other	39	358	114	1076	1.03 (0.69, 1.53)
Crude POR	1.63 (1.49, 1.78)				
M-H Summary POR	1.47 (1.34, 1.61)**				

Table 6c. Effect of highest household education on asthma prevalence odds ratio between 33,315 non-breastfed and breastfed children from the NSCH, 2003†

	not breastfed		breastfed		
education	asthma	no asthma	asthma	no asthma	POR (95 % CI)
less than high school	68	529	92	1061	1.48 (1.05, 2.09) *
12 years, high school graduate	320	2429	336	3576	1.40 (1.19, 1.65) *
more than high school	512	4902	1158	17839	1.61 (1.44, 1.80) *
Crude POR	1.62 (1.49, 1.77)				
M-H Summary POR	1.53 (1.41, 1.68)**				

† comparisons are for never compared to ever breastfed

* indicates significance at the $p < 0.05$ level

** indicates signficance at the $p < 0.0001$ level

Table 6d. Effect of household's poverty level on asthma prevalence odds ratio between 33,315 non-breastfed and breastfed children from the NSCH, 2003†

	not breastfed		breastfed		
poverty level	asthma	no asthma	asthma	no asthma	POR (95 % CI)
less than 100% poverty level	230	1420	262	2473	1.53 (1.26, 1.85) *
100% to below 133% poverty level	98	631	94	1377	2.28 (1.67, 3.10) *
133% to below 150% poverty level	36	311	59	643	1.26 (0.80, 1.99)
150% to below 185% poverty level	70	558	118	1399	1.49 (1.08, 2.05) *
185% to below 200% poverty level	36	281	63	738	1.50 (0.95, 2.36)
200% to below 300% poverty level	136	1351	264	3891	1.48 (1.19, 1.85) *
300% to below 400% poverty level	65	1014	230	3282	0.91 (0.68, 1.23)
at or above 400% poverty level	112	1540	368	6708	1.33 (1.06, 1.66) *
Crude POR	1.55 (1.41, 1.70)				
M-H Summary POR	1.43 (1.30, 1.57)**				

Table 6e. Effect of household tobacco use on asthma prevalence odds ratio between 33,315 non-breastfed and breastfed children from the NSCH, 2003†

	not breastfed		breastfed		
cigarettes, cigars, or pipe tobacco	asthma	no asthma	asthma	no asthma	POR (95 % CI)
yes	238	1849	270	3127	1.49 (1.24, 1.80) *
no	315	3073	708	10745	1.56 (1.35, 1.79) *
Crude POR	1.59 (1.43, 1.78)				
M-H Summary POR	1.53 (1.37, 1.71)**				

† comparisons are for never compared to ever breastfed

* indicates significance at the $p < 0.05$ level

** indicates signficance at the $p < 0.0001$ level

Table 7. Multivariate logistic regression for asthma among 33,315 children from NCHS, 2003†

Variable	Total (N)	Asthma (N)	Crude POR (95% CI)	Adjusted POR (95% CI)
age				
0	5822	126	1.00	1.00
1	6230	327	2.50 (2.03, 3.09) *	2.88 (2.12, 3.90) *
2	4848	370	3.74 (3.04, 4.59) *	4.31 (3.19, 5.83) *
3	5673	529	4.65 (3.81, 5.67) *	4.98 (3.72, 6.67) *
4	5418	578	5.40 (4.44, 6.57) *	6.24 (4.67, 8.33) *
5	5212	588	5.75 (4.72, 7.00) *	6.29 (4.71, 8.40) *
race classification				
white only	24234	1538	1.00	1.00
black only	3070	459	2.59 (2.32, 2.90) *	2.16 (1.84, 2.53) *
multiple race	1721	182	1.75 (1.48, 2.05) *	1.76 (1.42, 2.19) *
other	1635	157	1.57 (1.32, 1.86) *	1.64 (1.30, 2.07) *
household's highest education				
less than high school	1756	161	1.37 (1.16, 1.63) *	1.01 (0.74, 1.39)
high school graduate	6691	663	1.50 (1.36, 1.64) *	1.26 (1.09, 1.46) *
more than high school	24564	1683	1.00	1.00
poverty level				
less than 100% poverty level	4399	494	2.16 (1.89, 2.46) *	0.73 (0.56, 0.93) *
100% to below 133% poverty level	2206	192	1.62 (1.37, 1.93) *	0.79 (0.57, 1.09)
133% to below 150% poverty level	1056	96	1.70 (1.36, 2.14) *	0.80 (0.63, 1.03)
150% to below 185% poverty level	2156	189	1.64 (1.37, 1.95) *	0.89 (0.65, 1.21)
185% to below 200% poverty level	1121	99	1.65 (1.32, 2.07) *	0.71 (0.58, 0.87) *
200% to below 300% poverty level	5672	403	1.30 (1.14, 1.49) *	0.72 (0.58, 0.90) *
300% to below 400% poverty level	4644	328	1.30 (1.12, 1.50) *	0.64 (0.52, 0.78) *
at or above 400% poverty level	8801	488	1.00	1.00
tobacco use in household				
yes	5518	513	1.38 (1.23, 1.54) *	1.21 (1.07, 1.38) *
no	14928	1035	1.00	1.00
child ever breastfed or fed breast milk				
yes	24204	1591	1.00	1.00
no	8809	906	1.63 (1.50, 1.78) *	1.18 (1.04, 1.34) *

