

# Severity and persistence of asthma and mental health: a birth cohort study

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**Background.** The goal of the current study was to investigate asthma and mental health among youth in the community, and to consider the role of asthma severity and persistence in this link.

**Method.** Data were drawn from the Raine Study, a population-based birth cohort study in Western Australia. Logistic regression models and generalized estimating equations were used to examine the relationship between asthma at age 5 years and the range of internalizing and externalizing mental health problems at ages 5–17 years. Analyses were stratified by asthma severity and persistence, and adjusted for a range of potential confounders.

**Results.** More severe and persistent asthma at age 5 was associated with significantly increased odds of affective, anxiety, somatic, oppositional defiant and conduct problems at ages 5–17. Mild asthma and remitted asthma were not associated with heightened vulnerability to mental disorders.

**Conclusions.** Our results suggest that youth with symptomatic asthma are more likely to suffer from a wide range of mental health problems, and that the likelihood of mental health problems appears to increase as a function of asthma severity. Youth with poorly controlled and/or more severe and persistent asthma may be considered a vulnerable group who might benefit from mental health screening in clinical, school and community settings.

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## Introduction

In recent years, there has been growing interest in the relationship between asthma and mental disorders. Data from several cross-sectional (McQuaid *et al.* 2001; Ortega *et al.* 2002, 2003, 2004; Goodwin *et al.* 2003*b*; Katon *et al.* 2007; Delmas *et al.* 2011) and longitudinal (Goodwin *et al.* 2004, 2005*a*; Alati *et al.* 2005; Feldman *et al.* 2006) community-based studies of youth show a consistent link between asthma and other respiratory symptoms and anxiety disorders among youth. Clinical data has also shown that psychiatric symptoms are associated with increased severity of asthma symptomatology, health service use, functional impairment and poorer asthma control, compared to that among youth without psychiatric symptoms

(Morrison *et al.* 2002; Feldman *et al.* 2006; McCauley *et al.* 2007; Richardson *et al.* 2008).

While evidence of a link between childhood asthma and mental disorders is growing, several key questions remain. First, studies consistently find a link between asthma and anxiety disorders among youth (McQuaid *et al.* 2001; Morrison *et al.* 2002; Ortega *et al.* 2002, 2003, 2004; Goodwin *et al.* 2003*a,b*, 2004, 2005*a,b*; Alati *et al.* 2005; Feldman *et al.* 2006; Katon *et al.* 2007). Yet, relatively few studies have looked at whether and to what degree asthma is associated with mood disorders or with externalizing disorders and findings to date are inconsistent (Wamboldt *et al.* 2000; Ortega *et al.* 2004; Alati *et al.* 2005; Goodwin *et al.* 2005*a*). Second, several studies to date have primarily relied on retrospective reports of asthma attacks and/or on reports of asthma that are often grouped with other respiratory symptoms (e.g. 'participant has bronchitis or asthma') (Ortega *et al.* 2002; Alati *et al.* 2005; Goodwin *et al.* 2005*a*). This has resulted in lack of certainty that results are specific to asthma *versus*

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transient wheeze and/or bronchitis, which are very common in early childhood and are not interchangeable with asthma. Third, lack of specificity about the time-frame during which asthma occurred has made it difficult to understand the temporal relationship between asthma and mental disorders. Fourth, a substantial percentage of childhood asthma cases resolve by adulthood and it remains unclear whether these carry a risk similar to that associated with chronic and persistent asthma that continues into adulthood. Fifth, there has been little available information on the potential role of asthma severity or chronicity in the relationship between asthma and mental disorders. Previous studies have looked at asthma severity in relation to organic disease and pulmonary function (Federico *et al.* 2007), yet no previous study of the relationship between asthma and mental disorders has included this information. According to National Heart Blood and Lung Institute (NHBLI) guidelines (NHBLI, 2007), distinguishing asthma into mild, moderate or severe and intermittent or persistent is critical in evaluation and treatment planning.

