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US Childhood Asthma Prevalence Estimates: The Impact of the 1997 National Health Interview Survey Redesign

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The 1997 redesign of the National Health Interview Survey (NHIS) affected US childhood asthma prevalence estimates. The 1997 asthma attack prevalence estimate for children 0–17 years was 5.4%. Pre-redesign NHIS childhood asthma period prevalence estimates peaked in 1995 at 7.5%. It is unclear whether the difference reflects the change in survey methodology or changing asthma prevalence. To examine the impact of the NHIS redesign on childhood asthma prevalence estimates, the authors analyzed the 1988 NHIS that contained two sets of asthma questions: the core survey used until 1996 and the Child Health Supplement (CHS) with questions more similar to those in the redesigned 1997 NHIS. The authors measured the difference between 1988 core and CHS childhood asthma prevalence estimates to calculate an inflation factor for 1997–2000 NHIS estimates. The 1988 CHS questions produced asthma prevalence estimates 19–34% lower than the 1988 core question, depending on the methodology used to assess the difference. Inflating the 1997 asthma attack prevalence estimate by these differences yielded modified 1997 estimates ranging from 6.5% (95% confidence interval: 5.6%, 7.5%) to 7.3% (95% confidence interval: 6.4%, 8.2%). The change in the 1997 NHIS asthma questions likely explains much of the difference in asthma prevalence estimates between 1995 and 1997.

asthma; child; health surveys; National Center for Health Statistics (U.S.); prevalence

Abbreviations: CHS, Child Health Supplement; CI, confidence interval; NHIS, National Health Interview Survey.

Editor's note: *An invited commentary on this article appears on page 105, and the authors' response appears on page 108.*

Asthma prevalence among children 0–17 years of age in the United States increased from 3.6 percent in 1980 to a peak of 7.5 percent in 1995 (1, 2). This "asthma epidemic" has spurred research and debate about its causes, and it has prompted increased intervention and prevention efforts (3–5). Because asthma poses a high burden to affected children and their families and results in high health care costs (6, 7), interest has been focused on recent asthma prevalence trends. However, the National Health Interview Survey (NHIS) that produces national asthma prevalence estimates underwent a major redesign in 1997 that changed both the

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	1980-1996 NHIS core (including 1988 NHIS)	1988 NHIS Child Health Supplement (CHS)	Redesigned (1997-2000) NHIS core
Screener question to determine if child ever had asthma:	(None)	Did your child ever have asthma?	Has a doctor or other health professional ever told you that your child had asthma?
Question to estimate asthma prevalence:	During the past 12 months, did anyone in the family have asthma?	IF YES: Did your child have asthma in the past 12 months?	IF YES: During the past 12 months, has your child had an episode of asthma or an asthma attack?

FIGURE 1. Comparison of National Health Interview Survey (NHIS) asthma questions, 1980–2000.

survey structure and the survey questions. The redesigned survey produced estimates for asthma *attack* prevalence that were lower than previous NHIS estimates for period prevalence of asthma. Although the estimates from the redesigned survey are not comparable with previous estimates (1), the redesign created an impression that childhood asthma prevalence may have recently declined.

The overall burden from childhood asthma, including morbidity, ambulatory visits, hospitalizations, and premature death, remains high (2, 3, 5, 6). However, a decline in asthma prevalence, if "true" rather than an artifact of changes in surveillance, may be a harbinger that the burden will decrease. Therefore, we conducted an analysis to estimate how much of the recent change in reported childhood asthma prevalence might be attributed to changes in the NHIS asthma questions. The Child Health Supplement (CHS) of the 1988 NHIS presents an opportunity to compare asthma prevalence estimates for survey participants responding to two different sets of asthma questions. This analysis can provide an approximation of the impact of the redesign. Unfortunately, a precise measurement cannot be provided because the 1988 CHS questions are not exactly the same as the redesigned 1997 NHIS questions.

