

MORBIDITY

The association between hospitalization for asthma in childhood and alcohol use disorder hospitalization during adolescence and early adulthood among males in an Australian birth cohort

Wenbin Liang, MBBS, MPH, PhD and Tanya Chikritzhs, PhD

National Drug Research Institute, Division of Health Science, Curtin University, Perth, Australia

Abstract

Objective: Associations between asthma and a range of mental disorders have been increasingly reported from cross-sectional studies. The aim of this study is to investigate whether hospitalization for asthma during childhood is associated with an increased risk of hospitalization for alcohol use disorders during adolescence and early adulthood. **Method:** This study used a population-based birth-cohort design and included males ($n = 56369$) born between 1980 and 1984 in Western Australia (WA). Hospitalizations for asthma and alcohol use disorders were identified using ICD-9 codes and ICD-10 codes. Survival analysis and multivariate Poisson regression model were used in the analysis. **Results:** The risk of alcohol use disorder hospitalization was significantly higher among participants who had been hospitalized for asthma during ages 3–6 years and 12–18 years. **Conclusion:** In this cohort study of Western Australian males, hospitalizations for asthma during childhood were associated with an increased risk of alcohol use disorder hospitalization among males.

Keywords

Alcohol use disorder, children, cohort study, hospitalization, mental disorders

History

Received 9 May 2013
Revised 18 July 2013
Accepted 23 July 2013
Published online 29 August 2013

Introduction

Asthma is a common chronic lung disease affecting about 300 million people worldwide [1]. The prevalence of asthma varies by age, gender and race [2,3]. For instance, in the United States, the overall prevalence of asthma is 7.8%, but varies from: 7.8% among adults to 9.3% among children; 6.9% among males to 8.6% among females; and 7.8% among the white population to 9.5% among the black population [4]. In Australia, the overall prevalence of asthma in the population is 10.2%. Among children aged 0–14 years, 11.4% of males and 7.2% of females have been diagnosed with the disease. Asthma is more prevalent among populations for which English is a first language compared to populations which speak other languages (10.9% versus 5.8%). Prevalence of the disease also tends to be higher among populations with lower social economic status [5].

Patients with mild asthma may experience only coughing while others with more severe asthma may frequently experience difficulty breathing (dyspnea) and be unable to perform daily tasks [1]. Similar to other chronic diseases, persistent and serious asthma symptoms may increase the

level of psychological stress experienced by patients [3,6,7] and in turn, chronic stress may increase the risk of anxiety disorders and affective disorders [8,9]. Associations between asthma and a range of mental disorders have been increasingly reported from cross-sectional studies [10–17]. Moreover, recent studies have suggested that mental disorders may increase the risk of alcohol use disorders, that is, acute alcohol intoxication, amnesic syndrome and dependence syndrome [18–20].

Given these links, it may be hypothesized that patients with severe asthma are at increased risk of alcohol use disorder hospitalizations. There is very limited prospective data available on the association between severe asthma and alcohol use disorder hospitalizations. However, results from a large scale cross-sectional study suggested that higher prevalence of alcohol abuse and dependence occur among populations with a lifetime diagnosis of asthma [21].

A large proportion of severe asthma occurs during childhood [22], and alcohol-related mental disorders are often first observed during adolescence or early adulthood [23]. It is yet to be established, however, whether there is a significant association between asthma during childhood and likelihood of experiencing alcohol use disorder hospitalizations later in life. We therefore conducted this population-based cohort study to investigate whether severe childhood asthma (i.e. requiring hospitalization) is associated with an increased risk of alcohol use disorder hospitalization during adolescence and early adulthood.

Correspondence: Dr Wenbin Liang, National Drug Research Institute, Curtin University, GPO Box U 1987, Perth, WA 6845, Australia. Tel: +61 8 92661617. Fax: +61 8 92661611. E-mail: W.Liang@curtin.edu.au

Methods

This study was a population-based birth-cohort study of males born between 1980 and 1984 in Western Australia (WA). Males were identified using birth registry records and followed-up from the age of 12 years to (i) 31 December 31 2009, (ii) age at first hospital admission for alcohol use disorder or (iii) death, whichever came first. Linked health data was provided by the Western Australian Data Linkage System.

