

A Twin Study of Post-Traumatic Stress Disorder Symptoms and Asthma

Renee D. Goodwin¹, Mary E. Fischer², and Jack Goldberg^{2,3}

¹Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, New York; ²Vietnam Era Twin Registry, VA Epidemiologic Research and Information Center, Seattle, Washington; and ³Department of Epidemiology, School of Public Health and Community Medicine, University of Washington, Seattle, Washington

Rationale: Studies have suggested heightened anxiety among adults with asthma; the mechanism of this association is not known.

Objectives: To determine the association between post-traumatic stress disorder (PTSD) symptoms and asthma among adults, and to examine if this association is due to confounding by environmental and genetic factors.

Methods: Data were obtained from twins in the Vietnam Era Twin Registry, which includes male veteran twin pairs born between 1939 and 1956 who served during the Vietnam era (1965–1975). Measurements included a symptom scale for PTSD, history of a doctor diagnosis of asthma, and sociodemographic and health confounding factors. Co-twin control analytic methods used mixed-effects logistic regression to account for the paired structure of the twin data and to examine the association between PTSD symptoms and asthma in all twins. Separate analyses were conducted within twin pairs and according to zygosity.

Measurements and Main Results: PTSD symptoms were associated with a significantly increased likelihood of asthma ($P_{\text{trend}} < 0.001$) even after adjustment for confounding factors. Among all twins, those in the highest quartile of PTSD symptoms were 2.3 times as likely (95% confidence interval, 1.4–3.7) to have asthma compared with those in the lowest quartile. These findings persist when examined within twin pairs and when stratified by zygosity.

Conclusions: Symptoms of PTSD were associated with an elevated prevalence of asthma. Even after careful adjustment for familial/genetic factors and other potential confounding factors, an association between PTSD symptoms and asthma remains. Efforts to understand this comorbidity may be useful in identifying modifiable environmental risk factors contributing to this pattern and therefore in developing more effective prevention and intervention strategies.

Keywords: asthma; post-traumatic stress disorder; anxiety disorders; respiratory illness

There is a growing interest in the relationship between mental disorders and asthma. Data suggesting an association between a range of mental disorders and asthma come from clinical samples of adult outpatients (1–3), clinical samples of youths in a variety of settings (4–10), and community samples of both adults (11–14) and youths (15–18). Several studies demonstrate links between asthma and suicidal ideation and behavior among youths (19) and adults (20).

Although evidence of a link between depression and asthma is inconsistent and results to date are mixed, anxiety disorders are the mental disorders most strongly and consistently associ-

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Little is known about the potential mechanisms of the association between asthma and anxiety among adults, and whether or to what degree genetic and/or environmental risk factors may explain the link.

What This Study Adds to the Field

Our findings provide evidence of an association between asthma and increased post-traumatic stress disorder symptoms in a community-based sample and suggest that this association is not primarily explained by common genetic influences.

ated with asthma in pediatric and adult clinical samples, as well as in community-based samples (21, 22). More specifically, evidence to date suggests that panic disorder and post-traumatic stress disorder (PTSD) are the anxiety disorders most strongly associated with asthma in clinical samples. For instance, among adolescent psychiatric inpatients (9) and adolescent patients with asthma, PTSD is related to asthma and asthma severity (10). PTSD is also linked to asthma among adult primary care patients (2). Studies have also shown a strong link between asthma and panic disorder among adults in the community (23). Yet, the link between asthma and PTSD has not been examined in a nonclinical sample.

Although findings are relatively consistent in showing a link between anxiety disorders and asthma, the underlying mechanism remains unclear. One possibility is that asthma causes mental disorders; a second possibility is that mental disorders cause asthma. Few studies have examined the temporal relationship between mental disorders and asthma. One study demonstrated that asthma leads to an increased prevalence of panic attacks (13) and suicidal behavior and completion (20), whereas another study found that panic attacks lead to increased asthma activity (14).