Beginning in 2001, an additional asthma question was added to the NHIS core questionnaire. Estimates for current asthma prevalence will be available once 2001 NHIS data are released. Although this estimate will not be strictly comparable with those of pre-1997 NHIS asthma period prevalence, it will capture a group of people more similar to those in the pre-1997 asthma case definition than do the 1997–2000 NHIS asthma attack estimates. Therefore, we modified 1997–2000 NHIS estimates to provide a crude "bridge" between the asthma period prevalence (through 1996) and current asthma prevalence (available when 2001 data are processed and analyzed).

MATERIALS AND METHODS

The NHIS is a continuing household survey of a representative sample of the noninstitutionalized civilian US population (8). In 1997, the NHIS was redesigned to improve the content, simplify the survey, and reduce the questionnaire length (9). Two major changes affected information collected on health conditions. First, instead of asking a household informant about the health conditions of all household members, one sample adult and one sample child (for households containing children) are now randomly chosen to respond to questions about health conditions. As has always been the practice for the NHIS, a knowledgeable adult, usually a parent, responds in proxy for children. The second change involved streamlining data collection on selected health conditions and changes in question wording. Prior to the redesign, over 100 health conditions were divided among six separate lists. Each list was presented to one sixth of the survey sample. In the redesigned survey, each sample child and sample adult receive all health condition questions, but the total range of conditions is more limited compared with the pre-redesign NHIS. These changes resulted in a larger annual sample of children with responses to the asthma questions and smaller sampling error for asthma prevalence estimates.

In contrast to the previous NHIS asthma question that produced asthma period prevalence estimates, the redesigned questions in the 1997–2000 NHIS produce an estimate of asthma attack prevalence. To be included as a "case," a respondent must report that he or she has been diagnosed with asthma by a health professional and had an attack or episode of asthma in the past 12 months (figure 1). Since this case definition is more specific, it is not surprising that asthma attack prevalence estimates are lower than pre-1997 asthma period prevalence estimates that were based on

respondents' reporting that they had asthma in the previous 12 months. No part of the 1996 or 1997 NHIS sample received both the pre- and post-redesign questions to directly measure the impact of the redesign on NHIS asthma prevalence estimates. Therefore, we used the 1988 NHIS to attempt to measure the impact of the 1997 redesign.

The 1988 NHIS contained both the core asthma question used until 1996 and a CHS, with asthma questions more similar to but not the same as those used in the redesigned NHIS (figure 1). As described above, one sixth of the 1988 NHIS sample aged 0–17 years received the core asthma question. One half of the 1988 NHIS sample aged 0–17 years received the asthma questions from the CHS. Estimates from the 1988 NHIS core and 1988 CHS were compared. The difference was used to calculate an inflation factor to modify the 1997–2000 asthma attack prevalence estimates to make them more comparable with previous asthma period prevalence estimates. We used two different subgroups (referred to as study groups 1 and 2) of 1988 NHIS respondents. Study group 1 contained two overlapping subsamples of children. Prevalence estimates for the 5,509 children responding to the asthma question on the core survey (one sixth of the 1988 sample) were compared with prevalence estimates for the 16,624 children responding to the CHS asthma questions (one half of the 1988 sample). Study group 2 contained approximately one twelfth of the NHIS sample (2,805 children) that received *both* the core and CHS asthma questions.

Inflation factors for each study group were calculated as the ratio of the difference between 1988 core and CHS estimates to the CHS estimate. The 1997 asthma attack prevalence estimates were then multiplied by these inflation factors to obtain a modified estimate. Since previous work demonstrated a differential change in asthma prevalence after the redesign depending on ethnicity (1), age/race/ethnicity-specific inflation factors were calculated within each study group. Core and CHS estimates were compared for each of nine race/ethnicity/age groups: non-Hispanic White, non-Hispanic Black, and Hispanic and ages 0–4 years, 5–10 years, and 11–17 years. Other race/ethnicity groups were not included because of insufficient sample size and therefore also were excluded from the overall analyses so that the sample remained uniform for all analyses. The 1997–2000 estimates for each stratum were multiplied by these inflation factors, and overall estimates were produced using the 1997–2000 population distribution for each stratum.