Hospitalizations for asthma, alcohol use disorders and patient demographics were identified for the birth cohort from three databases and linked by the Western Australian Data Linkage System [24]. Data sources included the: (i) Midwives Notifications Data which included all births attended by a registered midwife in hospital or home settings in Western Australia. Data for this study matched more than 99% of the Birth Register Data in Western Australia; (ii) WA Hospital Morbidity Data System, which included separations from all WA public and private acute hospitals; and (iii) Mortality Data System, which included all deaths registered in WA [24]. The reliability and quality of these linked data have been confirmed previously [24]. Demographic information in the Midwives Notifications Data, records of asthma hospitalization in the WA Hospital Morbidity Data, records of first hospital admission with alcohol use disorder in the WA Hospital Morbidity Data and a limited number (732 and 675 deaths before or after the 12th birthday, respectively) of death records from the WA Mortality Data were linked together using a unique linked ID for each person. Participants who did not have a residential address in WA were removed from the data set because their morbidities were unlikely to be captured by the Western Australian Data Linkage System (<1%). Participants were also excluded if they died before the age of 12 years (1%). If information on some of the variables was missing (12%), participants were excluded from the multivariate analysis. The main variables with missing data were father's age (5.5% of the sample) and socioeconomic status (7.5% of the sample). There were 49 246 (out of a total sample of 56 369) participants included in the multivariate analysis.

In the Hospital Morbidity Data, all hospital admission records for the male birth cohort were extracted. Diagnoses were recorded using ICD-9 (original and modified versions) for the period 1979–1999 and ICD-10 (original and modified versions) from 1999 onwards. Both ICD-9 codes (493.0, 493.1, 493.8 and 493.9) and ICD-10 codes (J45 and J46) were used to identify hospital admissions coded with a primary diagnosis for asthma.

Hospital admissions for alcohol use disorders were defined as primary diagnoses where an ICD-9 code was 291, 303 or 305.0 or where an ICD-10 code was F10 (specific to alcohol-related disorders). When there was more than one admission for the same person, the date of first admission (sorted by date of admission) was selected for the survival analysis.

To control for potential confounding effects of socioeconomic status, residential location (Local Government Area, LGA) at birth was coded using the Australian Bureau of Statistics' (ABS) Index of Relative Socio-Economic Disadvantage (IRSED, a general measure of economic disadvantage of residential families in an area). IRSED is a standardized relative measure based on geographically coded demographics such as low income, low educational attainment, high unemployment and jobs in relatively unskilled occupations. The higher an area's index value, the less disadvantaged the area compared with other areas. [25].

Statistical analysis

For the descriptive and univariate analyses, participants were divided into two groups based on whether they had been hospitalized for asthma prior to their 12th birthday. The cumulative risks of first hospitalization for alcohol use disorder from age 12 years onward between the two groups (hospitalization for asthma versus no hospitalization for asthma before 12th birthday) were described and compared using a Kaplan–Meier survival graph and Log rank test. To describe the association between asthma hospitalization and first alcohol use disorder hospitalization at different ages, incidence rates of first hospitalization of alcohol use disorder were calculated for ages: ≥ 12 to <19 years; ≥ 19 to <24 years; and ≥ 24 years to the end of follow-up (Table 1). Associations between asthma hospitalizations at different age periods and alcohol use disorder hospitalizations were described through cross tabulations (Table 2 and 5).

Multivariate Poisson regression was used to estimate the effect of hospitalization for asthma during childhood on the risk of first hospitalization for an alcohol use disorder while controlling for potential confounders including: age of mother and father at delivery; year of birth and socioeconomic status (IRSED). All confounding factors were treated as categorical variables, and details of categorization are shown in Table 3.

To investigate the possible effects of age-specific asthma hospitalizations, multivariate Poisson regression was further applied to examine the effect of asthma hospitalizations occurring during different age periods. Asthma hospitalizations during different age periods: <3 years; ≥ 3 to <6 years;

Table 1. Incidence rates (per 1000 person-years) of first hospitalization for alcohol use disorder at different ages by asthma hospitalization status prior to 12 years of age.

Age of hospitalization for alcohol use disorder	Whether hospitalization for asthma occurred before 12 years					
	No			Yes		
	Rate	95% CI*		Rate	95% CI*	
≥ 12 to <19 years	0.73	0.64	0.82	1.14	0.80	1.62
≥ 19 to <24 years	0.88	0.78	1.01	1.52	1.05	2.18
≥ 24 years	0.58	0.48	0.69	0.82	0.47	1.44
Overall	0.74	0.68	0.80	1.18	0.94	1.49

*95% confidence interval.