† comparisons are for never compared to ever breastfed

* indicates significance at the $p < 0.05$ level

Table 8. Crude and adjused POR for risk of asthma by breastfeeding and race among 33,315 children from NCHS, 2003[†]

race classification	Total (N)	Asthma (N)	Crude POR (95% CI)	Adjusted[††] POR (95% CI)
white only	24307	1538	1.54 (1.37 , 1.72) *	1.23 (1.05 1.44) *
black only	3084	459	1.36 (1.11 , 1.67) *	1.10 (0.83 1.46)
multiple race	1732	182	1.62 (1.15 , 2.28) *	1.66 (1.05 , 2.61) *
other	1642	157	1.03 (0.69 , 1.53)	0.71 (0.41 , 1.24)

[†] comparisons are for never compared to ever breastfed

[††] adjusted for age, household's highest education, poverty level, and tobacco use using multivariate logistic regression

* indicates signficance at the $p < 0.05$ level

Figures

Figure 1. Distribution of age when stopped breastfeeding (natural log transformed)

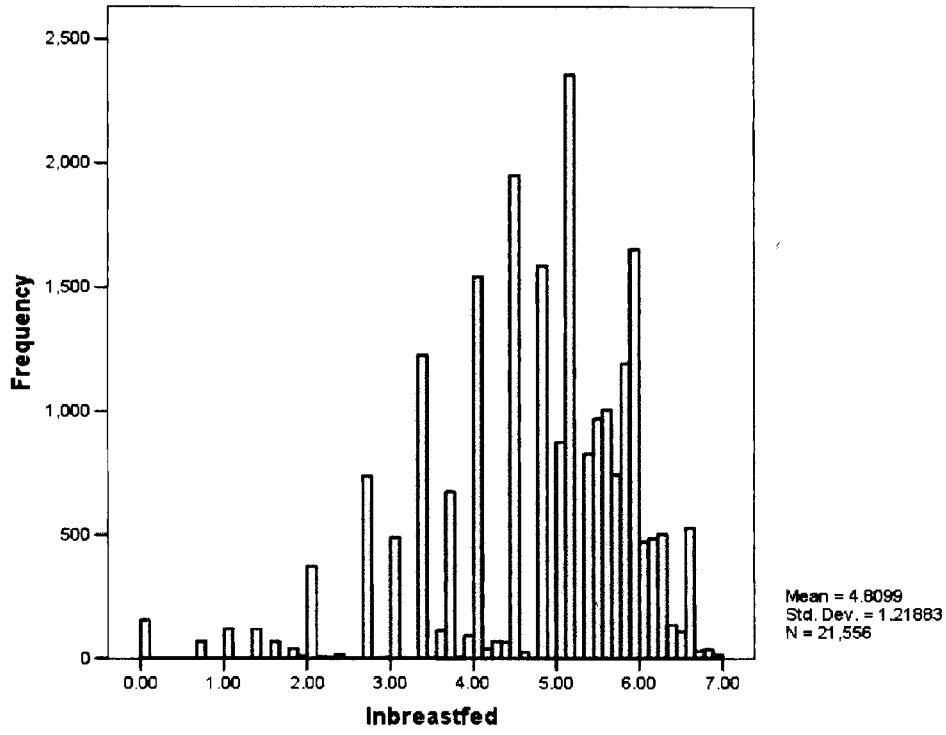
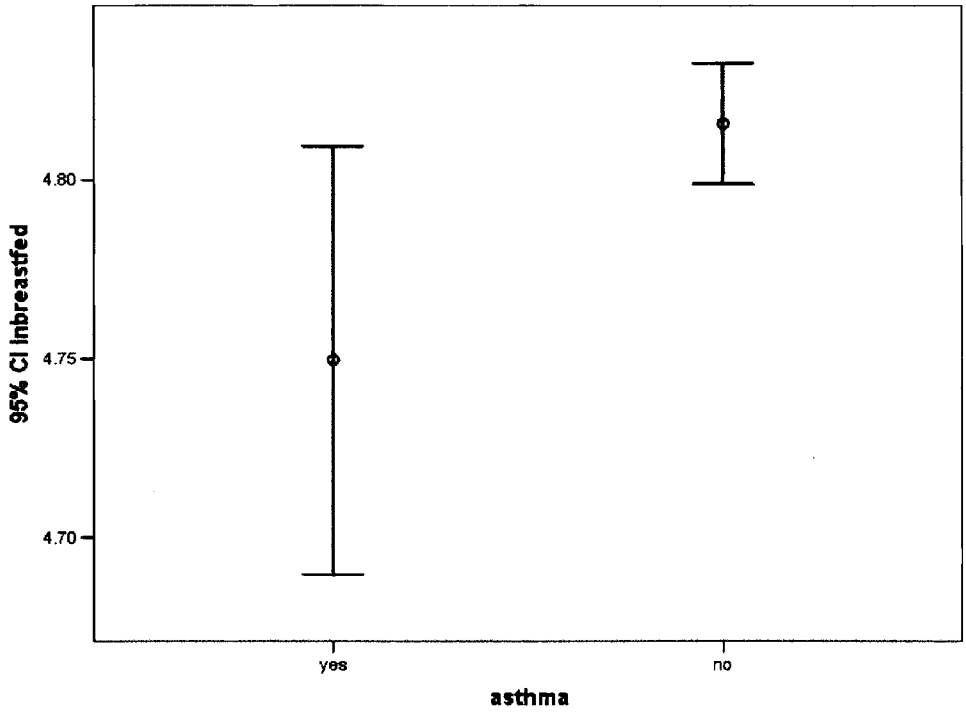


