

Decreased prevalence of asthma among farm-reared children compared with those who are rural but not farm-reared

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Background: Farm exposure has been associated with decreased asthma prevalence.

Objectives: We compared asthma prevalence among rural farm-reared and non-farm-reared children and examined farm demographic and environmental factors.

Methods: We performed a cross-sectional, population-based survey among 36,500 rural kindergarten through 12th grade school children. Surveys were distributed through schools and returned by mail.

Results: Of the 4152 participants, 18% had lived or were currently living on a farm. Compared to other rural children, farm children had more siblings (3.0 vs 2.5; $P < .015$), were more likely to be breast-fed (64% vs 58%; $P < .002$), to have pets (88% vs 79%; $P < .001$), and were less likely to have attended daycare (39% vs 50%; $P < .001$). Farm-reared children were less likely to have had a history of wheezing (28% vs 34%; $P < .003$) or a diagnosis of asthma (22% vs 26%; $P < .002$). This effect was greater among children younger than 10 years of age than among older children. There was no difference in the frequency of either asthma or non-asthma allergy symptoms during the previous 12 months. When analyzed by age and sex, decreased asthma prevalence was associated with farm rearing among younger children more than among adolescents. Farm residence beginning during the first 5 years, but not later, was associated with decreased rates of ever asthma (23.7% vs 33.7%; $P < .005$).

Conclusions: Asthma, but not other manifestations of allergy, is less commonly reported among farm-reared children. Early exposures may be more important than those occurring later. Without ongoing exposures, their effects on disease expression may diminish over time. (*J Allergy Clin Immunol* 2005;115: 67-73.)

Key words: Asthma, allergy, farm, epidemiology, childhood

Investigators in Europe, Australia, and Canada have reported that farm-reared, as opposed to either urban or

Abbreviations used

ECRHS: European Community Respiratory Health Survey

ISAAC: International Study of Asthma and Allergies in Children

K-12: Kindergarten through 12th grade

LRI: Lower respiratory illness

MSA: Metropolitan statistical area

OR: Odds ratio

rural non-farm-reared, children have a decreased prevalence of wheezing, asthma, and, in some cases, allergic rhinitis.¹⁻⁷ The International Study of Asthma and Allergies Among Children⁸ (ISAAC) and the European Community Respiratory Health Survey⁹ (ECRHS), among others,¹⁰ have demonstrated dramatic differences in the prevalence of asthma between and even within countries.^{10,11} Higher rates of asthma and atopy have been consistently associated with both westernization and urbanization.^{12,13}

Factors that contribute to the clinical expression of asthma have been identified, in part, from comparisons of asthma prevalence across populations.^{14,15} There is reason to believe that differences in asthma prevalence are due to environmental differences.^{16,17} Most studies of asthma among children on farms have found that the frequency of wheezing, asthma, and other indices of atopy are decreased compared to other groups of children. Neither a “healthy farmer” effect nor genetic differences appear to explain these findings. These studies have suggested that specific environmental and demographic factors unique to a farm setting may be important in the induction or the expression of the asthma phenotype and further suggest that the timing of these exposures may be critical in determining their effect on the subsequent expression of asthma.

Studies that have compared children reared on farms to those reared in both urban and rural non-farm areas have shown significant differences in both the immediate environment and lifestyle in terms of family size, exposure to livestock and pets, dampness, molds and dust, methods of heating and cooking, environmental tobacco smoke exposure, and dietary habits.^{2,18,19} The prevalence of asthma among non-urban children in the United States has not been studied extensively.^{7,20} Furthermore, studies done in Europe and elsewhere may not be applicable to

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TABLE I. Characteristics of rural school children by participation status

	Participants* 4152 (97.8%)	Refusals 95 (2.2%)	95% CI for differences (%)
Age (mo)	120.9 ± 38.3	124.7 ± 35.4	9.1-17.1
Current residence			
In town	25.9% (1051)	18.3% (17)	−0.4 to 15.6
Out of town	61.5% (2497)	74.2% (70)	−21.8 to −3.4
On a farm	12.7% (515)	7.5% (7)	−0.3 to 10.6
Ever lived on a farm	18.4% (3392)	12.8% (12)	−1.2 to 12.5
History of wheeze/whistle in the chest	33.0% (1352)	25.5% (24)	1.2-16.7
Been told by doctor wheeze or asthma	25.8% (1063)	16.8% (16)	−1.5 to 16.4
Taken medications for asthma	28.1% (1156)	20.0% (19)	0.0-16.3
Has allergies†	35.7% (1439)	27.4% (26)	−0.7 to 17.4

*Not all participants responded to all questions.