Because evidence to date confirming a causal link between the two is lacking, and the theoretical rationale for a purely causal association is not clear, an alternative explanation is that a common risk factor, either environmental or genetic, is shared by mental disorders and asthma. One study that examined the comorbidity of asthma and depression/anxiety disorders found that the link was no longer evident after adjusting for the effects of potentially confounding factors (23). However, this study did not assess the possibility of a common genetic vulnerability to both asthma and depression/anxiety disorders. Several studies have documented higher rates of respiratory disease in relatives of individuals with panic disorder (24) and depression (25), suggesting a potential familial or genetic link. One environmental factor that might contribute to both mental disorders and asthma is exposure to trauma. Specifically, several studies show a link between exposure to trauma earlier in life and increased

(Received in original form October 12, 2006; accepted in final form August 10, 2007)

The U.S. Department of Veterans Affairs has provided financial support for the development and maintenance of the Vietnam Era Twin Registry.

Correspondence and requests for reprints should be addressed to Renee Goodwin, Ph.D., M.P.H., Department of Epidemiology, Mailman School of Public Health, Columbia University, 722 West 168th Street, Room 1706, New York, NY 10032. E-mail: rdg66@columbia.edu

Am J Respir Crit Care Med Vol 176, pp 983–987, 2007

Originally Published in Press as DOI: 10.1164/rccm.200610-1467OC on August 16, 2007
Internet address: www.atsjournals.org

risk of asthma or respiratory disease in adulthood (23, 26–28). Yet, no previous study has specifically investigated the comorbidity of asthma and PTSD among adults in the community.

We conducted a co-twin control study (R11) of male Vietnam-era twin pairs using the Vietnam Era Twin Registry (VET registry) to examine the association between PTSD symptoms and asthma. The goals of the current study are as follows: (1) to determine the strength of the relationship between PTSD symptoms and asthma and (2) to examine if the association is due to familial or genetic confounding factors.

METHODS

Sample

The VET registry is one of the largest national samples of twins in the United States (29). The registry was assembled in the mid-1980s by the Department of Veterans Affairs to address questions about the post-discharge health of Vietnam-era veterans. Eligible registry members were male twin pairs, born between 1939 and 1957, both of whom served on active military duty during the Vietnam era (May 1965 to August 1975). Initial VET registry data were obtained from the military records; a total of 7,375 male-male twin pairs were identified. All twin pairs lived together in childhood.

A mail and telephone survey of all twin pairs was administered in 1987 to determine zygosity and basic health status, including PTSD symptoms. A total of 4,774 twin pairs responded to this initial survey for a 64% pairwise response rate. A subsequent mail and telephone survey conducted in 1991 assessed heart, lung, and blood disorders, including asthma. In total, 3,698 twin pairs responded to this second survey. The analytic sample of 3,065 twins for the current study included only those twins who responded to both the 1987 and 1991 surveys and had complete data for zygosity, PTSD symptoms, and asthma.

Measures

Zygosity was determined using a questionnaire similarity algorithm supplemented with limited blood group typing from the military records (30). This methodology is estimated to correctly classify zygosity in more than 95% of twins (31, 32).

PTSD was assessed in the 1987 survey using a set of 15 questions about the frequency of symptoms in the past 6 months. The questionnaire items were derived from the *Diagnostic and Statistical Manual of Mental Disorders*, third revision, criteria and are similar to those used in the PTSD Checklist (33) and Mississippi scale (34) of PTSD. The five-level ordinal response categories ranged from very often = 5 to never = 1. The items were summed to create a PTSD symptom scale. The internal reliability, as measured by Cronbach's α was 0.92, and the 6-month test-retest reliability was 0.57 (35). Categories for the PTSD symptom score were created based on approximate quartiles. A history of asthma was obtained in the 1991 survey, which included the single item: "Has a doctor ever told you that you have asthma?"

We also had a set of sociodemographic and health confounding factors available from the 1987 and 1991 surveys. Variables included the following: age, highest year of education attained, body mass index, cigarette smoking, a combat exposure index (36), and a single question on doctor diagnosis of depression.

Statistical Methods

Descriptive analysis compared the prevalence of asthma according to sociodemographic and health factors. We estimated the prevalence of asthma (percentage) in all twins according to quartiles of the PTSD symptom scale. We also estimated the monozygotic (MZ) and dizygotic (DZ) twin correlations for asthma and the PTSD symptom scale.