Figure 2. Comparison of mean age (in days) when breastfeeding was stopped by asthma diagnosis (natural log transformed)



Appendix

Appendix A – Variable List and Questionnaire Format

Subset of NSCH Interview File Variables
Created February 24, 2005

#	Variables	Type	Length	Format	Label
1	IDNUMR	Num	8		Unique ID number for this household
2	STATE	Num	3	STATE.	State of residence
4	AGEYR_CHILD	Num	3		Derived. Age in years of selected child (S.C.)
5	TOTKIDS4	Num	8	TOTKIDS.	How many people less than 18 years old live in this household (top coded to 4)
6	AGEPOS4	Num	8	BIRTHP.	Age position of the S.C relative to other children in the household
7	S1Q01	Num	3	S1Q01C.	Is [S.C.] male or female
8	RELATION	Num	8	RELATION.	Derived. Respondent's Relationship To Child
10	EDUCATIONR	Num	8	EDR.	What is the highest level of education attained by anyone in your household
11	PLANGUAGE	Num	8	PLANG.	What is the primary language spoken in your home
33	S2Q19	Num	3	YN.	Has a doctor or health professional ever told you that [S.C.] has asthma?
42	S2Q38	Num	3	YN.	During the past 12 months, that is since [MONTH/YEAR], have you been told by a doctor or other health care professional that [he/she] had hay fever or any kind of respiratory
43	S2Q39	Num	3	YN.	During the past 12 months, that is since [MONTH/YEAR], have you been told by a doctor or other health care professional that [he/she] had any kind of food or digestive allergy?
44	S2Q40	Num	3	YN.	During the past 12 months, that is since [MONTH/YEAR], have you been told by a doctor or other health care professional that [he/she] had eczema or any kind of skin allergy?
45	S2Q41	Num	3	YN.	During the past 12 months, that is since [MONTH/YEAR], have you been told by a doctor or other health care professional that [he/she] had frequent or severe headaches, including migraines?
49	S2Q49	Num	3	YN.	Does [S.C.] still have asthma?
50	S2Q50	Num	3	S2Q50C.	Would you describe the health difficulties caused by [his/her] asthma as minor, moderate, or severe?
51	S2Q51	Num	3	S2Q51C.	Overall, would you say [his/her] asthma puts a burden on your family a great deal, a medium amount, a little, or not at all?
52	S2Q52	Num	3	S2Q52C.	How long has it been since [he/she] last took asthma medication?
53	S2Q52A	Num	3	YN.	During the past 12 months, has [S.C.] had an episode of asthma or an asthma attack?
54	S2Q53	Num	3	YN.	During the past 12 months, has [S.C.] stayed overnight in a hospital because of [his/her] asthma?
199	S6Q59	Num	3	YN.	Was [S.C.] ever breastfed or fed breast milk?
200	S6Q60R	Num	8	S6Q60CR.	How old was [he/she] when [he/she] completely stopped breastfeeding or being fed breast milk? (AGE IN DAYS)
277	S9Q11B	Num	3	YNX.	Does anyone in the household use cigarettes, cigars, or pipe tobacco?
286	S11Q01	Num	3	YN.	Is [S.C.] of Hispanic or Latino origin?
287	RACE_MAIN	Num	8	RACEM.	Race classification for all states (White,Black,Mutiracial,Other)
291	S11Q03	Num	3	YN.	[Was [S.C.]'s [FILL MOTHER TYPE FROM S9Q02]/Were you] born in the United States?
292	S11Q04	Num	3	YN.	[Was [S.C.]'s [FILL FATHER TYPE FROM S9Q02]/Were you] born in the United States?
293	S11Q05	Num	3	YN.	Was [S.C.] born in the United States?
295	S11Q08	Num	3	YN.	Was anyone in the household employed at least 50 weeks out of the past 52 weeks?
296	POVERTY_LEVELR	Num	8	POVLVLR.	Derived. Poverty level of this household based on DHHS guidelines
297	C11Q11	Num	3	YN.	At any time during the past 12 months, even for one month, did anyone in this household receive any cash assistance from a state or county welfare program, such as [STATE
298	C11Q11A	Num	3	YN.	During the past 12 months, did [[S.C.]/ any child in the household] receive food stamps?
299	C11Q11B	Num	3	YN.	During the past 12 months, did [[S.C.]/ any child in the household] receive free or reduced-cost breakfasts or lunches at school?
300	S9Q34	Num	3	S9Q34C.	Does anyone who lives in the household currently receive benefits from the women, infants, and children (WIC) program?
301	WEIGHT_I	Num	8		POST-STRATIFIED ADJUSTED INTERVIEW WEIGHT