†See text for definition of variable.

the farming population of the US, where farming and the attendant lifestyle may be significantly different from those typical in Europe. This study examines the prevalence of asthma and allergies in a large sample of rural school children in Wisconsin.

METHODS

A population of non-urban school children was identified by using Wisconsin state educational data. Rural school districts were identified through the Wisconsin Department of Education School Database and the National Center for Educational Statistics.²¹ The eligible rural population was defined on the basis of metropolitan statistical area (MSA) codes (US Department of the Census). MSA codes designate a school's location relative to census population areas. MSA codes are numbered 1 to 8, with 1 denoting a district within a central city with a population of greater than 250,000. The following codes were used to define the eligible population: (1) MSA 6, "small town," defined as "a town not within an MSA and with a population of less than 25,000 and greater or equal to 2,500 people"; (2) MSA 7, "rural outside an MSA," defined as "a place with less than 2,500 people and coded rural and outside an MSA" by the census bureau; and (3) MSA 8, "rural inside an MSA," defined as "a place with less than 2,500 people and coded rural and inside an MSA" by the census bureau.

School district administrators were contacted by mail and then phone to solicit participation. If the administrator agreed, a short phone questionnaire was administered to ensure the rural character of the district. Questions included (1) Is agriculture a major industry in the district?, (2) Over the last 5 years, has the district become more urban or suburban?, and (3) Do most parents of students work outside of the district? If the administrator responded affirmatively to question 1 and negatively to questions 2 and 3, we determined that the district represented a rural population, and the administrators were solicited to have their districts participate in the survey.

Survey packets contained an introductory letter, a parental consent form, and a postage-paid reply envelope. Survey instruments were based on the written ISAAC questionnaires,^{22,23} to which were added questions about the family's residence at the time of the child's birth, during the first 5 years, after age of 5, and the area of current residence, whether urban, rural non-farm, or farm.

Study materials included a core questionnaire that asked for the following information: subject age, sex, whether the child attended daycare for at least ½ day for at least 3 months, whether the child was breast-fed at least ½ of all daily feeding; for a period of at least 1 month, whether there were current smokers in the child's home, whether the family lived "in town" in a rural area, "out of town but not on a farm," or "on a farm" when the child was born, between birth

and 5 years of age, and after 5 years of age, and the number of years in each environment. We asked in which environment the family lived at the time they filled out the questionnaire. Of those families on farms, we sought to determine whether there were livestock and silage present. We used questions taken from the ISAAC questionnaire to determine the presence of wheezing, asthma, nasal or ocular allergies, or eczema.²⁴ In addition, we asked whether the subject child had had a recurrent cough or wheeze or a lower respiratory tract illness ("infection in the chest; pneumonia, bronchitis, RSV [respiratory syncytial virus], or bronchiolitis") during the first 2 years of life.

We also included age-specific ISAAC questionnaires. Those younger than 10 years of age were asked to fill out the questionnaire designed for younger children and those equal to or older than 10 years were asked to fill out the questionnaire designed for older children. Parents were asked to fill out both the core and the age-appropriate questionnaires. If they declined to participate, we asked them to fill out the core questionnaire and return it. Packets were sent to the schools and distributed by teachers to all of the students in the eligible districts during May and June 2003. The study was approved by the Institutional Review Boards of the Children's Health System and Medical College of Wisconsin.

Data analysis

Categorical data were analyzed with the "crosstabs" procedure, SPSS 11.0 (SPSS Inc, Chicago, Ill). Differences between continuous variables were evaluated with the Student independent *t* test. Variables that were associated (*P* < .10) with outcomes of interest were included in a multiple logistic regression model. Variables were entered in a conditional, forward, stepwise manner (criteria for inclusion, *P* < .10 and for exclusion, *P* < .15). Variables were checked for collinearity. Variables with an *r*² of less than 0.50 were considered independent. A list of the variables that were evaluated is summarized in Table I. Farm residence was based on a non-0 response to any one of the 3 questions regarding how long the family lived on a farm when the child was born, during the child's first 5 years of life, or when the child was older than 5 years, or a response stating that at the time of the study, the family lived on a farm.