The goal of a co-twin control analysis is to estimate the association between a putative risk factor (PTSD symptoms) and an outcome of interest (asthma). The statistical analysis of a co-twin control study must use methods that account for the paired structure of the twin data (37). We used a mixed-effects logistic regression approach (38) to examine the relationship of PTSD symptoms with asthma taking into account the paired structure of the data. In the mixed-effects regression analyses, the twin pairs were defined as clusters and a separate random effect for MZ and DZ pairs was included in all models. In this model,

the overall association between PTSD and asthma was estimated for all pairs, with indicator variables created for quartiles and the first quartile set as the reference level; a trend test was also conducted using the ordinal categories. From this model, we estimated odds ratios and 95% confidence intervals for each of the PTSD quartiles compared with the reference level. All models were adjusted for sociodemographics and health factors. We repeated this analysis estimating within-pair influences of PTSD symptoms on asthma; this analysis adjusts for familial/genetic confounding effects as well as measured confounding factors. Last, we stratified our within-pair regression analysis according to zygosity. Analyses within MZ pairs are completely controlled for genetic influences affecting both PTSD symptoms and asthma.

The prevalence estimates were obtained using SAS system for Windows version 8 (SAS Institute, Cary, NC), and the mixed-effects logistic regressions were performed using the MIXOR program (39).

RESULTS

The overall prevalence of asthma was 6% and was similar in MZ and DZ pairs (Table 1). Twins with asthma were slightly younger than those without ($P < 0.05$), but otherwise there were no significant differences in sociodemographic characteristics or zygosity between participants with and without asthma. Those with asthma were significantly more likely to have a history of depression ($P < 0.001$) compared with those without asthma. There were no significant differences in history of combat exposure or cigarette smoking between twins with and without asthma.

The twin correlations for asthma were larger in MZ ($r_{MZ} = 0.69$) than DZ ($r_{DZ} = 0.32$) pairs, suggesting a genetic influence ($P < 0.001$). Similarly, the twin correlations for the ordinal PTSD symptom scale suggests a genetic influence with the MZ correlation ($r_{MZ} = 0.42$) exactly twice the DZ correlation ($r_{DZ} = 0.21$) ($P < 0.001$).

TABLE 1. CHARACTERISTICS OF VIETNAM ERA TWIN REGISTRY TWINS ACCORDING TO ASTHMA DIAGNOSIS

Characteristics	Asthma	
	Yes	No
Total, n (%)	346 (6)	5,458 (94)
Zygosity, n (%)		
MZ	190 (6)	3,102 (94)
DZ	156 (6)	2,356 (94)
Mean age in 1987, yr (SD)*	38.0 (3)	38.4 (3)
Mean BMI in 1987, yr (SD)	25.6 (4)	25.5 (3)
Education, n (%)		
Less than high school graduate	18 (9)	174 (91)
High school graduate or GED	100 (6)	1,640 (94)
Technical school	61 (7)	861 (94)
College	126 (6)	2,132 (94)
Graduate school	41 (6)	651 (94)
Cigarette smoking history, n (%)		
Never	112 (6)	1,846 (94)
Former	106 (6)	1,663 (94)
Current	128 (6)	1,949 (94)
Combat exposure, n (%)		
Did not serve in southeast Asia	210 (6)	3,361 (94)
Served in southeast Asia		
No combat	26 (5)	516 (95)
Low combat	32 (5)	573 (95)
Medium combat	47 (7)	600 (93)
High combat	31 (7)	408 (93)
History of depression†		
Yes	40 (10)	358 (90)
No	306 (6)	5,100 (94)
Mean PTSD symptom score in 1987 (SD)†	28.0 (11)	25.2 (9)

Definition of abbreviations: BMI = body mass index; DZ = dizygotic; MZ = monozygotic; PTSD = post-traumatic stress disorder.

* $P < 0.05$.

† $P < 0.001$.