Against this background, the current study addresses two main questions using a birth cohort study with well-measured asthma and well-defined mental health. First, the study investigates whether childhood asthma at age 5 years is associated with increased vulnerability to the range of internalizing and externalizing disorders up to age 17 years. Second, the study examines whether and to what degree asthma severity and/or persistence impact the relationship between asthma and mental health problems.

## Method

The Western Australian Pregnancy Cohort (Raine) Study, initially established between 1989 and 1992, consists of 2868 children from Perth, Western Australia, who have been followed from birth. The study first began as a pregnancy cohort in which 2900 women were enrolled (representing 90% of eligible women approached to take part in the study), approximately 100 women per month for 3 years, at around week 18 of gestation (Newnham *et al.* 1993). The women were enrolled from the antenatal booking clinics at King Edward Memorial Hospital (KEMH), the principal tertiary obstetrics hospital in Perth, Western Australia. The criteria for enrolment were gestational age between 16 and 20 weeks, sufficient proficiency in English to understand the implications of participation, an expectation to deliver at the hospital, and an intention to remain in Western Australia so that follow-up through childhood would be possible. Mothers were *not* selected on the basis of any asthma or atopy criteria. As KEMH is the only

specialist obstetric care center in Western Australia, the initial sample was at moderate obstetric risk, and the participating mothers reflect the population obtaining obstetrical care in this region. Thus this is a community-based cohort representing about 20% of all live births in Western Australia, with exclusions only for very low birthweight or birth defects. The population was 84% Caucasian, 4% Aboriginal and 12% other (primarily Asian); reflective of the population in Western Australia at the time. All children were examined at birth and extensive antenatal data were collected regarding maternal sociodemographic characteristics, including age and education. Informed consent was obtained at the time of enrolment in the study and at every subsequent follow-up and study protocols were approved by the Human Ethics Committees at KEMH and Princess Margaret Hospital for Children in Perth, Western Australia.

The cohort attended follow-up visits at ages 1, 2, 3, 5, 8, 10, 14 and 17 years, consisting of comprehensive behavioral and physical health questionnaires completed by the primary caregiver (usually mother). At the 17-year follow-up, 1754 study adolescents and their families completed all or part of the follow-up (414 deferred participation, 184 were unable to be traced, 480 had withdrawn and 36 were deceased). There were complete mental health data available for 1368 adolescents at the 17-year follow-up, representing just over 47% of the original cohort.

## Asthma

Current asthma at age 5 was defined by the presence of parental report of physician diagnosis of asthma, wheezing or a cough in the absence of a cold over the last 12 months, and taking asthma medication in the preceding 12 months by parental report (Joseph-Bowen *et al.* 2004). Asthma was categorized as mild, moderate, and severe on the basis of parental report of clinical symptoms throughout the year according to a schema adapted from the *Asthma Management Handbook* (National Asthma Council Australia, 2006). A mild case of asthma included 1–2 episodes of wheezing in the past 12 months. A moderate case of asthma included 3–12 wheezing episodes, and on average only one occasion of nocturnal waking per week due to wheezing episodes over last 12 months. Severe asthma was defined as at least one of the following characteristics occurring over the past year: greater than 12 instances of wheeze, more than one episode of nocturnal waking due to wheezing, or on average one or more episodes of acute asthma limiting speech. Finally, we examined active *versus* remitted asthma by analyzing those with asthma at age 5 compared to reports of wheezing in the last 12 months at

the 8-year follow-up. From this data we created a four-level variable representing no asthma at age 5 and no recent wheezing at age 8 (reference category), asthma at age 5 but no recent wheezing at age 8 ('remitted'), no asthma at age 5 but recent wheezing at age 8 ('later onset') and asthma at age 5 and wheezing at age 8 ('persistent'). The diagnostic level of the severest level of symptoms reported was assigned.