RESULTS

Of 114 eligible school districts identified as rural, 72 participated (63.2%). Of those that did not participate, 20 schools (47.6%) were considered not to be rural by the administrators. Three (7.1%) declined because of concerns about privacy. Four (9.5%) declined because of lack of time, lack of administrator or school board interest, or

TABLE II. Characteristics of rural school children by farm residence

	Farm residence (N = 760)*	Non-farm residence (N = 3478)	95% CI for difference (%)
Age (mo)	123.0 ± 42.5	120.6 ± 37.2	0.64-6.70
Age 25 th , 75 th percentiles	90.9, 149.7	91.9, 144.0	
No. children in the family	3.0 ± 1.5	2.5 ± 1.1	0.4-0.6
Sex (male)	49.4% (370)	51.6% (1773)	NS
Premature delivery	11.0% (82)	10.3% (355)	NS
Breast-fed†	63.9% (482)	57.8% (2005)	1.7-9.3
Daycare†	39.2% (297)	50.4% (1745)	-15.0 to -7.3
Smoker living in the house	24.3% (182)	24.2% (839)	NS
Currently have pets	88.3% (667)	79.1% (2740)	6.5-11.9
Indoor pets	70.6% (469)	84.4% (2312)	-17.5 to -10.1
History of wheeze or whistle in the chest	28.1% (212)	33.8% (1158)	-9.0 to -1.8
Been told by doctor wheeze or asthma	22.2% (167)	26.3% (905)	-7.4 to -0.8
Taken medications for asthma or wheezing	25.6% (193)	28.4% (1167)	-6.2 to 0.7
Has allergies*	30.5% (225)	36.6% (1232)	-8.7 to -2.3
Recurrent rash or eczema	19.1% (144)	18.0% (617)	NS
Recurrent cough or wheeze first 2 y of life	16.2% (122)	19.7% (677)	-6.4 to -0.5
Chest infection first 2 y of life	22.2% (166)	25.2% (867)	-6.4 to 0.3

*Not all participants responded to all questions.

†See text for definition of variable.

TABLE III. Lifetime prevalence of wheezing by age group and area of residence*

Area of residence	Ever wheeze (%) by age group		
	Only when the child was ≤5 y	Only when the child was >5 y	Both before and after the child was 5 y
In town	30.6% (204/665)	32.3% (45/139)	36.1% (486/1344)
Rural but non-farm	38.9% (95/244)	35% (148/419)	32.1% (681/2120)
Farm	33.7% (29/86)	35.9% (55/152)	23.7% (111/468)

*Subject family may have lived in multiple environments during any time period.

sufficient funds. Fifteen schools (35.7%) never responded to repeated attempts at contact. Thirty-four thousand packets were sent directly to the school districts, 1,500 (4.4%) were returned because of the district's inability to distribute them, and 2,500 (7.4%) packets were mailed directly to parents at the school administrators' request. There were no differences in MSA classification or selection criteria between eligible districts that did or did not participate. No other data were available to compare districts that did and did not participate.

Between June 1 and October 1, 2003, 4481 (12.8% of those delivered) questionnaires were returned. Two hundred twelve responses (4.7%) that did not include the core questionnaire were excluded because of missing data on age or environmental variables. Twenty-two questionnaires (0.5%), in which the responses to "ever asthma" were inconsistent between the core and age-specific questionnaires, were also excluded. Thus, 4247 responses, 94.8% of those returned, were included in this analysis.

Ninety-eight percent of those responding answered both the core and age-appropriate questionnaires, and 2.2% of "refusals" answered only the core questionnaire (Table I). There were no differences in number of siblings, sex, ethnicity, or breast-feeding. Refusal children were more likely to be in daycare and were less likely to have ever lived on a farm (12.8% vs 18.4%). Refusals were less

likely to have had a history of wheezing, taken medication for asthma, or to have allergies. There were no differences in the frequency of recurrent cough or wheeze or chest infection during the first 2 years of life between cases and refusals.

When subjects were compared on the basis of a history of ever or never having lived on a farm (Table II), children who had lived on a farm were significantly older, tended to have more siblings, were more frequently breast-fed, and were less frequently in daycare. Although farm children more often had pets, they were less frequently indoor pets.

