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Original Research

ASTHMA

Beginning School With Asthma Independently Predicts Low Achievement in a Prospective Cohort of Children

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Background: **Concerns about the achievement of children with asthma and respiratory conditions are especially important in New Zealand, which has one of the world's highest rates of childhood asthma. The present study evaluated whether entering school with asthma was associated with low achievement after the first year.**

Methods: **A child cohort was recruited to a prospective study at time of first enrollment into randomly selected schools in Christchurch. Parent interviews covered demographics and respiratory status. Physician reports were sought for children with asthma, and all respiratory information was clinically reviewed. The children's achievement in reading and math was individually assessed at school entry and reassessed after 12 months. Schools reported absences. Intelligence subtests were administered.**

Results: **Two hundred ninety-eight children were recruited, including 55 (18.5%) with current asthma. At 1-year follow-up, retention was 93.7%. Children who entered school with asthma were more likely to be ≥ 6 months behind other participants in reading words ($P = .023$) and books ($P = .026$), but not in math ($P = .167$) at the end of the first year of school. Achievement was not related to asthma severity. Entering school with asthma reliably predicted low reading achievement independent of other known covariates of low achievement (high absenteeism, minority status, male gender, single-parent family, poor academic skills at school entry, and low socioeconomic status).**

Conclusions: **Entering school with asthma was a significant predictor of low achievement in reading at 12-month follow-up, independent of asthma severity, high absenteeism, or other covariates of low achievement.** ***CHEST 2010; 138(6):1349–1355***

Abbreviations: ISAAC = International Study of Asthma and Allergic Conditions; SES = socioeconomic status; WIAT = Wechsler Individual Achievement Test, Second Edition; WISC = Wechsler Intelligence Scale for Children, Fourth Edition

New Zealand has high asthma prevalence: 28.4% of children aged 6 to 7 years old have ever been diagnosed with asthma,[1,2] and 20%[3] have asthma symptoms that are poorly controlled.[4] Chronic health problems can impact educational attainment[5] and literacy can affect the health care of asthmatic adults.[6,7] Although it is crucial that health professionals understand how asthma can impact on achievement in order to improve patient care and communication,[8-12]

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studies of achievement and asthma have produced mixed[13] results and have not analyzed whether children with asthma are more likely to have low achievement.[11,14-18] Some studies have not separated asthma from other factors that impact on achievement, including socioeconomic status (SES), age/years in school, family composition, ethnicity, gender, skill level at school entry ("readiness"), and absenteeism.[14,15,19-23] We recruited a cohort of children as they started school, to determine if starting school with asthma was related to poor school achievement after 1 year of school. Our study differed from previous studies in several ways. First, children were recruited before they began school and, thus, before low academic achievement was manifested. Second, the design controlled for age, time in school, and readiness (skills learned prior to formal schooling). Third, we independently assessed individual achievement using standardized tests, rather than parent or school reports. Fourth, we analyzed low achievement by asthma status.

Materials and Methods

New Zealand children typically commence formal education at first grade on their fifth birthday (prereading and premath skills are not typically included in preschool activities in New Zealand). Study measures were obtained at school entry (Time 1) and repeated 12 months later (Time 2). The study thus spanned the participants' first year of school. The design ensured that the children's age and length of formal education were uniform at both time points. Ethical approvals were obtained from the National Health Research and the University of Canterbury Human Ethics Committees.

The Ministry of Education classifies schools based on SES.[24] We clustered Christchurch schools into high, mid-, and low-SES groups based on the Ministry of Education classification prior to randomization (this same procedure was used in the International Study of Asthma and Allergies in Children [ISAAC]).[25] From each SES cluster, schools were randomly sampled with replacement, with a view to recruiting 100 pupils from each cluster (schools with < 10 enrolments each year were excluded from randomization). (Fig 1 illustrates cohort recruitment.)

The inclusion criteria were children who enrolled in school on their fifth birthday or, if their birthday fell during a school vacation, enrolled on the next school day; who did not require special education for high or very high needs, such as severe intellectual disability or cerebral palsy; and who had at least one respondent caregiver and whose own first language was either English, Maori, or a Pacific Island language. Children not satisfying these criteria were excluded. School personnel gave caregivers of eligible children study information, and they were invited by a research assistant to participate. Formal informed consent was obtained.