Appendix B – Variable Coding Dictionary

```
VALUE ID
 2000000 - 29999999 = "UNIQUE HH ID"
;

VALUE POVLVLR
  .P = ".P - PARTIAL INTERVIEW"
  .M = ".M - MISSING"
   1 = " 1 - LESS THAN 100% POVERTY LEVEL"
   2 = " 2 - 100% TO BELOW 133% POVERTY LEVEL"
   3 = " 3 - 133% TO BELOW 150% POVERTY LEVEL"
   4 = " 4 - 150% TO BELOW 185% POVERTY LEVEL"
   5 = " 5 - 185% TO BELOW 200% POVERTY LEVEL"
   6 = " 6 - 200% TO BELOW 300% POVERTY LEVEL"
   7 = " 7 - 300% TO BELOW 400% POVERTY LEVEL"
   8 = " 8 - AT OR ABOVE 400% POVERTY LEVEL"
;

VALUE S1Q01C    1 = " 1 - MALE"
          2 = " 2 - FEMALE"
          6 = " 6 - DON'T KNOW"
          7 = " 7 - REFUSED"
          .L = ".L - LEGITIMATE SKIP"
          .M = ".M - MISSING"
          .P = ".P - PARTIAL INTERVIEW"
          .N = ".N - NOT IN UNIVERSE"
;

VALUE  S2Q50C  1 = " 1 - MINOR DIFFICULTIES"
          2 = " 2 - MODERATE DIFFICULTIES"
          3 = " 3 - SEVERE DIFFICULTIES"
          6 = " 6 - DON'T KNOW"
          7 = " 7 - REFUSED"
          .L = ".L - LEGITIMATE SKIP"
          .M = ".M - MISSING"
          .P = ".P - PARTIAL INTERVIEW"
          .N = ".N - NOT IN UNIVERSE"
;

VALUE  S2Q51C  1 = " 1 - A GREAT DEAL"
          2 = " 2 - A MEDIUM AMOUNT"
          3 = " 3 - A LITTLE"
          4 = " 4 - NOT AT ALL"
          6 = " 6 - DON'T KNOW"
```

```
            7 = " 7 - REFUSED"
            .L = ".L - LEGITIMATE SKIP"
            .M = ".M - MISSING"
            .P = ".P - PARTIAL INTERVIEW"
            .N = ".N - NOT IN UNIVERSE"
;

VALUE   S2Q52C
   1 = "01 - LESS THAN ONE DAY AGO"
   2 = "02 - 1-6 DAYS AGO"
   3 = "03 - 1 WEEK TO LESS THAN 3 MONTHS AGO"
   4 = "04 - 3 MONTHS TO LESS THAN 1 YEAR AGO"
   5 = "05 - 1 YEAR TO LESS THAN 3 YEARS AGO"
   6 = "06 - 3 YEARS TO 5 YEARS AGO"
   7 = "07 - MORE THAN 5 YEARS AGO"
   8 = "08 - HAS NEVER USED MEDICATION"
  96 = "96 - DON'T KNOW"
  97 = "97 - REFUSED"
  .L = ".L - LEGITIMATE SKIP"
  .M = ".M - MISSING"
  .P = ".P - PARTIAL INTERVIEW"
  .N = ".N - NOT IN UNIVERSE"
;

VALUE S6Q60CR
  /*0 - 1095 = "RANGE 0 - 1095"*/
     1095 = "1095 - 1095 DAYS OR MORE"
     9995 = "9995 - STILL BREASTFEEDING"
     9996 = "9996 - DON'T KNOW"
     9997 = "9997 - REFUSED"
      .L = " .L - LEGITIMATE SKIP"