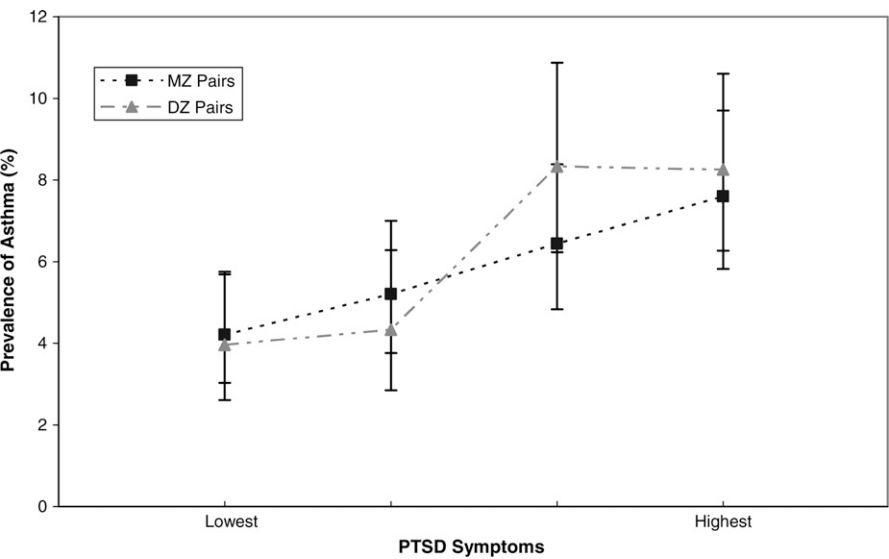


Figure 1. Prevalence of asthma and 95% confidence intervals by post-traumatic stress disorder (PTSD) symptoms.

PTSD symptoms are associated with an increase in the prevalence of asthma (Figure 1). There is a strong and highly significant monotonic association between PTSD symptoms and the prevalence of asthma ($P_{\text{trend}} < 0.001$). Odds ratio estimates from the mixed-effects regression analysis in all twins indicate a significant trend even after adjusted for potential confounding factors (Table 2); there is a twofold increase in asthma for twins in the highest PTSD symptom quartile compared with twins in the lowest quartile (95% confidence interval, 1.4–3.7). There is virtually no change in the magnitude of these odds ratios when a within-pair analysis is conducted controlling for familial and genetic factors.

Table 3 presents within-pair odds ratios for PTSD symptoms and asthma after stratifying for zygosity and adjusting for confounding factors. The PTSD–asthma association continued to be significant within DZ pairs ($P_{\text{trend}} = 0.04$) and was marginally significant within MZ pairs ($P_{\text{trend}} = 0.08$). The magnitudes of the odds ratios for the PTSD symptoms with asthma are similar in both DZ and MZ pairs. There is perhaps a small amount of genetic confounding as evidenced by the attenuation of the effects in MZ pairs. The test of the difference between the within-pair PTSD and asthma association in MZ and DZ pairs is not significant ($P = 0.94$); this means that the within-pair odds ratios for PTSD and asthma are similar in the both MZ and DZ pairs.

TABLE 2. THE ASSOCIATION BETWEEN POST-TRAUMATIC STRESS DISORDER SYMPTOMS AND ASTHMA

PTSD Quartile	All Twins		Within-Pair Effects	
	OR*	95% CI	OR*	95% CI
Quartile 1 (lowest)	1.0		1.0	
Quartile 2	1.2	0.8–1.9	1.2	0.7–2.1
Quartile 3	2.3	1.5–3.5	2.4	1.4–4.0
Quartile 4 (highest)	2.3	1.4–3.7	2.0	1.1–3.6
P_{trend} value	<0.0001		<0.01	

Definition of abbreviations: CI = confidence interval; OR = odds ratio; PTSD = post-traumatic stress disorder.

* Adjusted for education, combat exposure, cigarette smoking, age, body mass index, and depression in a mixed-effects logistic regression model accounting for twin pairs.

DISCUSSION

Our results are consistent with and extend previous knowledge on the link between anxiety and asthma with three main findings. First, these data suggest a strong and significant association between asthma and PTSD symptoms among males in the community. Second, our results indicate that the association between PTSD symptoms and asthma is not explained by confounding with depression, cigarette smoking, or demographic factors. Third, the results of the within-pair analysis show that the link between PTSD symptoms and asthma is not explained by common familial or genetic influences.