Information on demographics and asthma symptoms using questions from the ISAAC[26] was collected during face-to-face parent interviews at Time 1. The Word Reading and Mathematical Reasoning subtests of the Wechsler Individual Achievement Test, Second Edition (WIAT)[27] were administered to children at Time 1 (Readiness) and at Time 2 (Achievement). The Vocabulary and Block Design subtests of the Wechsler Intelligence Scale for Children, Fourth Edition (WISC)[28] and running records of oral reading from standard school texts[29-32] (Text Reading) were obtained at Time 2. Because New Zealand children do not receive reading instruction in preschool and would not be able to read school texts, the word reading score was used to indicate text reading readiness at Time 1. Schools reported attendance in half-days at Time 2. Achievement scores were age adjusted using test norms to control for any differences in age at the second assessment.

If the parent answered "yes" to any ISAAC question regarding respiratory conditions, the interviewer sought consent to contact the family physician; If obtained, the physician was mailed the parent's consent form and a short questionnaire. The second author, a pediatric respiratory specialist, classified current asthma using a pediatric clinical review of information from answers, additional information volunteered by parents (recorded verbatim) during interviews, and the doctor's report. "Current" refers to symptoms in the 12 months before the interview. Children with "current asthma" had a diagnosis of asthma and wheezing symptoms. Children with a diagnosis of asthma based on coughing symptoms but who had never had wheezing or shortness of breath were not classified as current asthma, because current research indicates that coughing on its own is not a sign of airway obstruction or asthma in children.[33] Thus, the category of current asthma was stringently defined after detailed examination of the children's records and did not include children who had no wheezing or shortness of breath in the previous 12 months. Children without current asthma as defined above were designated as "control." A score of functional asthma severity was determined using parent-reported information.[34]

Independent sample t tests, χ^2, and logistic regression analyses were conducted using Predictive Analytics software, version 18 (SPSS, Inc; Chicago, IL), with significance set at $P \leq .05$. Z scores were calculated using cohort mean standard scores to provide a common metric for low achievement. "Low achievement" was defined as $\leq$-0.50 z for word reading, $\leq$-0.50 z for text reading, and a reading age of $\leq$66 months. (The lowest possible reading age was 61 months.)[35] All variables in χ^2 and logistic regression were treated as binomials. Continuous variables were coded as dichotomous variables as follows[36,37]: the top quartile indicated high absenteeism; low WISC subtests scores were 2 SD below the indicated population mean;[28] the lowest three deciles identified low SES; and "poor readiness" was defined as $\geq$6 months lower than cohort peers ($\leq$–0.50 z). WISC subtest scores were not entered into the logistic regression analysis because these tests are highly correlated with the WIAT scores[27] and would therefore confound this analysis. However, the use of the age 5 word reading score from the WIAT as an indicator of low readiness provided a covariate of the WISC tests in the logistic regression analysis.

In addition to the demographic data collected from parents, a New Zealand Deprivation Decile Score[38] was determined for each participant's address. This score is based on data on family income, income source, home ownership, employment, qualifications, living space, and access to telephone and car, collected in a small neighborhood area during the 2006 Census. Scores were assigned using a standard government-controlled database available to researchers.[39] In the present study, the deprivation score represented individual SES.

Results

Recruitment

A 93.7% participant recruitment rate was achieved (Fig 1). The demographic characteristics are shown in Table 1.