      .P = " .P - PARTIAL INTERVIEW"
      .M = " .M - MISSING"
      .N = " .N - NOT IN UNIVERSE"
;

VALUE S9Q34C    1 = " 1 - YES"
            2 = " 2 - NO"
            3 = " 3 - NEVER HEARD OF WIC"
            6 = " 6 - DON'T KNOW"
            7 = " 7 - REFUSED"
            .L = ".L - LEGITIMATE SKIP"
            .M = ".M - MISSING"
            .P = ".P - PARTIAL INTERVIEW"
            .N = ".N - NOT IN UNIVERSE"
;
```

```
 VALUE YN        1 = " 1 - YES"
                 0 = " 0 - NO"
                 6 = " 6 - DON'T KNOW"
                 7 = " 7 - REFUSED"
                .L = ".L - LEGITIMATE SKIP"
                .P = ".P - PARTIAL INTERVIEW"
                .M = ".M - MISSING"
                .N = ".N - NOT IN UNIVERSE"
 ;

 VALUE YNX       1 = " 1 - YES"
                 0 = " 0 - NO"
                 6 = " 6 - DON'T KNOW"
                 7 = " 7 - REFUSED"
                .L = ".L - LEGITIMATE SKIP"
                .P = ".P - PARTIAL INTERVIEW"
                .M = ".M - MISSING"
                .N = ".N - NOT IN UNIVERSE"
                .A = ".A - INTERVIEW COMPLETED PRIOR TO ADDITION OF QUESTION"
 ;

/* SPECIAL FORMATS */

/* NEW FORMATS */
 value racem
  .M = ".M - MISSING"
   1 = "1 - WHITE ONLY"
   2 = "2 - BLACK ONLY"
   3 = "3 - MULTIPLE RACE"
   4 = "4 - OTHER"
 ;

value edr
  .M = ".M - MISSING"
   1 = "1 - LESS THAN HIGH SCHOOL"
   2 = "2 - 12 YEARS, HIGH SCHOOL GRADUATE"
   3 = "3 - MORE THAN HIGH SCHOOL"
  96 = "96 - DON'T KNOW"
  97 = "97 - REFUSED"
 ;

  value birthp
   1 = "1 - ONLY CHILD"
   2 = "2 - OLDEST CHILD"
   3 = "3 - 2ND OLDEST CHILD"
```

```
  4 = "4 - 3RD OLDEST CHILD"
  5 = "5 - 4TH OLDEST CHILD"
 ;

 value ageyrg
  1 = "1 - AGES 0-5  "
  2 = "2 - AGES 6-11 "
  3 = "3 - AGES 12-17"
 ;

value plang
 .M = ".M - MISSING"
  1 = "1 - ENGLISH"
  2 = "2 - ANY OTHER LANGUAGE"
  6 = "3 - DON'T KNOW"
  7 = "4 - REFUSED"
 ;

value totkids
  1 = "1 - 1 CHILD"
  2 = "2 - 2 CHILDREN"
  3 = "3 - 3 CHILDREN"
  4 = "4 - 4 OR MORE CHILDREN"
;

value relation
  .M = ".M - MISSING"
   1 = "1 - MOTHER (BIOLOGICAL,STEP,FOSTER,ADOPTIVE)"
   2 = "2 - FATHER (BIOLOGICAL,STEP,FOSTER,ADOPTIVE)"
   3 = "3 - OTHER"
   6 = "6 - DON'T KNOW"
   7 = "7 - REFUSED"
;
```