Previous population-based studies have documented links between asthma and a range of anxiety problems. However, our results provide the first evidence of a link between PTSD symptoms and asthma, because no previous investigation has included PTSD and asthma in an adult community-dwelling sample. Clinical data have suggested a strong association between PTSD symptoms and asthma (10) in asthma treatment settings, as well as in primary care (2). Asthma and anxiety disorders share a number of common social and environmental risk factors, which may play a role in their co-occurrence. Yet, although previous studies show links between asthma and mental disorders, these generally have not adjusted for a wide range of these factors. As such, our study sought to control for a number of potential confounding factors

TABLE 3. THE ASSOCIATION BETWEEN POST-TRAUMATIC STRESS DISORDER SYMPTOMS AND ASTHMA

PTSD Quartile	Within-MZ Pair Effects		Within-DZ Pairs Effects	
	OR*	95% CI	OR*	95% CI
Quartile 1 (lowest)	1.0		1.0	
Quartile 2	1.0	0.4–2.4	1.3	0.6–2.8
Quartile 3	2.7	1.1–6.4	2.1	1.1–4.3
Quartile 4 (highest)	1.8	0.7–4.9	2.0	0.9–4.4
P_{trend} value	0.08		0.04	

Definition of abbreviations: CI = confidence interval; DZ = dizygotic; MZ = monozygotic; OR = odds ratio.

$P_{\text{interaction}}$ value MZ vs. DZ within = 0.94.

* Adjusted for education, combat exposure, cigarette smoking, age, body mass index, and depression in a mixed-effects logistic regression model accounting for twin pairs.

that might explain the association between PTSD symptoms and asthma. For example, we included educational attainment in our models to account for socioeconomic status, which is related to both anxiety disorders and asthma (40). Similarly, we adjusted for cigarette smoking and body mass index, which are both associated with anxiety disorders and asthma (41–44). Indeed, we found that the link between PTSD symptoms and asthma was not fully explained by any of these common factors. However, we did not have all of the potential confounding factors that might explain this relationship. For instance, risk factors for asthma, such as exposure to cockroach allergen and environmental tobacco smoke during childhood, were unavailable. As such, it is conceivable that there are other environmental factors associated with asthma and anxiety that play a role in this link and need to be examined in future studies. Other possible factors include childhood abuse or exposure to adverse life events during childhood, which have been linked with both asthma (23) and PTSD (45). The current study also provides evidence of a significant link between asthma and depression. This is consistent with growing evidence that there is a relationship between asthma and depression (11, 23) among adults; however, the association is less clear among community samples of children (15). The association of asthma with depression is also consistent with a recent study that found a stronger association between asthma and depression, compared with anxiety disorders, in a general-population study of adults 60 years and older in Singapore (46). Therefore, the inconsistency in the link between asthma and depression, compared with asthma and anxiety, may be age related.

Our analysis included a combat exposure index as a covariate. Traumatic exposure is a potential risk factor for asthma (34) and is definitely associated with symptoms of PTSD (47). However, combat did not attenuate the association between PTSD symptoms and asthma. We did not have other measures of traumatic exposure, such as childhood abuse, which are linked with asthma (23, 26–28) in previous studies; it is possible that non-combat trauma is more relevant to the development of asthma. In addition, it may be that trauma plays a different role in the link between anxiety disorders and asthma in females, compared with males. The VET registry only includes male Vietnam-era veterans.

Our within-pair analysis of PTSD symptoms and asthma has implications for understanding the etiology of asthma. We observed only a modest change in the magnitude of the association between PTSD symptoms and asthma, even when the analysis was restricted to MZ pairs and adjusted for relevant confounding factors. This implies that neither common familial nor genetic factors can completely explain the relationship of PTSD symptoms and asthma. The biologic mechanism of this association is not known. It is conceivable that traumatic stress, which has been associated with compromised immune functioning (48–51), leads to increased vulnerability to immune-system-related diseases, including asthma. This possibility may warrant further examination in clinical and community samples. Alternatively, it may be that having asthma places adults at increased risk for PTSD as it increases the likelihood that they will be exposed to a traumatic situation because they have a life-threatening chronic medical condition. Longitudinal population-based studies could help to untangle the pathways linking mental health and asthma. Such studies ideally would include detailed measures of trauma exposure, mental disorders, and physician diagnoses of asthma, as well as objective and physiologic measures of lung function.