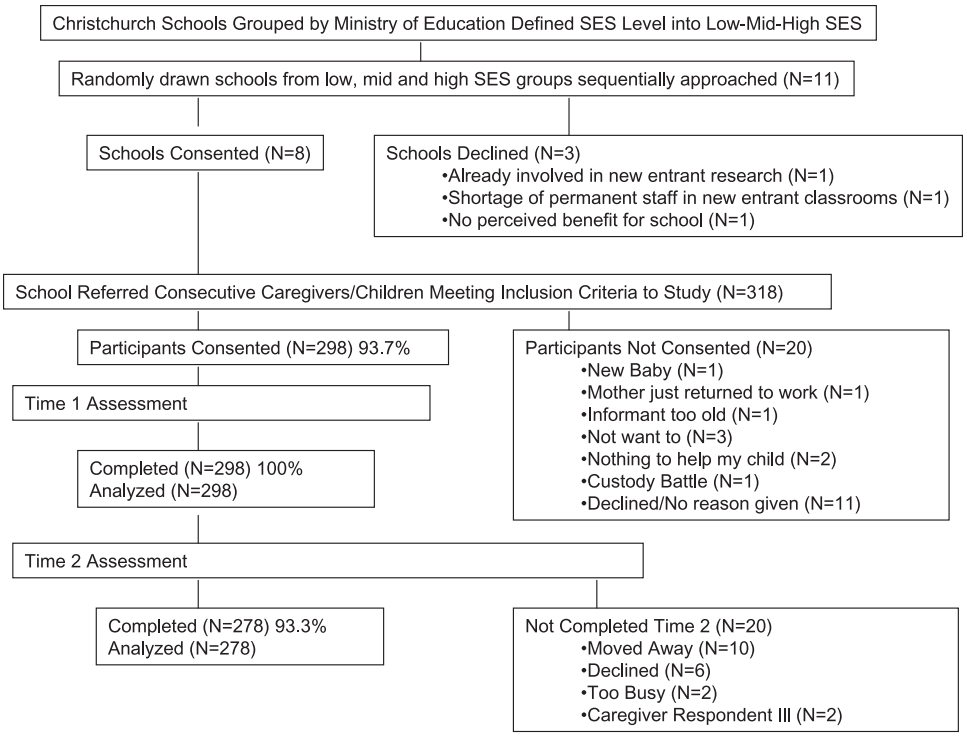

FIGURE 1. Sample recruitment and retention. SES = socioeconomic status.

Baseline Comparisons

The children's respiratory status at school entry was categorized as current asthma or not current asthma (control group). There were 55 participants with current asthma (N = 55, 18.5%). Asthma severity scores were low (23.6%), mild (32.7%), moderate (34.5%), and high (9.1%). All children categorized as current asthma also had doctor-prescribed medication for asthma. There were no significant differences between the current asthma and control groups in mean achievement test scores at school entry at age 5 (Table 2). There were also no significant differences at baseline between the current asthma and control groups in the variables associated with low achievement (Table 3).

Outcome Comparisons

A retention rate of 93.3% was achieved (Fig 1). There were no significant differences between retained and nonretained participants in the distributions at Time 1 in gender ($P = .819$), ethnicity ($P = .125$), SES ($P = .121$), word reading ($P = .493$), or math reasoning ($P = .936$). The modal interval between the Time 1 and Time 2 assessments was 12.5 months.

There were significant differences in the mean scores of the current asthma group compared with the control group at Time 2 in word reading and text reading (Table 2). To estimate the clinical impact of these differences, we next determined whether children with current asthma were more likely to be low achieving (see "Materials and Methods" for definition). Contingency table analyses (Table 3) demonstrated that children entering school with current asthma were more likely than control children to be categorized at Time 2 as low achieving in word reading and text reading but not in math. Because current asthma was not associated with a greater probability of low achievement at age 6 in math, no further examination of math achievement was made.

Current Asthma and Low Achievement

We next analyzed common factors (covariates) associated with low achievement to identify which of these factors were significantly associated with low achievement in our cohort as a whole. For low achievement in word reading, current asthma ($\chi^2 = 5.20$, $P = .023$), poor readiness ($\chi^2 = 65.80$, $P = .0001$), low SES ($\chi^2 = 15.36$, $P = .001$), and high absenteeism ($\chi^2 = 6.10$, $P = .013$) were significantly associated. Although "single-parent family" was borderline ($\chi^2 = 3.75$, $P = .053$), it was retained in the analysis of word reading because it is frequently identified as a covariate of low achievement.[23] For text reading, current asthma ($\chi^2 = 4.99$, $P = .026$), as well as poor readiness ($\chi^2 = 51.13$, $P = .0001$), low SES ($\chi^2 = 18.18$, $P = .0001$), and high absenteeism ($\chi^2 = 8.467$, $P = .004$) were significantly associated with low achievement.

Table 1—*Characteristics of Cohort (N = 298) at School Entry (Time 1)*

Characteristic	Measure
Age, mo, mean (SD)	60.19 (0.95)
Gender, No. (%)	
Boys	145 (48.9)
Girls	153 (51.3)
Living situation, No. (%)	
With two parents	231 (77.8)
With one parent	61 (20.5)
Other	5 (1.7)
Family income[a], No. ($ mode)	266 (34,500)
Socioeconomic status, No. (%)	
High	64 (21.5)
Mid	122 (40.9)
Low	112 (37.6)
Ethnicity, No. (%)	
European	223 (74.8)
Maori	47 (15.8)
Other	28 (9.4)
Educational characteristics	
Attend preschool,[b] No. (%)	295 (99)
WIAT-II word reading ("Readiness"), mean (SD)	97.62 (11.25)
WIAT-II math reasoning ("Readiness"), mean (SD)	101.66 (11.90)
WISC block design,[c] mean (SD)	10.00 (2.92)
WISC vocabulary,[c] mean (SD)	9.68 (2.53)
Days absent, mean (SD)	11.70 (8.08)

WIAT = Wechsler Individual Achievement Test, Second Edition; WISC = Wechsler Intelligence Scale for Children, Fourth Edition.
[a]Correlated with socioeconomic status (Deprivation Score) $P = .0001$.
[b]For at least 12 mo before beginning school.
[c]Administered at age 6 y.