Appendix C – Additional Data Tables

Table 1. Asthma and allergy characteristics of 33,315 children between the ages of 0 and 5 in the 2003 National Survey of Children's Health

	Total			Asthma			Combined Allergies		
Variable	N	%†	%‡	N	Prevalence (%)	95% CI	N	Prevalence (%)	95% CI
asthma diagnosis (ever)									
yes	2518	7.6	8.8				1347	53.5	(51.5, 55.4)
no	30685	92.1	90.8				6303	20.5	(20.1, 21.0)
don't know	110	0.3	0.3				58	52.7	(43.4, 62.1)
refused	2	0.0	0.0				0		
hay fever or respiratory allergy									
yes	3530	10.6	10.7	1014	28.7	(27.2, 30.2)			
no	29662	89.0	88.9	1481	5.0	(4.7, 5.2)			
don't know	122	0.4	0.4	22	18.0	(11.2, 24.9)			
refused	1	0.0	0.0	1					
food or digestive allergy									
yes	1649	4.9	4.5	304	18.4	(16.6, 20.3)			
no	31581	94.8	95.3	2207	7.0	(6.7, 7.3)			
don't know	85	0.3	0.2	7	8.2	(2.4, 14.1)			
refused	0								
eczema or skin allergy									
yes	4256	12.8	12.1	579	13.6	(12.6, 14.6)			
no	28991	87.0	87.7	1935	6.7	(6.4, 7.0)			
don't know	67	0.2	0.2	4	6.0	(0.3, 11.6)			
refused	1	0.0	0.0	0					
combined allergies (respiratory, food, and skin)									
yes	7708	23.1		1347	17.5	(16.6, 18.3)			
no	25429	76.3		1154	4.5	(4.3, 4.8)			
don't know	176	0.5		16	9.1	(4.8, 13.3)			
refused	2	0.0		1					

† unweighted percentages

‡ percentages weighted to national population characteristics

Appendix C – Additional Data Tables

Table 2a. Respiratory and digestive allergy prevalence and crude POR by breastfeeding history for 33,315 children, aged 0 - 5 years, in NSCH, 2003

Variable	hay fever or respiratory allergy			food or digestive allergy		
	Prevalence(%)	Crude POR	(95% CI)	Prevalence %	Crude POR	(95% CI)
child ever breatfed or fed breast milk						
yes	10.1	1.00	(referent)	5	1.00	(referent)
no	11.9	1.20	(1.29, 1.11)	4.8	0.97	(0.87, 1.09)
duration of breatfeeding						
less than one week (0-6 days)	10.2	1.00	(referent)	5	1.00	(referent)
one week to 6 weeks (7-42 days)	11.9	1.18	(0.89, 1.57)	5.9	1.21	(0.81, 1.80)
6 weeks to 3 months (43-90 days)	10.7	1.06	(0.79, 1.41)	5.3	1.08	(0.72, 1.60)
3 months to 6 months (91-180 days)	10.8	1.06	(0.80, 1.41)	4.7	0.95	(0.64, 1.41)
6 months to one year (181-365 days)	11	1.09	(0.82, 1.44)	4.8	0.96	(0.65, 1.42)
one to two years (366-730 days)	10.4	1.02	(0.76, 1.36)	5.4	1.10	(0.73, 1.66)
more than two years (>731 days)	13.2	1.34	(0.87, 2.05)	5.8	1.17	(0.63, 2.17)
still breastfeeding	2.3			3.6		

* indicates significance at the p < 0.05 level

Table 2b. Skin and combined allergy prevalence and crude POR by breastfeeding history for 33,315 children, aged 0 - 5 years, in NSCH, 2003

Variable	eczema or skin allergy			combined allergies		
	Prevalence(%)	Crude POR	(95% CI)	Prevalence %	Crude POR	(95% CI)
child ever breatfed or fed breast milk						
yes	13.1	1.00	(referent)	22.9	1.00	(referent)
no	12.1	0.91	(0.85, 0.98)	24.1	1.07	(1.01, 1.13)
duration of breatfeeding						
less than one week (0-6 days)	13	1.00	(referent)	22.8	1.00	(referent)
one week to 6 weeks (7-42 days)	13	1.01	(0.78, 1.30)	25.6	1.17	(0.95, 1.43)
6 weeks to 3 months (43-90 days)	12.8	0.98	(0.76, 1.28)	23.6	1.04	(0.85, 1.29)
3 months to 6 months (91-180 days)	13.1	1.01	(0.78, 1.31)	22.9	1.00	(0.82, 1.23)
6 months to one year (181-365 days)	14	1.09	(0.85, 1.40)	24.1	1.07	(0.88, 1.31)
one to two years (366-730 days)	14.8	1.16	(0.90, 1.52)	23.9	1.06	(0.86, 1.31)
more than two years (>731 days)	11.5	0.87	(0.57, 1.34)	25.1	1.13	(0.82, 1.57)
still breastfeeding	10.1			13.9		