Standard errors for the modified estimates were also calculated. There are two main sources of error in calculating modified estimates: the associated sample errors with the 1997–2000 asthma prevalence estimates, and those associated with the inflation factors based on the variances of the 1988 core and CHS prevalence estimates. To calculate the overall confidence intervals around the modified 1997–2000 asthma prevalence estimates, we assumed that the correlation between the estimators for the 1988 core and 1988 CHS prevalence values could be approximated by the ratio of their standard errors (Dr. Van Parsons, National Center for Health Statistics, Centers for Disease Control and Prevention, personal communication, 2001). To account for the complex survey design of the NHIS, we calculated standard errors using SUDAAN software (Research Triangle Institute, Research Triangle Park, North Carolina).

TABLE 1. Asthma prevalence estimates, by race/ethnicity and age group, before and after the 1997 National Health Interview Survey redesign, children aged 0–17 years, United States

	1995/1996 average annual asthma period prevalence (%)	1997 asthma attack prevalence (%)	% difference
Overall	6.86 (0.32)*	5.44 (0.22)	−20.6
Race/ethnicity			
Non-Hispanic White	6.53 (0.42)	5.22 (0.29)	−20.1
Non-Hispanic Black	8.21 (0.83)	6.75 (0.56)	−17.8
Hispanic	7.61 (0.69)	5.13 (0.43)	−32.6
Age group (years)			
0–4	5.03 (0.52)	4.12 (0.39)	−18.1
5–10	7.43 (0.59)	5.85 (0.41)	−21.3
11–17	7.74 (0.54)	6.04 (0.38)	−22.0

* Numbers in parentheses, standard error.

RESULTS

Asthma prevalence estimates for the years spanning the NHIS redesign are shown in table 1. Data from the last 2 years of the previous version of the NHIS (1995–1996) were combined to obtain adequate sample sizes for all race/ethnicity and age subgroups. The asthma attack prevalence estimate from the 1997 NHIS, 5.4 percent, is 21 percent lower than the asthma prevalence estimate from the 1995–1996 NHIS, 6.9 percent. For all race/ethnicity and age groups, the difference was approximately 20 percent, except for Hispanic children for whom the difference was 33 percent. In addition, in contrast to 1995–1996 when Hispanic children had higher asthma period prevalence than did non-Hispanic White children, 1997 asthma attack prevalence was similar for Hispanic and non-Hispanic White children.

Table 2 shows the difference in asthma prevalence estimates between the 1988 core NHIS and CHS for the overall sample of each study group and for race/ethnicity and age subgroups. For study group 1 (comprising all children with responses to the core asthma question and all children with responses to the CHS asthma questions), the overall difference in asthma prevalence was similar regardless of whether the difference was adjusted for age/race/ethnicity. The core asthma question yielded asthma estimates about 19 percent higher than the CHS asthma questions. Study group 2 comprised the smaller sample of children who had responses to *both* the core and CHS asthma questions. The differences found in this study group were substantially larger. The core estimate was 34 percent higher than the CHS overall estimate. In contrast to our expectations given the results in table 1, the core and CHS estimates for Hispanic children in study group 2 were the same or very similar.

Table 3 shows the results of applying the inflation factors calculated from the 1988 NHIS to the 1997–2000 NHIS data.

TABLE 2. Differences between asthma prevalence estimates from the 1988 core and the 1988 Child Health Supplement, National Health Interview Survey, children aged 0–17 years, United States