### *Mental health problems*

The 118-item Child Behavior Checklist for Ages 4–18 (CBCL/4-18) was administered at the 5-, 8-, 10-, 14- and 17-year follow-ups and completed by the primary caregiver (Achenbach, 1991). The CBCL demonstrated good sensitivity (83% overall) and specificity (67% overall) to a clinical psychiatric diagnosis and good test–retest reliability in a Western Australian clinical calibration (Zubrick *et al.* 1997). The CBCL/4-18 produces a raw score that was transformed into *T* scores (standardized by age and sex) for six problem scales using the CBCL DSM-Oriented Scales (Achenbach, 2001). The problem scales are considered to map well against the diagnostic criteria of DSM-IV for affective problems (e.g. major depression, dysthymia), anxiety problems (e.g. generalized anxiety disorder), somatic problems (e.g. somatization disorder), attention deficit hyperactivity problems (e.g. inattentive or hyperactive-impulsive type disorders), oppositional defiant problems (e.g. oppositional defiant disorder) and conduct problems (e.g. conduct disorder) (APA, 2000). For this study, we applied the recommended clinical cut-off scores (by age and sex) to obtain a binary variable indicative of clinically significant affective, anxiety, somatic, attention deficit hyperactivity disorder (ADHD), oppositional defiant and conduct problems. The clinical cut-offs were as specified by the CBCL DSM-Oriented Scales, and applied to raw scores normalized for age and sex ( $T \geq 65$ ). The term 'clinically significant' refers to maladaptive behavior that falls within a defined clinical range for behavioral problems (Achenbach, 1991).

### *Maternal mental health and cigarette smoking*

At 18 weeks' gestation, women reported the number of cigarettes currently smoked per day and this was categorized into a dichotomous variable of 'any' and 'no smoking' in pregnancy. The classification was deliberately broad to account for social desirability factors in responding. The number of cigarettes smoked per day at 34 weeks' gestation was strongly correlated with the number of cigarettes smoked at 18 weeks' gestation ( $r=0.866$ ,  $p<0.001$ ), indicating

few women quit smoking after 18 weeks' gestation. At the 5-year follow-up interview, information on maternal smoking was obtained from the parent/caregiver, and this was categorized as no smoking compared to smoking one or more cigarettes per day. Information was retrospectively collected at the 8-year follow-up as to whether the mother had ever been treated for an emotional or mental health problem, and this was classified according to yes/no responses.

### *Family functioning*

We used the parent-report General Functioning Scale (GFS) from the McMaster Family Assessment Device (FAD) administered at the 5-year follow-up as a measure of family functioning (Epstein *et al.* 1983). This short-form scale consists of 12 statements that were derived from an item-analysis of the complete 60-item scale, including questions on problem solving, family communication, affective responsiveness, and behavior control. The GFS has excellent reliability [ $r$  (Guttman's split-half)=0.83] and internal consistency (Cronbach's  $\alpha=0.86$ ) (Byles *et al.* 1988).

### *Data analysis*

Frequency data were compared for all control variables according to asthma diagnosis at age 5 (predictor variable). We used a logistic regression model to examine the ability of our predictor variable to effect changes in *T* scores reflecting clinically meaningful differences in affective, anxiety, somatic, ADHD, oppositional defiant and conduct problems from ages 5–17 years (i.e. a score above the relevant clinical cut-off point for age and sex). The logistic regression model accounted for loss of independence due to repeated observations of the same individuals over time by incorporating generalized estimating equations (GEE) with a first-order autoregressive [AR(1)] working correlation matrix structure. Our model first examined univariate relationships, followed by the inclusion of all potentially confounding and intermediate variables (maternal age at 18 weeks' gestation, maternal completion of high school education, maternal smoking at age 5, maternal mental health history at age 8, family functioning at age 5). Given that the GEE model may hide age-specific effects, we examined age interaction effects in all three of our logistic regression with GEE models. We then performed a similar logistic regression model analysis examining the effect of different levels of severity of asthma on CBCL DSM-IV-oriented problem scales, comparing mild, moderate and severe asthma to no asthma diagnosis with adjustment for the confounding and mediating variables outlined above, and then