* indicates significance at the p < 0.05 level

Appendix C – Additional Data Tables

Table 3. Hay fever or respiratory allergy prevalence by demographic and risk characteristics of 33,315 children, aged 0 - 5 years, in NSCH, 2003

Variable	Total (N)	Hay Fever or Respiratory Allergy (N)	Prevalence % (95% CI)	Crude POR (95% CI)
gender				
male	16983	1992	11.7 (11.3, 12.2)	1.27 (1.18, 1.36) *
female	16194	1535	9.5 (9.0, 9.9)	1.00
don't know	1	0	0.0	
refused	14	3	21.4 (4.4, 62.6)	
age				
0	5831	199	3.4 (3.0, 3.9)	1.00
1	6232	518	8.3 (7.6, 9.0)	2.57 (2.17, 3.03) *
2	4843	544	11.2 (10.4, 12.2)	3.58 (3.03, 4.23) *
3	5668	709	12.5 (11.7, 13.4)	4.05 (3.44, 4.76) *
4	5413	760	14.0 (13.1, 15.0)	4.62 (3.94, 5.43) *
5	5205	800	15.4 (14.4, 16.4)	5.14 (4.38, 6.03) *
race classification				
white only	24207	2612	10.8 (10.4, 11.2)	1.00
black only	3074	399	13.0 (11.8, 14.2)	1.23 (1.10, 1.38) *
multiple race	1728	201	11.6 (10.2, 13.3)	1.09 (0.93, 1.27)
other	1637	158	9.7 (8.3, 11.2)	0.88 (0.75, 1.05)
Hispanic or Latino origin				
yes	5417	420	7.8 (7.1, 8.5)	1.00
no	27456	3079	11.2 (10.8, 11.6)	1.50 (1.35, 1.67) *
don't know	40	4	10.0 (2.7, 25.6)	
refused	33	6	18.2 (6.7, 39.6)	
primary language in home				
English	29661	3344	7.8 (10.9, 11.6)	2.30 (1.97, 2.68) *
any other language	3512	184	5.6 (4.5, 6.0)	1.00
don't know	17	2	11.8 (1.4, 42.5)	
refused	2	0		
household's highest education				
less than high school	1757	116	6.6 (5.4, 7.8)	1.00
high school graduate	6689	666	10.0 (9.2, 10.7)	1.56 (1.28, 1.92) *
more than high school	24554	2738	11.2 (10.8, 11.5)	1.78 (1.47, 2.15) *
don't know	158	8	5.1 (2.2, 8.5)	
refused	33	2	6.1 (0.7, 21.9)	
poverty level				
less than 100% poverty level	4396	468	11.2 (9.7, 11.6)	0.94 (0.83, 1.05)
100% to below 133% poverty level	2203	219	8.7 (8.7, 11.2)	0.87 (0.74, 1.01)
133% to below 150% poverty level	1064	124	9.0 (9.7, 13.6)	1.04 (0.85, 1.26)
150% to below 185% poverty level	2157	227	8.7 (9.2, 11.8)	0.92 (0.79, 1.08)
185% to below 200% poverty level	1121	111	8.8 (8.2, 11.7)	0.86 (0.70, 1.06)
200% to below 300% poverty level	5666	566	7.1 (9.2, 10.8)	0.87 (0.78, 0.97)
300% to below 400% poverty level	4646	554	7.0 (11.0, 12.9)	1.06 (0.95, 1.19)
at or above 400% poverty level	8796	993	5.5 (10.6, 12.0)	1.00
state or county welfare				
yes	1842	236	13.9 (11.3, 14.3)	1.32 (1.14, 1.53) *
no	14657	1466	8.2 (9.5, 10.5)	1.00
don't know	36	2	2.8 (0.7, 20.1)	
refused	3	1		
tobacco use in household				
yes	5511	685	12.4 (11.6, 13.3)	1.27 (1.16, 1.40) *
no	14925	1497	10.0 (9.6, 10.5)	1.00
don't know	4	1		
refused	6	1		

* indicates significance at the $p < 0.05$ level

Appendix C – Additional Data Tables

Table 4. Respiratory allergy prevalence by breastfeeding for 33,315 children, aged 0 - 5 years, in NSCH, 2003