Stepwise logistic regression analyses (Table 4) were conducted to identify independent predictors of low achievement, entering significant variables from the analyses above. The only predictors that reached significance in the final model for word reading were current asthma and poor reading readiness. In the final model for text reading, the significant predictors were current asthma, low SES, and poor readiness. Current asthma was independent of the typical predictors of low achievement (Table 4), and children with current asthma were not more likely than control children to be from low SES or to have high absenteeism or poor readiness (Table 3).

Table 2—*Achievement Test Scores at Age 5 (School Entry) and Age 6 (End First Year of School) and Absenteeism During the First Year of School*

Variable	Current Asthma (n = 55 for age 5; n = 51 for age 6), Mean (SD)	Control Group (n = 243 for age 5; n = 227 for age 6), Mean (SD)	*t* Test *P* Value
WIAT word reading			
Age 5	-0.068 (0.99)	0.016 (1.01)	.577
Age 6	-0.279 (0.820)	0.063 (1.03)	.027[a]
Text reading (age 6)	-0.254 (0.91)	0.057 (1.01)	.033[a]
WIAT math reasoning			
Age 5	0.016 (1.02)	-0.003 (1.02)	.892
Age 6	-0.043 (0.80)	0.009 (1.04)	.691
Days absent (age 5 to age 6)	12.7 (8.11)	11.5 (8.07)	.331

See Table 1 for expansion of abbreviations.
[a]$P \leq .05$.

Asthma has additional associations with low achievement. First, an analysis showed that 39.2% of children with current asthma were ≥ 9 months behind their peers in word reading (extremely low achieving), compared with 22.5% of control children ($\chi^2 = 6.143$; $P = .013$; OR, 2.226; 95% CI, 1.178-4.213). Similarly, 45.1% of children with current asthma were extremely low achieving in text reading compared with 25.6% of control children ($\chi^2 = 7.707$; $P = .006$; OR, 2.393; 95% CI, 1.285-4.460). Second, analysis showed that 24 children with current asthma and 58 control children were low achieving in both word reading and text reading. Thus, of the 51 children with current asthma assessed at Time 2, 47% were low achieving in both measures of reading compared with 25.6% of control children ($\chi^2 = 9.264$; $P = .002$; OR, 2.590; 95% CI, 1.393-4.819).

Discussion

Children entering school with current asthma had significantly lower mean scores than others in the cohort on two measures of reading achievement, and were more likely to have fallen 6 months or more behind in reading by the end of their first year in school. In addition, significantly more children entering school with current asthma were extremely low achieving, and more likely than control children to be low achieving in both areas of reading after the first year of school. Current asthma was a significant predictor of achievement status at the end of the first year in school, independent of the standard factors associated with reading achievement, including high absenteeism, poor readiness, gender, ethnicity, and low SES. These variables have all been consistently identified as correlates of low achievement in other research studies.[13,22,40] However, current asthma as an independent predictor of low achievement has not been identified in other studies.

Several limitations in the study design suggest caution when interpreting the present findings. First, the sample of children entering school with asthma is relatively small. Second, the sample is limited to children in the first year of school, and is not necessarily generalizable to older children. Finally, the extent to which the present findings can be generalized to countries with a lower prevalence of childhood

Table 3—*Baseline and Outcome Comparisons Between Current Asthma and Control Groups*

Factor	Current Asthma[a]	Control Group[b]	χ^2 (*P* Value)
Baseline			
Low socioeconomic status	24 (43.6)	88 (36.2)	1.053 (.305)
Single-parent household	12 (21.8)	54 (22.2)	0.006 (.936)
Gender (boys)	29 (52.7)	116 (47.7)	0.447 (.504)
Minority ethnicity	14 (25.5)	61 (25.1)	0.003 (.957)
Low vocabulary score	2 (3.9)	4 (1.8)	0.920 (.338)
Low block design score	1 (2.0)	3 (1.3)	0.129 (.729)
Low word reading, age 5 (poor readiness in reading)	23 (41.8)	90 (37.0)	0.436 (.509)
Low math reasoning, age 5 (poor readiness in math)	17 (30.9)	79 (32.5)	0.053 (.819)
Outcome			
Low achievement in word reading	26 (51)	77 (33.3)	5.196 (.023)[c]
Low achievement in text reading	28 (54.9)	86 (37.9)	4.985 (.026)[c]
Low achievement in math reasoning	12 (23.5)	76 (33.5)	1.906 (.167)
High absenteeism	15 (29.4)	59 (26.1)	0.232 (.630)