Limitations of this study need to be considered when evaluating results. First, we did not have any information on timing or severity of asthma. Asthma is a variable condition with mild, moderate or severe, and persistent or intermittent diagnostic status. A previous population-based study found that severity of

asthma may influence the link between asthma and mental disorders (11). Furthermore, our measurement of PTSD symptoms in 1987 was not contemporaneous with the measurement of a lifetime history of asthma in 1991. It would be desirable to replicate our findings using more detailed information on asthma severity and a longitudinal research design. Second, we were unable to assess the link between asthma and other types of anxiety because other forms of anxiety were not assessed. Third, the study only included males; therefore, the results are not generalizable to women. Fourth, there is a possibility of a bias because individuals with more PTSD symptoms may seek out medical care more frequently than those with fewer symptoms. In addition, it is conceivable that individuals suffering from PTSD may be more likely than those without PTSD to overreport physical illnesses, including asthma, contributing to the observed association. A recent study (52) showing a link between self-reported mental health problems and impairment in lung function obtained by physiologic measurement increases confidence that this result is unlikely entirely due to self-report bias. Finally, because our data are cross-sectional, we did not have the ability to discern the temporal relationship between PTSD symptoms and asthma with our survey data.

In summary, our findings provide initial evidence of a link between asthma and PTSD symptoms among males, and this finding is not explained by common demographic, familial, or genetic risk factors. Asthma and PTSD are common, potentially debilitating, and costly conditions both to the individual and society. Efforts to understand their comorbidity may be useful in identifying modifiable environmental risk factors contributing to this pattern to develop more effective prevention and intervention strategies.

Conflict of Interest Statement: None of the authors has a financial relationship with a commercial entity that has an interest in the subject of this manuscript.

Acknowledgment: Numerous organizations have provided invaluable assistance in the conduct of this study, including the Department of Defense; National Personnel Records Center, National Archives and Records Administration; the Internal Revenue Service; National Institutes of Health; National Opinion Research Center; National Research Council, National Academy of Sciences; the Institute for Survey Research, Temple University. Most importantly, the authors gratefully acknowledge the continued cooperation and participation of the members of the VET registry and their families. Without their contribution, this research would not have been possible.

References

1. Nascimento I, Nardi AE, Valenca AM, Lopes FL, Mezzasalma MA, Nascentes R, Zin WA. Psychiatric disorders in asthmatic outpatients. *Psychiatry Res* 2002;110:73–80.
2. Weisberg RB, Bruce SE, Machan JT, Kessler RC, Culpepper L, Keller MB. Nonpsychiatric illness among primary care patients with trauma histories and posttraumatic stress disorder. *Psychiatr Serv* 2002;53:848–854.
3. Feldman JM, Siddique MI, Morales E, Kaminski B, Lu SE, Lehrer PM. Psychiatric disorders and asthma outcomes among high-risk inner-city patients. *Psychosom Med* 2005;67:989–996.
4. Bussing R, Burket RC, Kelleher ET. Prevalence of anxiety disorders in a clinic-based sample of pediatric asthma patients. *Psychosomatics* 1996; 37:108–115.
5. Lavoie KL, Cartier A, Labrecque M, Bacon SL, Lemiere C, Malo JL, Lacoste G, Barone S, Verrier P, Dittlo B. Are psychiatric disorders associated with worse asthma control and quality of life in asthma patients? *Respir Med* 2005;99:1249–1257.
6. Vila G, Nolle-Clemencon C, de Blic J, Mouren-Simeoni MC, Scheinmann P. Asthma severity and psychopathology in a tertiary care department for children and adolescents. *Eur Child Adolesc Psychiatry* 1998;7:137–144.
7. Vila G, Hayder R, Bertrand C, Falissard B, De Blic J, Mouren-Simeoni MC, Scheinmann P. Psychopathology and quality of life for adolescents with asthma and their parents. *Psychosomatics* 2003;44:319–328.
8. Vila G, Nolle-Clemencon C, de Blic J, Mouren-Simeoni MC, Scheinmann P. Prevalence of DSM IV anxiety and affective disorders in a pediatric population of asthmatic children and adolescents. *J Affect Disord* 2000; 58:223–233.