Table 2. Cross-tabulation of asthma hospitalization at different ages during childhood (up to 18 years) and hospitalization for alcohol use disorder during follow-up.

	Whether hospitalization for alcohol use disorder occurred during follow-up		
	No	Yes	Total
Asthma hospitalization at <3 years of age*			
No	54176	655	54831
Yes	1509	29	1538
Asthma hospitalization at ≥3 to <6 years of age*			
No	53810	648	54458
Yes	1875	36	1911
Asthma hospitalization ≥6 to <12 years of age			
No	53907	656	54563
Yes	1778	28	1806
Asthma hospitalization at ≥12 to <19 years of age*			
No	55071	671	55742
Yes	614	13	627

* $p < 0.05$ by chi-square test.

≥6 <12 years; ≥12 to <19 years; and ≥19 years to the end of follow-up were encoded by five binary variables for inclusion in the model (Table 3). To account for possible associations and interaction effects at different age periods, a second multivariate Poisson regression was fitted for the matrix of the first four age-specific asthma hospitalization variables while controlling for potential confounders. Asthma hospitalizations between 19 years and the end of follow-up were not included in the matrix due to very small numbers of alcohol use disorder hospitalizations (Table 4). Age groupings for asthma were based on known phases of psychological development: 0–3 years (infancy phase and toddlerhood phase); 3–6 years (early childhood phase); 6–12 years (late childhood phase); and 12–19 years (adolescence phase) [26]. In addition, it has been suggested that misdiagnosis of asthma is more likely before the age of 3 years [27], therefore the infancy phase (0–1.5 years) and toddlerhood phase (1.5–3 years) were combined into one group.

Ethics

Ethics approval for this study was obtained from the Department of Health, Government of Western Australia, Human Research Ethics Committee (DOHWA HREC).

Results

A total 56 369 participants with 684 first hospitalization cases for alcohol use disorder were included in the descriptive analyses. Overall, the cumulative risk of having a first hospitalization for an alcohol use disorder between ages 12 and 30 years was higher among participants who had been hospitalized for asthma prior to their 12th birthday compared to those without a history of hospitalization for asthma in that age period (Figure 1). The increased risk of alcohol use disorder hospitalizations associated with asthma hospitalization was significant (log-rank test, $p < 0.001$). Moreover, incidence rates per 1000 person-years (95% confidence interval) of first hospitalization for alcohol use disorder

Table 3. Risk of first hospitalization for alcohol use disorder by childhood asthma hospitalization status at different ages.

	IRR	<i>p</i> Value	95% CI	
Asthma hospitalization at <3 years of age				
No	1.00			
Yes	1.17	0.523	0.73	1.87
Asthma hospitalization at ≥3 to <6 years of age				
No	1.00			
Yes	1.54	0.045	1.01	2.35
Asthma hospitalization at ≥6 to <12 years of age				
No	1.00			
Yes	1.00	0.991	0.62	1.61
Asthma hospitalization at ≥12 to <19 years of age				
No	1.00			
Yes	1.88	0.045	1.01	3.48
Asthma hospitalization at ≥19 years of age				
No	1.00			
Yes	*			
Age of mother (in years)				
12–17	2.61	0.000	1.55	4.37
18–24	1.31	0.019	1.05	1.65
25–29	1.00			
30–34	1.05	0.707	0.81	1.38
35–39	1.30	0.239	0.84	2.03
40+	1.00	1.000	0.31	3.26
Age of Father (in years)				
12–17	1.88	0.240	0.66	5.41
18–24	1.14	0.319	0.88	1.46
25–29	1.00			
30–34	0.96	0.750	0.76	1.22
35–39	1.01	0.932	0.72	1.42
40 +	1.10	0.693	0.69	1.75
Index of Relative Socioeconomic Disadvantage for residence area				
1st quintile	1.00			
2nd quintile	0.78	0.057	0.60	1.01
3rd quintile	0.74	0.018	0.58	0.95
4th quintile	0.84	0.168	0.66	1.07
5th quintile	0.65	0.005	0.48	0.88
Year of birth				
1980	1.00			
1981	1.13	0.354	0.87	1.47
1982	1.09	0.530	0.83	1.43
1983	1.14	0.332	0.87	1.49
1984	1.18	0.241	0.90	1.54

IRR: incidence rate ratio.