	Total	Hay Fever or Respiratory Allergy		
Variable	N	N	Prevalence (95% CI)	Crude POR (95% CI)
child ever breatfed or fed breast milk				
yes	24208	2452	10.1 (9.8 , 10.5)	1.00
no	8796	1045	11.9 (11.2 , 12.6)	1.20 (1.11 , 1.29) *
don't know	187	32	17.1 (11.7 , 24.2)	
refused	7	1	14.3 (0.4 , 79.6)	
duration of breatfeeding				
less than one week (0-6 days)	586	60	10.2 (7.8 , 13.2)	1.00
one week to 6 weeks (7-42 days)	3633	432	11.9 (10.9 , 13.0)	1.18 (0.89 , 1.57)
6 weeks to 3 months (43-90 days)	3751	403	10.7 (9.8 , 11.8)	1.06 (0.79 , 1.41)
3 months to 6 months (91-180 days)	4840	523	10.8 (10.0 , 11.7)	1.06 (0.80 , 1.41)
6 months to one year (181-365 days)	5886	650	11.0 (10.3 , 11.9)	1.09 (0.82 , 1.44)
one to two years (366-730 days)	2686	279	10.4 (9.3 , 11.6)	1.02 (0.76 , 1.36)
more than two years (>731 days)	295	39	13.2 (9.4 , 18.1)	1.34 (0.87 , 2.05)
still breastfeeding	2304	53	2.3 (1.7 , 3.0)	
don't know	203	11	5.4 (2.7 , 9.7)	
refused	19	2	10.5 (1.3 , 38.0)	

† unweighted percentages

‡ percentages weighted to national population characteristics

* indicates significance at the $p < 0.05$ level

Appendix C – Additional Data Tables

Table 5. Multivariate logistic regression for respiratory allergy among 33,315 children from NCHS, 2003

Variable	Total (N)	Allergy (N)	Crude POR (95% CI)	Adjusted POR (95% CI)
age				
0	5831	199	1.00	1.00
1	6232	518	2.57 (2.17 , 3.03) *	2.46 (1.95 , 3.11) *
2	4843	544	3.58 (3.03 , 4.23) *	4.01 (3.19 , 5.03) *
3	5668	709	4.05 (3.44 , 4.76) *	3.99 (3.19 , 4.99) *
4	5413	760	4.62 (3.94 , 5.43) *	5.06 (4.06 , 6.32) *
5	5205	800	5.14 (4.38 , 6.03) *	4.94 (3.96 , 6.18) *
race classification				
white only	24207	2612	1.00	1.00
black only	3074	399	1.23 (1.10 , 1.38) *	1.22 (1.04 , 1.43) *
multiple race	1728	201	1.09 (0.93 , 1.27)	1.08 (0.88 , 1.33)
other	1637	158	0.88 (0.75 , 1.05)	0.86 (0.68 , 1.08)
household's highest education				
less than high school	1757	116	1.00	1.00
high school graduate	6689	666	1.56 (1.28 , 1.92) *	1.51 (1.07 , 2.12) *
more than high school	24554	2738	1.78 (1.47 , 2.15) *	1.74 (1.24 , 2.43) *
poverty level				
less than 100% poverty level	4396	468	0.94 (0.83 , 1.05)	1.09 (0.92 , 1.30)
100% to below 133% poverty level	2203	219	0.87 (0.74 , 1.01)	0.93 (0.75 , 1.15)
133% to below 150% poverty level	1064	124	1.04 (0.85 , 1.26)	1.04 (0.79 , 1.37)
150% to below 185% poverty level	2157	227	0.92 (0.79 , 1.08)	0.94 (0.76 , 1.15)
185% to below 200% poverty level	1121	111	0.86 (0.70 , 1.06)	0.96 (0.74 , 1.26)
200% to below 300% poverty level	5666	566	0.87 (0.78 , 0.97)	0.86 (0.75 , 1.00) *
300% to below 400% poverty level	4646	554	1.06 (0.95 , 1.19)	0.98 (0.85 , 1.13)
at or above 400% poverty level	8796	993	1.00	
tobacco use in household				
yes	5511	685	1.27 (1.16 , 1.40) *	1.27 (1.14 , 1.41) *
no	14925	1497	1.00	1.00
child ever breastfed or fed breast milk				
yes	24208	2452	1.00	1.00
no	8796	1045	1.20 (1.11 , 1.29) *	1.04 (0.93 , 1.16)

* indicates significance at the $p < 0.05$ level

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