9. Koltek M, Wilkes TC, Atkinson M. The prevalence of posttraumatic stress disorder in an adolescent inpatient unit. *Can J Psychiatry* 1998; 43:64–68.
10. Kean EM, Kelsay K, Wamboldt F, Wamboldt MZ. Posttraumatic stress in adolescents with asthma and their parents. *J Am Acad Child Adolesc Psychiatry* 2006;45:78–86.
11. Goodwin RD, Jacobi F, Thfeld W. Mental disorders and asthma in the community. *Arch Gen Psychiatry* 2003;60:1125–1130.
12. Goodwin RD, Pine DS. Respiratory disease and panic attacks among adults in the United States. *Chest* 2002;122:645–650.
13. Goodwin RD, Eaton WW. Asthma and the risk of panic attacks among adults in the community. *Psychol Med* 2003;33:879–885.
14. Hasler G, Gergen PJ, Kleinbaum DG, Ajdacic V, Gamma A, Eich D, Rössler W, Angst J. Asthma and panic in young adults: a 20-year prospective community study. *Am J Respir Crit Care Med* 2005;171:1224–1230.
15. Ortega AN, Huertas SE, Canino G, Ramirez R, Rubio-Stipek M. Childhood asthma, chronic illness, and psychiatric disorders. *J Nerv Ment Dis* 2002;190:275–281.
16. Ortega AN, McQuaid EL, Canino G, Goodwin RD, Fritz GK. Comorbidity of asthma and anxiety and depression in Puerto Rican children. *Psychosomatics* 2004;45:93–99.
17. Ortega AN, McQuaid EL, Canino G, Ramirez R, Fritz GK, Klein RB. Association of psychiatric disorders and different indicators of asthma in island Puerto Rican children. *Soc Psychiatry Psychiatr Epidemiol* 2003;38:220–226.
18. Goodwin RD, Pine DS, Hoven CW. Asthma and panic attacks among youth in the community. *J Asthma* 2003;40:139–145.
19. Goodwin RD, Marusic A. Asthma and suicidal ideation among youth in the community. *Crisis* 2004;25:99–102.
20. Goodwin RD, Eaton WE. Asthma, suicidal ideation, and suicide attempts: findings from the Baltimore epidemiologic catchment area follow-up. *Am J Public Health* 2005;95:717–722.
21. Goodwin RD. Asthma and anxiety disorders. *Adv Psychosom Med* 2003;24:51–71.
22. Katon WJ, Richardson L, Lozano P, McCauley E. The relationship of asthma and anxiety disorders. *Psychosom Med* 2004;66:349–355.
23. Goodwin RD, Fergusson DM, Horwood LJ. Asthma and depressive and anxiety disorders among young persons in the community. *Psychol Med* 2004;34:1465–1474.
24. van Beek N, Schruers KR, Griez EJ. Prevalence of respiratory disorders in first-degree relatives of panic disorder patients. *J Affect Disord* 2005;87:337–340.
25. Goodwin RD, Wickramaratne P, Nomura Y, Weissman MM. Familial depression and respiratory illness in children. *Arch Pediatr Adolesc Med* 2007;161:487–494.
26. Goodwin RD, Wamboldt MZ, Pine DS. Lung disease and internalizing disorders: is childhood abuse a shared etiologic factor? *J Psychosom Res* 2003;55:215–219.
27. Romans S, Belaise C, Martin J, Morris E, Raffi A. Childhood abuse and later medical disorders in women: an epidemiological study. *Psychosom Med* 2002;71:141–150.
28. Goodwin RD, Stein MB. Association between childhood trauma and physical disorders among adults in the United States. *Psychol Med* 2004; 34:509–520.
29. Goldberg J, Curran B, Vitek ME, Henderson WG, Boyko EJ. The Vietnam Era Twin Registry. *Twin Res* 2002;5:476–481.
30. Eisen S, Neuman R, Goldberg J, Rice J, True W. Determining zygosity in the Vietnam Era Twin Registry: an approach using questionnaires. *Clin Genet* 1989;35:423–432.
31. Jablon S, Neel JV, Gershowitz H, Atkinson GF. The NAS-NRC twin panel: methods of construction of the panel, zygosity diagnosis, and proposed use. *Am J Hum Genet* 1967;19:133–161.