95% CI: 95% confidence interval.

*Unable to estimate due to insufficient number of events.

Model adjusted for age of mother and father at delivery; year of birth and social economic status (IRSED).

were constantly higher (though insignificant in two periods) among participants with asthma hospitalization before the age of 12 compared to those without asthma hospitalization before the age of 12 years (Table 1).

Shown in Table 2 are the numbers of participants with/without an asthma hospitalization at different ages by whether or not hospitalization for an alcohol use disorder had occurred during follow-up. The proportion of participants with a hospitalization for alcohol use disorder was significantly higher among participants who had been hospitalized for asthma at ages <3 years, ≥3 to <6 years and ≥12 to <19 years compared to those who had not been hospitalized for asthma during the same periods.

Table 4. Risk of first hospitalization for alcohol use disorder by history of asthma hospitalization at different ages.

Whether asthma hospitalization occurred (yes = 1/no = 0) at different ages (in years)				IRR	p Value	95% CI	
<3	≥3 to <6	≥6 to <12	≥12 to <19				
0	0	0	0	1.00			
0	0	0	1	1.38	0.578	0.44	4.30
0	0	1	0	1.24	0.497	0.66	2.32
0	0	1	1	2.71	0.086	0.87	8.44
0	1	0	0	1.87	0.018	1.12	3.12
0	1	0	1	4.05	0.049	1.01	16.25
0	1	1	0	0.87	0.813	0.28	2.71
0	1	1	1	4.52	0.003	1.69	12.09
1	0	0	0	1.60	0.095	0.92	2.78
1	0	0	1	*			
1	0	1	0	1.22	0.84	0.17	8.71
1	0	1	1	*			
1	1	0	0	1.86	0.169	0.77	4.48
1	1	0	1	*			
1	1	1	0	1.25	0.757	0.31	5.00
1	1	1	1	*			

IRR: incidence rate ratio. 95% CI: 95% confidence interval. Model adjusted for all confounding factors are listed in Table 3.
*Unable to estimate due to insufficient number of events.

Table 5. Cross-tabulation of asthma hospitalization history (up to 18 years) and hospitalization for alcohol use disorder during follow-up.

Whether asthma hospitalization occurred (yes = 1/no = 0) at different ages (in years)				Whether hospitalization for alcohol use disorder occurred during follow-up	
<3	≥3 to <6	≥6 to <12	≥12 to <19	No	Yes
0	0	0	0	51 630	609
0	0	0	1	229	3
0	0	1	0	876	13
0	0	1	1	115	3
0	1	0	0	832	16
0	1	0	1	50	*
0	1	1	0	353	5
0	1	1	1	91	4
1	0	0	0	838	18
1	0	0	1	18	*
1	0	1	0	90	*
1	0	1	1	14	*
1	1	0	0	284	7
1	1	0	1	26	*
1	1	1	0	168	*
1	1	1	1	71	*

*Cell counts were less than 3, and values were masked to ensure the confidentiality of the participants.

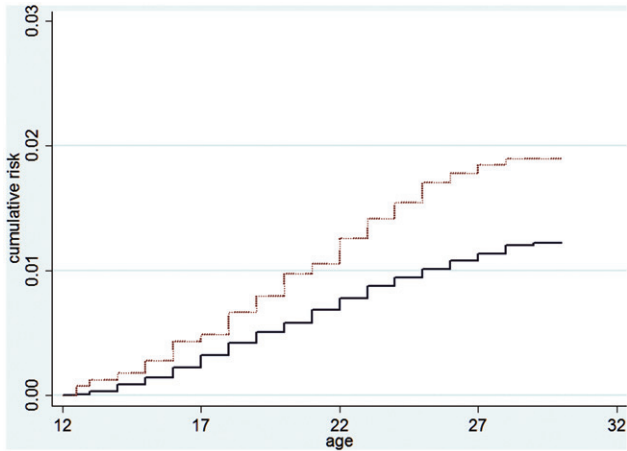


Figure 1. Cumulative risk of first hospitalization for alcohol use disorder by asthma hospitalization before 12 years. Upper gray line: Participants with asthma hospitalization before 12 years. Lower black line: Participants without asthma hospitalization before 12 years.