**Table 1.** Frequency data by asthma diagnosis at age 5 ( $N=2193$ )

	<i>N</i>	No asthma ( $N=1803$ ) <i>n</i> (%) <sup>a</sup>	Asthma ( $N=390$ ) <i>n</i> (%) <sup>a</sup>	<i>p</i> <sup>b</sup>
Gender of child	2193			<0.001*
Male		896 (79.4)	232 (20.6)	
Female		907 (85.2)	158 (14.8)	
Maternal age at conception	2140			0.087
<20 years		126 (77.3)	37 (22.7)	
20–24.9 years		335 (81.9)	74 (18.1)	
25–29.9 years		540 (81.9)	119 (18.1)	
30–34.9 years		497 (83.8)	96 (16.2)	
≥35 years		264 (83.5)	52 (16.5)	
Maternal education	2141			0.004*
<High school completion		994 (80.4)	242 (19.6)	
High school completion		769 (85.0)	136 (15.0)	
Maternal smoking at age 5 years	2188			0.113
Non-smoker		1271 (82.9)	263 (17.1)	
Smoker		527 (80.6)	127 (19.4)	
Maternal history of mental health problems	1945			0.014
No		1278 (84.0)	243 (16.0)	
Yes		336 (79.2)	88 (20.8)	
Family functioning at age 5 years	2048			0.460
Poor		279 (17.6)	83 (17.9)	
Good		1306 (82.4)	380 (82.1)	

<sup>a</sup> Row percentages presented, missing data not presented.

<sup>b</sup>  $\chi^2$ , *p* value for linear by linear trend.

\*  $p < 0.05$ .

performed the same analysis again for our remitted *versus* persistent asthma variable. SPSS v. 15.0 (SPSS Inc., USA) was used for the analyses.

## Results

At age 5 years, 390 (18%) children had a diagnosis of asthma, with approximately 9% classified in severity as mild, 4% moderate and 5% severe. Male children were more likely (two-tailed  $p < 0.005$ ) to have an asthma diagnosis at age 5 than female children (21% *v.* 15%), and children whose mothers had completed high school were less likely to have asthma at age 5 than the children whose mothers had not finished high school (15% *v.* 20%; Table 1). Children whose mothers reported a history of mental health problems at the 8-year follow-up were more likely to have previously had an asthma diagnosis at age 5 compared to children whose mothers did not report ever having an emotional or mental health problem (21% *v.* 16%). There were no significant differences between children who had asthma and those who did not have asthma at age 5 and maternal age or current smoking status at age 5.

The prevalence of anxiety, oppositional defiant and conduct problems were highest at age 5 (see Table 2). Affective problems showed a peak prevalence of 11% at age 8, and somatic problems had a high prevalence at ages 5 (14%) and 8 (14%) with a peak at age 10 (17%). ADHD problems were the least common with around 2% meeting the clinical criteria at ages 5–14 and only 1% ( $n=13$ ) meeting the criteria at age 17.

The unadjusted logistic regression model showed that an asthma diagnosis at age 5 was significantly associated (two-tailed  $p < 0.05$ ) with clinically significant scores on all six DSM-IV-oriented problem scales (Table 3). Following adjustment for control variables there was a significantly increased odds from ages 5–17 years for affective, anxiety, somatic, ADHD, oppositional defiant and conduct problems for children with asthma at age 5 compared to those without asthma. The effect size was similar across disorders. The interactions with age were not significant for the relationship between asthma diagnosis at age 5 and CBCL-DSM diagnoses indicating that the summarizing of scores for each age into the GEE model did not hide specific age effects.