Data presented as No. (%).
[a]N = 55 for baseline comparisons; N = 51 for outcome comparisons.
[b]N = 243 for baseline comparisons; N = 227 for outcome comparisons.
[c]$P \leq .05$

asthma remains uncertain, because asthma is a complex, multifactorial disease that may differ across countries. This points to the desirability of replicating our study in a location with lower asthma prevalence, as well as with a larger sample and with older children.

The findings of an association between current asthma at school entry and low achievement in reading a year later is at odds with New Zealand[10,11] and international studies,[12,15,17] which have concluded that there is no difference in achievement by asthma status, with the exception of one study that concluded that children with asthma were more likely to be categorized as "below progressing."[16] School absence is the factor identified as most likely to affect the achievement of children with asthma,[14,16,21,41] although high absenteeism has not always been reported for children with asthma[14,42] and our study did not find an association between high absence and low achievement in children with asthma. Additionally, although asthma severity and poor readiness in children with asthma have been given as possible explanations for low achievement,[5,9,21] these explanations were not supported in our study.

Our findings may differ from other studies[14,15] owing to methodologic differences. We used direct and individual measurements of reading, rather than school or parent reports. We also controlled for age differences by focusing on children of the same age, with the same amount of time in school. We also focused on a younger-aged population, because children start school at a younger age in New Zealand. In addition, previously reported findings have possibly focused on group comparisons of mean achievement scores, without considering the significance of low achievement.[17,43] A final difference in our study is that samples in other studies may have excluded children with learning disabilities or drawn samples from mainstream classes in school systems where children with reading difficulties are likely to have been streamed into separate programs.[14-16] Our study did not exclude these children because (1) they could not be identified prior to starting school and (2) New Zealand does not separately stream children with learning disabilities. Studies that excluded children with learning disorders may have underestimated the impact of asthma on achievement.[44,45] All of these differences may have affected findings.

Our findings warrant further study of low achievement in children with asthma entering school. Possible

Table 4—*Multivariate Logistic Regression Models for Low Achievement in Word and Text Reading on Selected Covariates*

Variables	OR	95% CI
Word reading		
Model 1		
Poor readiness	7.864	4.456-13.878
Low SES	1.846	1.037-3.289
Model 2		
Poor readiness	7.582	4.265-13.48
Low SES	1.813	1.016-3.235
High absence	1.216	0.647-2.284
Model 3		
Poor readiness	8.177	4.586-14.581
Low SES	1.772	0.989-3.176
Current asthma	2.200	1.075-4.501
Model 4		
Poor readiness	8.113	4.503-14.616
Low SES	1.768	0.986-3.171
Current asthma	2.203	1.076-4.514
Single parent	1.051	0.519-2.130
Final model		
Poor readiness	9.169	5.194-16.187
Current asthma	2.297	1.130-4.669
Text reading		
Model 1		
Poor readiness	5.562	3.208-9.642
Low SES	2.579	1.479-4.497
Model 2		
Poor readiness	5.209	2.985-9.089
Low SES	2.502	1.431-4.373
High absence	1.508	0.819-2.779
Final model		
Poor readiness	5.701	3.266-9.951
Low SES	2.501	1.427-4.381
Current asthma	2.031	1.014-4.074

SES = socioeconomic status.

reasons for low achievement in children with asthma include the presence of comorbid health problems (such as sleep deprivation, rhinitis, and increased BMI), asthma control, medication effects, and psychosocial factors.

Conclusions

We reached the following conclusions: (1) children with current asthma entering school in New Zealand may be at increased risk of low achievement in reading after 1 year of school in comparison with their peers and independent of other factors commonly associated with low achievement and (2) understanding of achievement by children with asthma can be strengthened by analyses of low achievement in relation to cohort peers in addition to comparison of mean achievement scores.

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Dr Pattemore: contributed to clinical review of respiratory data, classification of respiratory status, data interpretation, and preparation of manuscript drafts.
Dr Reid: contributed to data interpretation and preparation of manuscript drafts.
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