The results of multivariate analysis are shown in Table 3. Hospitalizations for asthma during ≥ 3 to <6 years and ≥ 12 to <19 years were associated with a significant increase in the risk of first hospitalization for alcohol use disorder after controlling for potential confounding factors. The results of the multivariate analysis for a matrix indicating history of hospitalization for asthma during the major childhood developmental periods are shown in Table 4. These results also indicated positive associations between history of asthma hospitalizations and risk of hospitalization for alcohol use disorders.

Discussion

In this population-based male birth cohort study, the risk of alcohol use disorder hospitalization was significantly

higher among participants who had been hospitalized for asthma during childhood. Asthma hospitalizations from ≥ 3 to <6 years and from ≥ 12 to <19 years were associated with a significant increase in the risk of first hospitalization for alcohol use disorders after controlling for a range of potential confounders. Notably, the incidence rate ratios indicated were age-specific in that they compared the risk of being hospitalized for an alcohol use disorder among those hospitalized for asthma at a specific age during childhood versus not having been hospitalized at that age, that is, the reference group included participants who had asthma hospitalization during other age periods (Table 3). Significant associations were not found for the age periods <3 years and ≥ 6 to <12 years; however, this may have been partly due to insufficient numbers of alcohol use disorder hospitalizations among participants with asthma hospitalizations only during these age periods (Table 2 and 5). In addition, high misdiagnosis of asthma before the age of 3 years [27] may also lead to insignificant observations. Compared to males who had not been hospitalized for asthma at any time up to age 18 years, males who, from age 3, had been repeatedly hospitalized during each age group were at particularly high risk of being hospitalized for alcohol use disorder (Table 4). Individuals who experience repeated hospitalizations for asthma from early childhood through to late adolescence (i.e. hospitalized for asthma in all of the periods: ≥ 3 to <6 years, ≥ 6 to <12 years and ≥ 12 to <19 years) are likely to have had severe and/or poorly controlled asthma and may also have been more likely to be treated by systemic corticosteroids over long periods of time.

The mechanism underlying the observed association is not yet clear. Data from large-scale cross-sectional studies has indicated a connection between asthma and alcohol use disorders with the prevalence of alcohol misuse being higher among adult populations with asthma [18–20]. It is possible

that severe childhood asthma may lead to the onset of alcohol use disorders in later life which are mediated by other mental disorders. Persistent severe asthma may produce chronic stress and acute asthma attacks may produce high level acute stress [21,28]. Both chronic stress and repeated acute stress increase activity of the hypothalamic–pituitary–adrenal axis [9], and further increase glucocorticoid levels. In addition, corticosteroid therapy, which is widely used for moderate and serious forms of asthma and asthma exacerbation [29], may further increase plasma levels of glucocorticoid. Increase in glucocorticoid alters neuronal activities and gene expression, especially in the limbic system which is an important area for memory and emotion, and is closely linked to mood and anxiety disorders [30,31]. There is emerging evidence suggesting that mental disorders may increase the risk of alcohol use disorder [18–20]

The human motivation system theory illustrated by West [32] offers an alternative explanation and suggests that planning and evaluations are curial components that determine responses to drives and impulses. People with asthma may have more difficulty controlling their drive and impulse because severe childhood asthma can lead to an increase in plasma levels of glucocorticoid and high levels this hormone may affect brain and psychological development [8,30,31], this may in turn result in impaired cognitive function related to evaluation and planning. Individuals with asthma symptoms are more likely to be at high distress level [16]. Distressed individuals have difficulty controlling drive and impulse [32] (e.g. less able to control drinking) and be at increased risk of alcohol use disorder hospitalization.

Strengths and limitations

Our study has several strengths. This is the first study to have investigated the association between hospitalization for childhood asthma and alcohol use disorder in later life. This population-based cohort study has a considerable sample size, a relatively long follow-up period and is not affected by recall bias. The main limitation of this study is that it only includes males. It is important therefore that the association between asthma and risk of alcohol use disorders be tested in a large population-based female cohort in the near future. Nevertheless, given the strong effects of gender on asthma [33], as well as on alcohol use disorders [34,35], it is desirable that the genders should be examined separately. This study only examined the association between relatively severe and/or poorly controlled forms of asthma and alcohol use disorders (i.e. those that required hospital treatment); however, a large proportion of asthma and alcohol use disorder sufferers may have been missed from our sample as they did not require hospitalization, that is, the prevalence of asthma and alcohol use disorders are estimated to be about 10% and 4.3%, respectively, in Australia [5,36]. Socioeconomic status is a predictor for both asthma and alcohol use disorder in Australia [37–39]. Socioeconomic status was controlled for using information collected at birth (and may have changed over time), and 12% of participants were excluded from the multivariate analysis due to missing information, therefore residual confounding effects which inflate the apparent effect size may remain. In addition, as mentioned previously,