**Table 2.** Percentage of participants with DSM-IV scale problems at each follow-up<sup>a</sup>

	Year 5 (N=2179) n (%)	Year 8 (N=2088) n (%)	Year 10 (N=2019) n (%)	Year 14 (N=1787) n (%)	Year 17 (N=1368) n (%)
Affective problems	207 (9.5)	225 (10.8)	190 (9.4)	122 (6.8)	105 (7.7)
Anxiety problems	180 (8.3)	143 (6.9)	120 (5.9)	87 (4.9)	39 (2.9)
Somatic problems	292 (13.5)	295 (14.2)	336 (16.7)	127 (7.1)	76 (5.6)
ADHD problems	51 (2.3)	50 (2.4)	36 (1.8)	36 (2.0)	13 (1.0)
Oppositional defiant problems	264 (12.1)	230 (11.0)	188 (9.3)	166 (9.3)	84 (6.1)
Conduct problems	290 (13.3)	245 (11.7)	187 (9.3)	111 (6.2)	70 (5.1)

ADHD, Attention deficit hyperactivity disorder.

<sup>a</sup> Percentages represent those participants with problems compared with those without problems at each follow-up.

**Table 3.** Relationship between asthma at age 5 and CBCL/DSM-IV problems from ages 5–17

Asthma age	Multivariate logistic GEE model (years 5–17 inclusive)					
	Affective problems	Anxiety problems	Somatic problems	ADHD problems	Oppositional defiant problems	Conduct problems
5 years						
Unadjusted						
OR	1.57**	1.72**	1.75**	1.72*	1.66**	1.72**
95% CI	1.24–1.98	1.31–2.26	1.44–2.12	1.10–2.70	1.30–2.10	1.36–2.18
p value	<0.001	<0.001	<0.001	0.017	<0.001	<0.001
Adjusted <sup>a</sup>						
OR	1.47*	1.64**	1.62**	1.84*	1.51**	1.53**
95% CI	1.11–1.95	1.21–2.23	1.31–2.02	1.11–3.02	1.15–1.98	1.18–2.00
p value	0.007	0.002	<0.001	0.017	0.003	0.002

CBCL, Child Behavior Checklist; GEE, generalized estimating equations; ADHD, attention deficit hyperactivity disorder; OR, odds ratio; CI, confidence interval.

<sup>a</sup> Adjusted for maternal age, maternal education, maternal smoking in pregnancy, maternal smoking at age 5, maternal history of mental health problems at age 8 and family functioning at age 5 years.

\*  $p < 0.05$ , \*\*  $p < 0.005$ .

In assessing severity of asthma at age 5 and vulnerability to mental health problems, we found that across all disorders, mild asthma was not associated with an increased likelihood of problems from ages 5–17, when compared to those who did not have asthma (Table 4). However, moderate asthma was significantly associated with an increased odds for somatic and ADHD problems ( $p < 0.05$ ) and relationships were in the same direction though they did not reach statistical significance for other problems. Severe asthma was associated with increased odds of all disorders; these associations were just below statistical significance for severe asthma. Once again there were no significant interactions with age.

Our final analysis examined the impact of remitting versus later onset and persistent asthma, compared to no asthma at age 5 or wheezing at age 8 (Table 5).

We found that with the exception of ADHD problems, there were no significant relationships between asthma at age 5 that had remitted by age 8 and vulnerability to mental health problems. There was a significant association between later onset asthma (i.e. recent wheezing at age 8) and internalizing problems (affective, anxiety and somatic problems), as well as ADHD but no significant relationships were observed between externalizing problems (oppositional defiant and conduct problems) following later onset asthma. There was a significant relationship between persistent asthma and all problem scales. We tested for age interaction effects and found a significant age interaction [adjusted for maternal age of 28 years (mean)] for the outcomes of affective, anxiety and ADHD problems, representing a decreasing likelihood of scoring above the clinical cut-point as age increased.