The prevalence of a reported doctor diagnosis of asthma or wheezing was lower for farm-reared children than for rural, non-farm children (22.2% and 26.3%, respectively; 95% CI for difference, -7.4% to -0.8%), as was a reported history of wheezing or whistling in the chest or allergies (Table II). Farm children also were less likely to report a history of use of medications for asthma (25.6% and 28.4%, respectively; 95% CI for difference, -6.2% to 0.7%) or to report a history of chest illnesses during the first 2 years of life.

Of those who reported their residence history, more than half reported having lived in more than one environment (Table III). Of those who lived on a farm, 12.2% (86) reported doing so only during the child's first 5 years of life, 66% (468) during both the child's first 5 years of life

TABLE IV. Respiratory symptoms by age grouping, sex, and farm vs non-farm residence

	Age 9 y or less AND male farm* Yes/No	Age 9 y or less AND female farm Yes/No	Age 10 y or greater AND male farm Yes/No	Age 10 y or greater AND female farm Yes/No
Ever had asthma	18.1/22.7 (34)/(224) −10.7 to 1.5	9.4/12.7 (185)/(117) −8.0 to 1.3	20.2/27.7 (38)/(213) −12.4 to −0.8	NS
History of wheeze or whistle in the chest	36/39 (68)/(389) −14.1 to 0.9	23/36 (44)/(283) −14.0 to −0.9	33.6/41.9 (60)/(323) −16.1 to −0.7	NS
Wheeze or whistle in chest last 12 mo	48.6/54.7 (36)/(223) −18.4 to 6.4	46.2/42.4 (24)/(136) −10.8 to 18.7	20.7/20.1 (37)/(155) −6.0 to 7.1	14.5/14.5 (27)/(105) −5.7 to 5.7
Wheeze after exercise in last year	12.6%/15.4 (24)/(153) −8.0 to 2.4	7.3/10.1 (14)/(94) −6.9 to 1.3	NS	NS
Night cough in last year	25.3/31.5 (48)/(205) −13.0 to 0.6	17.7/22.2 (34)/(518) −10.5 to 1.5	NS	11.2/16.9 (21)/(123) −10.9 to −1.4

Data in each column indicate percent, (n), and 95% CI for difference.

NS, Not significant.

*Not all participants responded to all questions.

TABLE V. Adjusted ORs (95% CI) for occurrence of asthma and asthma-related symptoms in relation to residence on a farm in rural Wisconsin

Adjusted OR (95% CI)*	Participants & refusals	All participants	Participants age 9 y or less	Participants age 10 y and older
Ever asthma	0.80 (0.66-0.98)	0.78 (0.63-0.97)	0.74 (0.54-1.03)	0.78 (0.59-1.0)
Ever wheeze	0.77 (0.64-0.92)	0.78 (0.65-0.93)	0.79 (0.62-1.02)	0.78 (0.59-0.98)
Wheeze in the last 12 mo	NS	NS	NS	NS
Exercise wheeze in last 12 mo	NS	NS	0.74 (0.50-1.07)	NS
Night cough in last 12 mo	NS	NS	0.73 (0.56-0.96)	NS
Ever hay fever	0.77 (0.64-0.91)	NS	NS	0.71 (0.51-0.99)
Ever eczema	NS	NS	NS	1.35 (1.0-1.91)

NS, Not significant.

*All odds ratios adjusted for sex, household pets, breast-feeding, exposure to daycare, exposure to second-hand tobacco smoke, and number of siblings in the household.

and beyond, and 22% (152) only after the child's fifth year. Subjects living on a farm who were younger than 6 years old and those who reported living on a farm at some time only during their first 5 years of life were more likely to report wheezing than those living on a farm during the first 5 years of life and beyond (95% CI for difference, −0.71% to 20.0%). Those who lived on a farm only after the age of 5 years were more likely to report a history of wheeze compared with those who were farm reared both before and after age 5 years (95% CI for difference, 3.9% to 21.0%). Similarly, children described as rural non-farm only during the time when they were age 5 years or younger were more likely to report ever having wheezed than those who lived in a rural non-farm environment both during and after that time (95% CI, 0.4% to 14.2% for difference). Children who lived on a farm both before and after age 5 years were less likely than children reared in town or a rural non-farm area to report ever having wheezed (95% CI, −17.1% to −7.8% for difference and 95% CI, −12.7% to −4.1% for difference).