	Study group 1					Study group 2			
	Core (no.)	Core asthma prevalence (%)	CHS* (no.)	CHS asthma prevalence (%)	% difference†	Core/CHS (no.)	Core asthma prevalence (%)	CHS asthma prevalence (%)	% difference†
Overall‡	5,509	5.10	16,624	4.27	19.4	2,805	5.35	4.00	33.8
Age/race/ethnicity									
Non-Hispanic White									
0–4 years	1,002	3.05	3,486	2.66	14.7	563	2.60	2.17	19.8
5–10 years	1,267	5.74	3,597	4.92	16.7	616	6.82	4.96	37.5
11–17 years	1,459	5.75	4,665	4.76	20.8	794	6.49	4.13	57.1
Non-Hispanic Black									
0–4 years	287	6.00§	793	5.17	16.1	135	6.17§	5.45	13.2
5–10 years	334	6.11	895	5.82	5.0	153	7.06§	5.13§	37.6
11–17 years	411	7.42	1,092	4.62	60.6	198	6.51	5.33§	22.1
Hispanic									
0–4 years	264	2.28§	586	2.01	13.4	145	2.55§	2.55§	0
5–10 years	226	4.95	810	4.88	1.4	95	4.80§	4.80§	0
11–17 years	259	4.89§	642	3.58	36.6	106	3.06§	3.87§	–20.9

* CHS, Child Health Supplement.
† Equals the % difference between the core and CHS estimates: (core estimate – CHS estimate)/CHS estimate × 100.
‡ Respondents of race/ethnicity other than non-Hispanic White, non-Hispanic Black, and Hispanic have been excluded.
§ The relative standard error is above 30 percent; the estimate is unreliable.

The overall 1997 estimate of 5.5 percent was inflated by 19 percent (method 1 using study group 1 results) and 34 percent (method 2 using study group 2 results) to yield modified 1997 asthma prevalence estimates of 6.5 percent and 7.3 percent, respectively. Accounting for the multiple sources of sampling error, we calculated 95 percent confidence intervals for each of the adjusted 1997 asthma prevalence estimates: 6.5 percent (95 percent confidence interval (CI): 5.6 percent, 7.5 percent) for method 1 and 7.3 percent (95 percent CI: 6.4 percent, 8.2 percent) for method 2. Using age/race/ethnicity-adjusted values, we found the modified 1997 asthma prevalence estimates for methods 1 and 2 to be 6.5 percent (95 percent CI: 4.2 percent, 8.7 percent) and 7.2 percent (95 percent CI: 4.2 percent, 9.7 percent), respec-

TABLE 3. Original and modified asthma attack prevalence estimates (1997–2000) in percentages using the inflation factor calculated from 1988 core and Child Health Supplement asthma period prevalence estimates, National Health Interview Survey, children aged 0–17 years, United States

	1997		1998		1999		2000	
	Estimate	95% CI*	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Original estimate†	5.5	5.0, 5.9	5.4	4.9, 5.9	5.3	4.8, 5.8	5.5	5.1, 6.0
Modified estimates								
Overall estimates								
Method 1‡	6.5	5.6, 7.5	6.4	5.5, 7.4	6.3	5.3, 7.3	6.6	5.6, 7.6
Method 2§	7.3	6.4, 8.2	7.2	6.3, 8.1	7.1	6.1, 8.0	7.4	6.4, 8.3
Age/race/ethnicity-adjusted estimates								
Method 1‡	6.5	4.2, 8.7	6.5	4.2, 8.6	6.3	4.2, 8.4	6.7	4.2, 8.9
Method 2§	7.2	4.2, 9.7	7.1	4.2, 9.6	7.0	4.2, 9.3	7.3	4.2, 9.8

* CI, confidence interval.
† Respondents of race/ethnicity other than non-Hispanic White, non-Hispanic Black, and Hispanic have been excluded.
‡ Method 1 inflates the original estimates using study group 1 results, which compared 5,509 responses with the core question and 16,624 responses with the Child Health Supplement question.
§ Method 2 inflates the original estimates using study group 2 results, which compared the core and Child Health Supplement responses for 2,804 children with responses to both sets of asthma questions.