**Table 4.** Relationship between severity and persistence of asthma and CBCL/DSM-IV problems from age 5–17

	Multivariate logistic GEE model (years 5–17 inclusive <sup>a</sup> )					
	Affective problems	Anxiety problems	Somatic problems	ADHD problems	Oppositional defiant problems	Conduct problems
<b>Severity of asthma age 5 years</b>						
No asthma						
OR	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Mild asthma						
OR	0.91	1.22	1.16	1.52	1.18	1.32
95% CI	0.58–1.44	0.75–1.98	0.84–1.62	0.73–3.16	0.78–1.81	0.89–1.96
<i>p</i> value	0.692	0.427	0.369	0.262	0.434	0.163
Moderate asthma						
OR	1.43	1.59	1.90**	2.54*	1.46	1.57
95% CI	0.85–2.41	0.90–2.79	1.30–2.77	1.16–5.58	0.87–2.44	0.94–2.62
<i>p</i> value	0.179	0.108	0.001	0.020	0.151	0.086
Severe asthma						
OR	3.42**	3.13**	2.70**	1.89	2.38**	2.24**
95% CI	2.29–5.10	1.98–4.95	1.93–3.79	0.84–4.27	1.56–3.64	1.48–3.39
<i>p</i> value	<0.001	<0.001	<0.001	0.126	<0.001	<0.001
<b>Persistence of asthma age 5 years</b>						
No asthma						
OR	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Remitted asthma						
OR	1.20	1.45	1.06	2.34*	1.34	1.29
95% CI	0.76–1.89	0.87–2.42	0.71–1.59	1.21–4.51	0.84–2.13	0.80–2.09
<i>p</i> value	0.431	0.156	0.775	0.011	0.220	0.300
Later onset asthma						
OR	1.97**	1.67*	1.42*	2.26*	0.95	1.11
95% CI	1.38–2.81	1.05–2.65	1.04–1.94	1.11–4.62	0.61–1.49	0.76–1.62
<i>p</i> value	<0.001	0.030	0.030	0.025	0.822	0.583
Persistent asthma						
OR	2.26**	2.64**	2.41**	2.63**	1.92**	1.91**
95% CI	1.65–3.10	1.84–3.79	1.86–3.13	1.38–5.03	1.37–2.69	1.39–2.62
<i>p</i> value	<0.001	<0.001	<0.001	0.003	<0.001	<0.001

CBCL, Child Behavior Checklist; GEE, generalized estimating equations; ADHD, attention deficit hyperactivity disorder; OR, odds ratio; CI, confidence interval.

<sup>a</sup> Adjusted for maternal age, maternal education, maternal smoking in pregnancy, maternal smoking at age 5, maternal history of mental health problems at age 8 and family functioning at age 5 years.

\* $p < 0.05$ , \*\* $p < 0.005$ .

Those with persistent asthma had around 33% probability of scoring above the cut-point by age 17 compared to 20% of participants with no asthma (Fig. 1; affective problems only, data for anxiety and ADHD problems not presented).

## Discussion

This study investigated the relationship between asthma at age 5 and vulnerability to the range of mental health problems from ages 5–17 among youth

in Western Australia. We found that asthma at age 5 is significantly associated with both internalizing-type (e.g. affective, anxiety and somatic problems) and externalizing-type (e.g. ADHD, oppositional defiant and conduct problems) disorders among young persons. To our knowledge, this study is the first to examine the impact of asthma severity and persistence on mental health over time from ages 5–17 in a representative, population-based sample. Our findings suggest that likelihood of mental health problems among youth with asthma increases as the severity of asthma