analyses of the effects of repeated asthma hospitalizations at different age periods was limited due to some strata having insufficient case numbers. As discussed above, other mental disorders may mediate the association between asthma and alcohol use disorder; however, because the majority of anxiety and affective disorder cases are treated as outpatients, this possibility was unable to be examined in this study. Further studies with sufficiently large sample sizes to support subgroup analyses as well as residual confounding and potential mediation effects of anxiety and affective disorders are needed in the future. Moreover, it will be useful to establish whether the associations hold for non-hospitalized populations, for example, among individuals treated for less serious acute attacks in emergency departments or at general practitioners.

Conclusion

In this Western Australian-based cohort study, hospitalizations for childhood asthma were associated with an increased risk of alcohol use disorder hospitalizations among males.

Acknowledgements

The linkage data was provided by the Department of Health Western Australia, and the use of data linkages was provided by Data Linkage Branch.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Reference

1. Bateman ED, Hurd SS, Barnes PJ, Bousquet J, Drazen JM, FitzGerald M, Gibson P, et al. Global strategy for asthma management and prevention: GINA executive summary. *Eur Respir J* 2008;31:143–178.
2. Lai CKW, Beasley R, Crane J, Foliaki S, Shah J, Weiland S; Group tiPTS. Global variation in the prevalence and severity of asthma symptoms: phase three of the International Study of Asthma and Allergies in Childhood (ISAAC). *Thorax* 2009;64:476–483.
3. Oraka E, King ME, Callahan DB. Asthma and serious psychological distress. *Chest* 2010;137:609–616.
4. Moorman JE, Zahran H, Trurman B, Molla MT. Current asthma prevalence United States, 2006–2008. *MMWR* 2011;60:84–86.
5. ABS. Australian Health Survey: first results, 2011–12. Canberra: Australian Bureau of Statistics 2013.
6. Goldbeck L, Koffmane K, Lecheler J, Thiessen K, Fegert JM. Disease severity, mental health, and quality of life of children and adolescents with asthma. *Pediatr Pulmonol* 2007;42:15–22.
7. Sawyer SM, Drew S, Yeo MS, Britto MT. Adolescents with a chronic condition: challenges living, challenges treating. *Lancet* 2007;369:1481–1489.
8. Lupien SJ, McEwen BS, Gunnar MR, Heim C. Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nat Rev Neurosci* 2009;10:434–445.
9. Juster RP, Bizik G, Picard M, Arseneault-Lapierre G, Sindi S, Trepanier L, Marin MF, et al. A transdisciplinary perspective of chronic stress in relation to psychopathology throughout life span development. *Dev Psychopathol* 2011;23:725–776.
10. Avallone KM, McLeish AC, Luberto CM, Bernstein JA. Anxiety sensitivity, asthma control, and quality of life in adults with asthma. *J Asthma* 2012;49:57–62.
11. Du Y-J, Li B, Zhang H-Y, Cao Y-X, Duan X-H, Gong W-Y, Dong J-C. Airway inflammation and hypothalamic-pituitary-adrenal axis