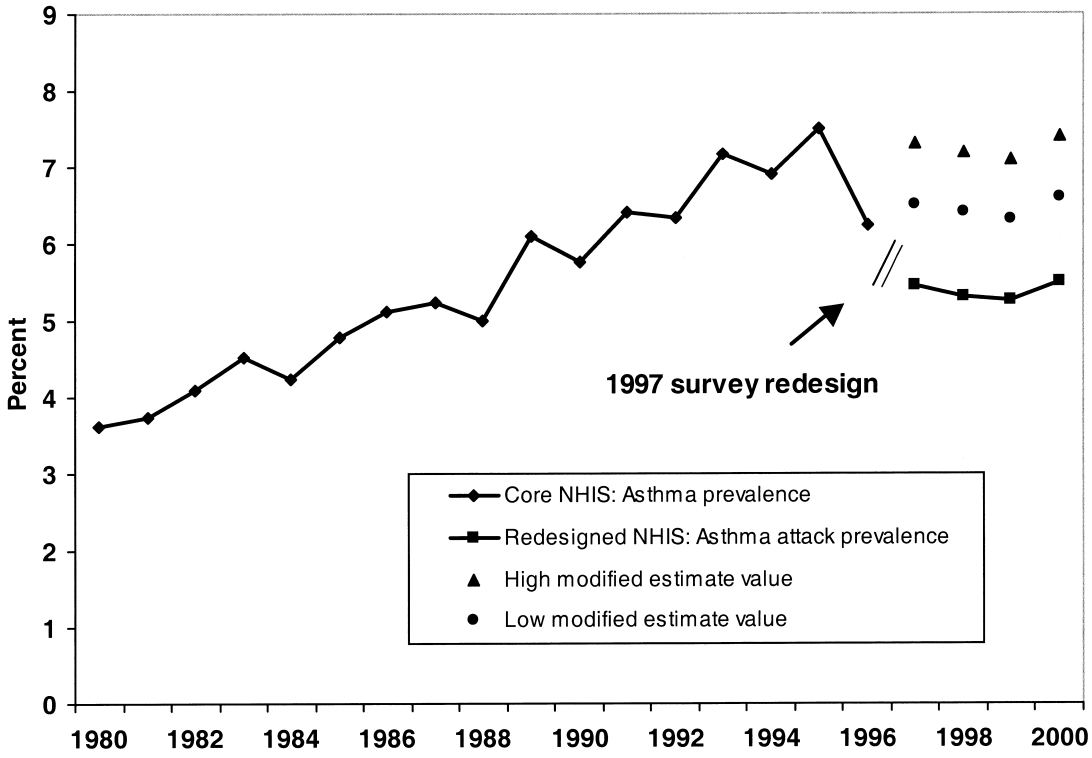

FIGURE 2. Childhood asthma period prevalence 1980–1996, childhood asthma attack prevalence 1997–2000, and modified childhood asthma prevalence 1997–2000, National Health Interview Survey (NHIS), United States. For the latter two analyses, the 1997–2000 asthma attack estimates from the redesigned NHIS and modified estimates include only non-Hispanic White, non-Hispanic Black, and Hispanic respondents, whereas the core NHIS prevalence estimates include all respondents aged 0–17 years. For 1997–2000, there is less than a 2 percent difference between these estimates and those for the entire sample before race/ethnicity exclusions.

tively. Figure 2 shows asthma period prevalence estimates from 1980–1996, asthma attack prevalence estimates from the redesigned survey in 1997–2000, and the lowest and highest values of the modified 1997–2000 estimates found in table 3.

DISCUSSION

Although changes in the NHIS survey design prohibit valid comparison of childhood asthma prevalence for the time periods spanning the redesign (i.e., 1996–1997) (1), the temptation to make these comparisons is difficult to resist. Results of this analysis suggest that the asthma attack prevalence estimates obtained since 1997 are 20–30 percent lower than asthma period prevalence estimates from earlier years, reinforcing the lack of comparability. After modification of the estimates from the redesigned NHIS to adjust for the change in the asthma questions, it appears that childhood asthma prevalence has not substantially changed from levels reached in the mid 1990s.