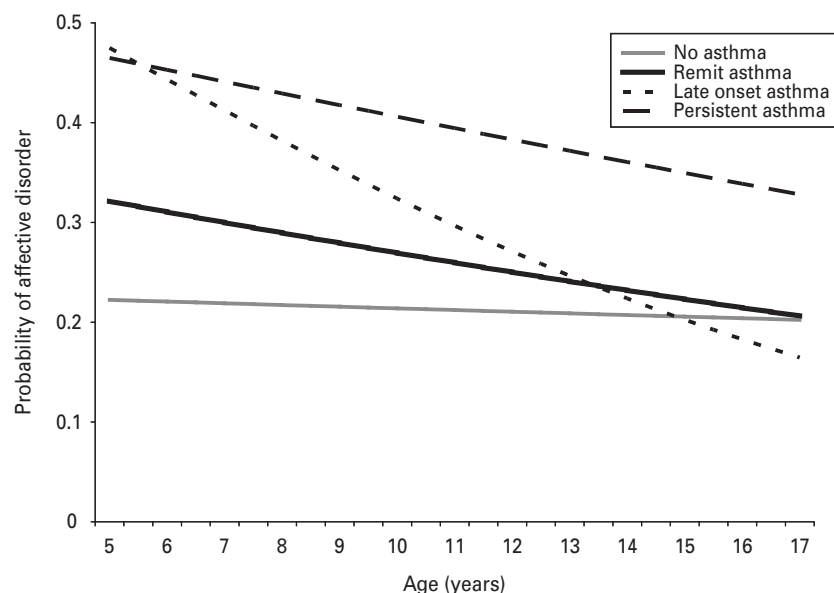


Fig. 1. The probability of affective problems at each age for asthma onset and persistence groups.

increases. The relationship does not appear to be statistically significant among those with mild asthma. Further, the relationship between persistent asthma and mental health problems is strong while asthma at age 5 that has remitted by age 8 does not appear to be associated with any greater vulnerability to mental health problems, compared to those who never had asthma. This vulnerability appears to be most prominent earlier in childhood but decreases with age.

Our results confirm and extend previous findings of a link between asthma and anxiety disorders among youth by demonstrating a relationship between asthma and both internalizing and externalizing problems into adolescence. Specifically, we found a significant relationship between asthma and conduct problems and oppositional defiant problems. Findings in the literature have been inconsistent on this association: Ortega *et al.* (2004) detected an association between parent-reported lifetime diagnosis of asthma and any disruptive disorder (OR 1.6, 95% CI 1.1–2.3) and asthma attack and oppositional defiant disorder [odds ratio (OR) 1.9, 95% confidence interval (CI) 1.2–3.0] among Puerto Rican children. Yet, the same study found no association between hospitalization for asthma and disruptive disorders (Ortega *et al.* 2004) and Ortega *et al.* (2003) found no significant association between parent-reported lifetime asthma and disruptive disorders among youth in US community samples. Further, Alati *et al.* (2005) found no relationship between asthma at age 5 and externalizing disorders in a birth cohort in Brisbane, Australia. The reason for these discrepancies is not clear. It could be due to differences in sample size, sample composition and/or measurement of asthma. We also found an

association between asthma and ADHD, which is consistent with several previous studies (Ortega *et al.* 2004; Goodwin *et al.* 2005a). The association was not statistically significant in the severe range, although it was in all others and this may have been due to low sample size as we had a very small number of participants with ADHD, potentially due to the stringent cut-off points for ADHD problems using DSM-IV-oriented scales. Remitted asthma was not associated with any mental disorders with the exception of ADHD. The reason for this specific association is not known but should be investigated further. Previous clinical studies have also found relationships between asthma and other externalizing-type/disruptive behaviors (McQuaid *et al.* 2001) suggesting that the overall weight of evidence to date supports an association between asthma and both internalizing and externalizing problems.

To our knowledge, this is the first study to examine the relationship between asthma and mental disorders among youth using both detailed report on the severity and persistence of asthma and standardized, well-validated measures of mental health. Several previous population-based studies have been performed using data from surveys that were designed primarily to study mental health, and as such included comparatively weaker and/or vague measures of physical health. Therefore, findings from the current study add to the literature in this area by providing new evidence indicating that it does not appear to be the case that any asthma in youth is associated with increased risk of mental health problems. Instead, the extent to which youth with asthma are vulnerable to mental health problems appears closely related to the severity

and persistence of asthma. One major limitation, however, with this finding is that 'severe' asthma cannot necessarily be distinguished from 'poorly controlled' asthma. Rather, they are potentially interchangeable here as we do not have measures of physical severity of asthma (*versus* the degree to which asthma is well controlled), nor do we have detailed data on asthma medicine use. As such, it is conceivable that the relationship between severe asthma and mental health problem emerges because youth with mental health problems do not manage their asthma well, potentially in part, because of mental health problems. Therefore, asthma of the same level of physiological severity – when it occurs in a young person who has depression – may be poorly controlled and therefore present as severe asthma while in a young person who does not have depression, the asthma is well managed and may appear mild. Another possibility is that a third variable, such as childhood abuse or neglect could lead to the co-occurrence of mental disorders and asthma, as it is independently associated with each (Goodwin *et al.* 2004); however, there is some evidence that childhood adversity alone does not account for the association between asthma and depression/anxiety in adults (Scott *et al.* 2008). Future studies aimed at untangling the relationship between mental health problems and asthma control/asthma morbidity over time are needed.