When children were compared on the basis of age grouping, gender, and farm rearing, farm rearing was associated with lower reported prevalence of ever asthma among all groupings except adolescent females (Table IV). In children age 9 years and younger, the reported prevalences of all asthma-related symptoms were lower in children who were reared on farms compared to the non-farm, rural children, although the confidence intervals for the differences all included one. No such consistent pattern was observed for the farm children 10 years or older. Farm rearing did not distinguish the overall 12-month period prevalence of asthma symptoms among any of the groupings, but both exercise-associated wheeze and chronic night cough were decreased among farm-reared children younger than 10 years of age (Table IV).

There was no consistent association of farm rearing with other markers of atopy. Hay fever was significantly less frequently reported among farm-reared adolescent males (13.9% vs 20.7%; 95% CI for difference, −12.81% to 0.99%), but eczema was reported significantly more

frequently among this same group (22.0% vs 14.9%; 95% CI for difference, 0.61% to 13.83%).

Multivariable analysis

Of the factors included in the initial logistic regression model, age, sex, number of siblings in the family, daycare, breast-feeding, and exposure to environmental tobacco smoke, only farm rearing, sex, and exposure to environmental tobacco smoke were independently associated with symptoms of asthma. Interaction terms, farm residence–smoking, farm residence–sex, smoking–sex, did not improve the fit of the 3 independent variables ($P < .10$).

Among the group as a whole (Table V), having lived on a farm was protective for ever wheezing (odds ratio [OR], 0.77; 95% CI, 0.6–0.92) or having been diagnosed with asthma (OR, 0.80; 95% CI, 0.66–0.98). When the analysis was confined to participants, farm residence was associated with a decreased likelihood of ever having wheezed or of having had asthma among both younger and adolescent age groups. Farm residence had a negative effect on the presence of a night cough (OR, 0.73; 95% CI, 0.50–0.96) but not exercise-induced wheezing (OR, 0.74; 95% CI, 0.5–1.07) during the previous 12 months among younger children.

Exposure to household tobacco smoke was significantly associated with ever having wheezed among younger (OR, 1.44; 95% CI, 1.18–1.76) and older (OR, 1.36; 95% CI, 1.09–1.70) participants, but not with a diagnosis of asthma. Among those children with a history of wheezing, environmental tobacco smoke exposure was not associated with wheezing during the previous 12 months, but it was associated with exercise-induced wheezing during the prior 12 months among younger children (OR, 1.34; 95% CI, 1.01–1.79), as well as with the presence of a night cough during the previous 12 months among both younger (OR, 1.31; 95% CI, 1.05–1.63) and older children (OR, 1.27; 95% CI, 0.99–1.65).

Number of siblings was not related to either wheezing (OR, 0.99; 95% CI, –0.96 to 1.02) or asthma, but daycare was associated with decreased chronic wheeze during the first 2 years of life (OR, 0.23; 95% CI, 0.07–0.39). Farm rearing was associated with a decreased occurrence of hay fever among older children (OR, 0.71; 95% CI, 0.51–0.99) but an increased occurrence of eczema (OR, 1.38; 95% CI, 1.0–1.91).

DISCUSSION

We observed that among children reared in a rural setting, current or past residence on a farm was associated with a lower reported cumulative prevalence of wheezing or asthma. This effect was more consistent among children younger than 10 years of age. Although farm rearing had no effect on the frequency of reported wheeze during the previous 12 months overall, there was a trend suggestive of decreased 12-month prevalence of both exercised-induced

wheeze and nighttime cough among younger farm-reared children. History of ever wheezing was less frequently reported among those who had lived on a farm continuously than among those who reported living on a farm only after the subject's fifth year of life. Among those who had tended to live in a single environment both before and after 5 years of age, wheezing was less prevalent among farm children compared with both rural non-farm children and those residing in towns. All of the above findings are consistent with the idea that factors associated with farming that affect asthma expression are dependent on their timing and duration. In our study, asthma was consistently reported less frequently among only younger farm-reared children, suggesting that exposures occurring early in life have a more significant effect in modifying asthma than those that occur later. Our findings further suggest that the effects of farm life on asthma prevalence persist during the period of exposure. However, the design of our study was cross-sectional, and given that our results were more consistent among younger children and for cumulative rather than previous 12-month period prevalence, it is possible that the protective effects of earlier exposure may be lost over time, or that increasing exposure to other environmental stimuli (antigens, tobacco smoke, ambient air pollutants from farm vehicles and equipment) could negate the protective effects of earlier farm exposures. The fact that farm rearing was associated with decreased wheeze or asthma among adolescent males but not females could be due to continuing exposures among farm males not experienced by females or to an increased prevalence of smoking among adolescent females compared with males reported elsewhere.⁵ We found that although farm rearing was associated with reduced asthma and wheezing, there were no differences in the prevalence of non-asthma allergies between farm and rural non-farm children, suggesting that there may be factors that modify asthma expression independent of non-asthma allergy.