- activity in asthmatic adults with depression. *J Asthma* 2013;50: 274–281.
12. Goldney RD, Ruffin R, Fisher LJ, Wilson DH. Asthma symptoms associated with depression and lower quality of life: a population survey. *Med J Australia* 2003;178:437–441.
 13. Goodwin RD, Chuang S, Simuro N, Davies M, Pine DS. Association between lung function and mental health problems among adults in the United States: findings from the First National Health and Nutrition Examination Survey. *Am J Epidemiol* 2007; 165:383–388.
 14. Lavoie KL, Cartier A, Labrecque M, Bacon SL, Lemièrre C, Malo J-L, Lacoste G, et al. Are psychiatric disorders associated with worse asthma control and quality of life in asthma patients? *Respiratory Medicine* 2005;99:1249–1257.
 15. Ringlever L, Otten R, van Schayck OCP, Engels RCME. The role of maternal illness perceptions in perceived asthma symptoms in school-aged children. *J Asthma* 2012;49:1030–1036.
 16. Wang G, Zhou T, Wang L, Wang L, Fu J-J, Zhang H-P, Ji Y-L. Relationship between current psychological symptoms and future risk of asthma outcomes: a 12-month prospective cohort study. *J Asthma* 2011;48:1041–1050.
 17. Arif AA. The association between symptomatic asthma and neurobehavioral comorbidities among children. *J Asthma* 2010; 47:792–796.
 18. Liang W, Chikritzhs T, Lenton S. Affective disorders and anxiety disorders predict the risk of drug harmful use and dependence. *Addiction* 2011;106:1126–1134.
 19. Liang W, Chikritzhs T. Affective disorders, anxiety disorders and the risk of alcohol dependence and abuse. *Br J Psychiat* 2011;199: 219–224.
 20. Dixit AR, Crum RM. Prospective study of depression and the risk of heavy alcohol use in women. *Am J Psychiatry* 2000;157: 751–758.
 21. Scott KM, Von Korff M, Ormel J, Zhang M-y, Bruffaerts R, Alonso J, Kessler RC, et al. Mental disorders among adults with asthma: results from the World Mental Health Survey. *Gen Hosp Psychiat* 2007;29:123–133.
 22. Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma – United States, 1980–1999. *Surveillance Summaries* 2002;51:1–13.
 23. Kessler R, Berglund P, Demler O, Jin R, Merikangas KR, Walters E. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication. *Arch Gen Psychiatry* 2005;62:593–602.
 24. Holman CDJ, Bass AJ, Rouse IL, Hobbs MST. Population-based linkage of health records in Western Australia: development of a health services research linked database. *Aust Nz J Publ Heal* 1999; 23:453–459.
 25. McLennan W. 1996 census of population and housing: socio-economic indexes for areas. Canberra: Australian Bureau of Statistics; 1998.
 26. Hales RE, Yudofsky SC, Gabbard GO, eds. *The American psychiatric publishing textbook of psychiatry*. 5th ed. Arlington, VA, United States: American Psychiatric Publishing; 2010.
 27. Martinez FD, Wright AL, Taussig LM, Holberg CJ, Halonen M, Morgan WJ. Asthma and wheezing in the first six years of life. *N Eng J Med* 1995;332:133–138.
 28. Cohen S, Rodriquez MS. Pathways linking affective disturbances and physical disorders. *Health Psychol* 1995;14:374–380.
 29. van Asperen Peter P, Mellis CM, Sly PD. The role of corticosteroids in the management of childhood asthma. *Med J Aust* 2002;176: 168–173.
 30. McEwen BS. Glucocorticoids, depression, and mood disorders: structural remodeling in the brain. *Metabolism* 2005;54:20–23.
 31. Sousa N, Cerqueira JJ, Almeida OF. Corticosteroid receptors and neuroplasticity. *Brain Res Rev* 2008;57:561–570.
 32. West R, Ainsley H. *Theory of addiction*. Oxford, UK: Blackwell Publishing; 2006.
 33. Postma DS. Gender differences in asthma development and progression. *Gen Med* 2007;4:S133–S146.
 34. Brady KT, Randall CL. Gender differences in substance use disorders. *Psychiatr Clin North Am* 1999;22:241–252.
 35. Medina KL, McQueeney T, Nagel BJ, Hanson KL, Schweinsburg AD, Tapert SF. Prefrontal cortex volumes in adolescents with alcohol use disorders: unique gender effects. *Alcohol Clin Exp Res* 2008;32:386–394.
 36. ABS. *National Survey of mental health and wellbeing: summary of results, 2007*. Canberra: Australian Bureau of Statistics; 2008.
 37. Turrell G, Mathers C. Socioeconomic inequalities in all-cause and specific-cause mortality in Australia: 1985–1987 and 1995–1997. *Int J Epidemiol* 2001;30:231–239.
 38. Moran P, Coffey C, Mann A, Carlin JB, Patton GC. Personality and substance use disorders in young adults. *Br J Psychiat* 2006;188: 374–379.
 39. Kozyrskyj AL, Kendall GE, Jacoby P, Sly PD, Zubrick SR. Association between socioeconomic status and the development of asthma: analyses of income trajectories. *American journal of public health* 2010;100:540–546.