As results of previous studies have suggested that asthma early in life is associated with increased vulnerability to mental health problems in young persons, a common question has been whether this increased risk applies to youth who 'outgrow' asthma. Childhood asthma remits by early adulthood in a substantial percentage of those who have been diagnosed early in childhood (Martinez *et al.* 1998; Morgan *et al.* 2005; Stern *et al.* 2008). Our findings suggest that indeed youth with asthma that remits in childhood do not appear to be at any greater risk for mental health problems, with the exception of ADHD, than those who never had asthma. The finding that ADHD is the only disorder elevated among those with remitted asthma deserves further study. Yet, overall, this result suggests that contrary to what the bulk of studies have concluded based on the available data in these studies (i.e. that youth with any lifetime asthma are at risk for mental disorders), this is not the case. Therefore, screening or special attention to all youth with any lifetime asthma is not necessarily warranted. Rather, those with persistent asthma (at least as best we could measure this that persists from ages 5–8) do indeed seem somewhat more vulnerable to a range of mental health problems and therefore it is this group who should be watched closely and screened. This information may be useful to clinicians who treat children

with asthma in general and specialty pediatric settings because these data provide somewhat compelling evidence that youth with persistent asthma may be more vulnerable to mental health problems. Of interest, we found that the probability of affective problems decreased with age for youth with any asthma – potentially suggesting that risk of affective problems may in some way be related to asthma at earlier ages. Although at older ages (late adolescence), the risk of affective disorders (but not anxiety or ADHD) was still comparatively elevated among those with persistent asthma.

In addition to those already mentioned, there are several limitations to our study that should be considered when interpreting the results. First, though detailed and validated measures were used, we relied on parental report for both asthma and mental health problems. It is conceivable that this could bias findings as separate reporters for each is preferable. Yet, it has been demonstrated that with children of this age, parental report of behavior should be fairly robust (Warnick *et al.* 2008) and in a large-scale community-based study, parental response to detailed questions regarding physician-diagnosed asthma is the most robust criteria. Second, measurement of asthma for age 8 included wheeze at one time point and asthma at another. While it is true that current wheezing (at least one episode in the past 12 months) is more common than current asthma as children get older, the likelihood that those with current wheeze have asthma and most likely persistent asthma increases. As such, the difference in assessment at the two ages is unlikely to make a major difference to our findings. Third, Western Australia is a westernized country similar in many ways to Western Europe and the USA, yet it is possible that the results may have limited generalizability to other countries. Replication of these findings with youth from diverse settings would be useful. Fourth, we were not able to control for all possible confounding factors in the relationship between asthma and mental health problems.

Recent findings suggest that youth with asthma may have specific, unique needs for social/emotional support to cope effectively with the demands of their illness and their limitations, and that these are not routinely considered in clinical practice (Stewart *et al.* 2011). These findings suggest it would be important to examine whether and to what degree specific interventions aimed at supporting youth in their management of chronic illness, especially among those with severe and persistent disease, may help to reduce mental health problems in this population. Such randomized clinical trials will also help to establish causality. Recent studies in adults show that effective control of asthma is associated with fewer mental



health problems in clinical settings (Kardos *et al.* 2011; Vieira *et al.* 2011), compared to uncontrolled asthma. It is therefore possible that screening and provision of mental health services for youth with asthma – as appropriate – could lead to better asthma control over the long term. It may also be that interventions that help children and families to better control the child's asthma may assist in reducing a child's future risk of mental health problems.

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### Declaration of Interest

None.

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