The different methods of modifying the estimates from the redesigned NHIS all have advantages and disadvantages. The inflation factor for study group 1 was based on a larger sample size than study group 2. Study group 2 included the sample that received both the 1988 NHIS core and 1988 CHS questions and made possible the direct comparison between a given sample's responses to each of two question sets. Age/race/ethnicity adjustment has the advantage of accounting for potential differences in race/ethnicity and age subgroups in their response to the changed asthma question. However, with nine strata, the sample size in each stratum tends to be small (the smallest stratum was in study group 2 with $n = 95$) and sampling error increased. Moreover, in contrast to our hypothesis that responses for Hispanic children may have been disproportionately affected by the change in the asthma question, the difference between 1988 core and CHS prevalence estimates for Hispanic children was small or nonexistent, depending on the age group. However, Hispanic children are a heterogeneous group, and the composition of the Hispanic sample included in the NHIS changed between 1988 and 1996 (NHIS, National Center for Health Statistics, Centers for Disease Control and Prevention, unpublished data, 1981 and 1996). Therefore, it remains unclear how to interpret the change in asthma prevalence among Hispanic children since 1996.

There were smaller differences between 1988 core and CHS responses for the youngest age groups compared with those for older children. The change in the asthma questions in 1997 to focus on episodes or attacks of asthma in the past 12 months may systematically lower asthma prevalence esti-

mates for older children. One possibility is that older children are more likely than younger children to have "outgrown" having asthma attacks. They are now counted in the estimate of prevalence of lifetime asthma diagnosis with the 1997 screener question but not counted in the asthma attack prevalence estimate. Before the redesign, because proxy reporters for children did not have an opportunity to acknowledge that the child had asthma with a screener question, they may have been more likely to disregard the 12-month recall period and to report that a child with resolved asthma had asthma in the past 12 months. Another possibility is that families with older children with asthma may be more likely than those with younger children to have developed effective management strategies to prevent asthma attacks (e.g., allergen avoidance, use of preventive medications). The exclusion of children with well-controlled asthma from the 1997 asthma attack case definition is a drawback in the redesign. This problem has been addressed in the 2001 and subsequent NHIS core questionnaires with an additional question: "Does your child still have asthma?" When 2001 NHIS data are available, it will be possible to measure the prevalence of children reported to have current asthma but no recent attacks.

Although the precise influence of the NHIS redesign on national asthma prevalence estimates is uncertain, we are confident that the redesigned NHIS core produces lower estimates than the previous core question. First, the directionality of our results is consistent regardless of the method used. Furthermore, a Child Health Supplement was also conducted in the 1981 NHIS with questions identical to those in the 1988 CHS. In 1981, the CHS asthma questions also yielded an asthma prevalence estimate approximately 20 percent lower than the core asthma question. We chose not to use the 1981 NHIS in this analysis because the race/ethnicity composition of the US population and, therefore, the NHIS sample changed significantly between 1981 and the late 1990s (NHIS, National Center for Health Statistics, Centers for Disease Control and Prevention, unpublished data, 1981 and 1996). Second, the modifications to asthma attack prevalence in 1997–2000 based on the 1988 CHS questions are likely to represent a conservative estimate of the decrease due to the NHIS redesign. Although the CHS and the redesigned core asthma questions are similar, the post-1997 estimates are based on a stricter case definition than the 1988 CHS questions. Although the CHS questions ask if a child ever had asthma and, if so, if he or she had asthma in the past 12 months, the redesigned question requires a diagnosis by a medical professional and an attack or episode of asthma in the past 12 months.

In summary, examining responses for the 1988 NHIS child participants shows that the redesigned NHIS core likely produces lower estimates than the previous core questionnaire for a given "background" asthma prevalence in the population. Directly comparing pre- and post-redesign estimates without taking the impact of the redesign into account *might* lead to an erroneous conclusion that childhood asthma prevalence has recently declined. When the change in the questions used to estimate asthma prevalence is taken into account, asthma prevalence in 1997–2000 appears to have remained at mid-1990s levels. However, only following the trend in asthma attack prevalence from 1997 and in current asthma prevalence from 2001 will definitively answer the question of whether the increasing trend in asthma prevalence of the past two decades has slowed or reversed.

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