We found demographic differences between farm-reared and rural non-farm children similar to those found in other studies from both Europe and Australia that reported decreased asthma among farm-reared children. In the present study, farm families overwhelmingly reported the presence of livestock, and more than 88% reported having pets. There is evidence that early exposure to multiple pets is protective for atopic sensitization,^{25–28} but among farm-reared children, this effect may be less important than early exposure to livestock. In the study by Riedler, children exposed to stables and farm milk during the first year of life were significantly less likely than those exposed thereafter to be diagnosed with asthma or wheezing during the previous 12 months. The mechanism by which this protective effect may operate has been hypothesized to be through early microbial and gram-negative endotoxin exposure.²⁹

Like the studies cited above, we found that compared to rural non-farm families, farm families tended to be larger, children were less likely to attend daycare, more often breast-fed, and pets were more common but less frequently indoors. Both increased sibship and breast-

feeding have been associated with decreased allergic sensitization.^{30,31} Although the long-term effects of breast-feeding on asthma are controversial,³² breast-feeding is clearly associated with decreased early wheeze and asthma.³¹ Daycare exposure has been associated with increased early wheeze and, in some studies, decreased atopic sensitization and asthma.³³ Increased sibship has been associated with decreased risk of atopic sensitization.^{34,35} It is attractive to speculate that breast-feeding and less exposure to daycare are related to decreased early wheezing and that early farm exposures and increased sibship are related to decreased allergic sensitization and subsequent asthma.

Only 12% of eligible families participated, and there was a trend for the 95 subjects whose parents completed only the core questionnaire to report fewer symptoms than the participant group. It is likely that our prevalence was inflated by nonresponse and self-selection bias, but although the prevalence of diagnosed asthma we reported is significantly greater than that reported by most European studies^{3,36} and by Ernst and Cormier⁵ in Quebec (5.8% among farm and 8.3% among non-farm children), it is only marginally greater than that reported by Chrischilles et al⁷ in Iowa (13%), similar to that reported from 2 US ISAAC sites (Moline, Ill, 16.1%³⁷ and Chicago, Ill, 24%³⁸) and significantly lower than the 43% reported by Downs et al³⁹ in Australia and the 33% reported by Wickens et al⁶ in New Zealand.

Although it is similarly possible that our 12-month prevalence rates were influenced by asthma families being more likely to respond, our reported prevalence among older children was similar to that found in other studies of rural children in the US and Canada. Chrischilles et al⁷ in Iowa reported prevalence of 19%, Ernst and Cormier⁵ in Quebec reported 17% and 13% among farm and rural children, respectively, and in rural Minnesota, 17.5% reported asthma symptoms during the previous 12 months (personal communication, W. Brennen, Minnesota Department of Health, August 2004).

Even allowing for nonresponse and selection bias, we found consistent and significant differences in prevalence between groups of farm and rural non-farm children, and we have no reason to believe that any bias would be different between town, rural, and farm populations. Furthermore, our findings are consistent with those of many other studies demonstrating lower rates of asthma and wheeze among farm-reared children.

Finally, we did not address several factors that have previously been found to affect the prevalence of asthma and atopy: parental allergic disease, housing conditions, heating fuels, dietary factors, or socioeconomic status.

Despite the limitations inherent in a questionnaire-based cross-sectional study, this study demonstrates that asthma is less prevalent among farm-reared children than among their rural, non-farm peers in Wisconsin and suggests that there are demographic and environmental factors unique to this farm population that may explain these differences. Furthermore, our results suggest that the effects of environmental exposure may be both time

sensitive and time limited. To our knowledge, this study is the first large cross-sectional study of asthma prevalence among a non-urban population in the US.

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