32. Cederlof R, Friberg L, Jonsson E, Kaij L. Studies on similarity diagnosis in twins with the aid of mailed questionnaires. *Acta Genet Stat Med* 1961;11:338–362.
33. Blanchard EB, Jones-Alexander J, Buckley TC, Forneris CA. Psychometric properties of the PTSD Checklist (PCL). *Behav Res Ther* 1996; 34:669–673.
34. Keane TM, Caddell JM, Taylor KL. Mississippi scale for combat-related posttraumatic stress disorder: three studies in reliability and validity. *J Consult Clin Psychol* 1988;56:85–90.
35. Roy-Byrne P, Arguelles L, Vitek ME, Goldberg J, Keane TM, True WR, Pitman RK. Persistence and change of PTSD symptomatology: a longitudinal co-twin control analysis of the Vietnam Era Twin Registry. *Soc Psychiatry Psychiatr Epidemiol* 2004;39:681–685.
36. Janes GR, Goldberg J, Eisen SA, True WR. Reliability and validity of a combat exposure index for Vietnam era veterans. *J Clin Psychol* 1991;47:80–86.
37. Carlin JB, Gurrin LC, Sterne JA, Morley R, Dwyer T. Regression models for twin studies: a critical review. *Int J Epidemiol* 2005;34: 1089–1099.
38. Hedeker D, Gibbons RD, Flay BR. Random-effects regression models for clustered data with an example from smoking prevention research. *J Consult Clin Psychol* 1994;62:757–765.
39. Hedeker D, Gibbons RD. MIXOR: a computer program for mixed-effects ordinal regression analysis. *Comput Methods Programs Biomed* 1996;49:157–176.
40. Von Korff MR, Eaton WW, Keyl PM. The epidemiology of panic attacks and panic disorder. Results of three community surveys. *Am J Epidemiol* 1985;122:970–981.
41. Clark NM, Gong M, Brown RW, Anderson EW, Yu J, Valerio MA, Joseph CL, Wu G, Zeng Z, Wu Z. Influences on childhood asthma in low-income communities in China and the United States. *J Asthma* 2005;42:493–497.
42. Rose D, Mannino DM, Leaderer BP. Asthma prevalence among US adults, 1998–2000: role of Puerto Rican ethnicity and behavioral and geographic factors. *Am J Public Health* 2006;96:880–888.
43. Vieweg WV, Fernandez A, Julius DA, Satterwhite L, Benesek J, Feuer SJ, Oldham R, Pandurangi AK. Body mass index relates to males with posttraumatic stress disorder. *J Natl Med Assoc* 2006;98:580–586.
44. Beckham JC, Feldman ME, Vrana SR, Mozley SL, Erkanli A, Clancy CP, Rose JE. Immediate antecedents of cigarette smoking in smokers with and without posttraumatic stress disorder: a preliminary study. *Exp Clin Psychopharmacol* 2005;13:219–228.
45. Heim C, Nemeroff CB. The role of childhood trauma in the neurobiology of mood and anxiety disorders: preclinical and clinical studies. *Biol Psychiatry* 2001;49:1023–1039.
46. Ng TP, Chiam PC, Kua EH. Mental disorders and asthma in the elderly: a population-based study. *Int J Geriatric Psychiatry* 2007;22:668–674.
47. American Psychiatric Association. Diagnostic and statistical manual of mental disorders, revision 4. Washington, DC: American Psychiatric Press; 2007;22:668–674.
48. Marshall GD Jr, Agarwal SK. Stress, immune regulation, and immunity: applications for asthma. *Allergy Asthma Proc* 2000;21:241–246.
49. Wright RJ, Cohen RT, Cohen S. The impact of stress on the development and expression of atopy. *Curr Opin Allergy Clin Immunol* 2005;5:23–29.
50. Wright RJ, Steinbach SF. Violence: an unrecognized environmental exposure that may contribute to greater asthma morbidity in high risk inner-city populations. *Environ Health Perspect* 2001;109:1085–1089.
51. Wright RJ, Finn P, Contreras JP, Cohen S, Wright RO, Staudenmayer J, Wand M, Perkins D, Weiss ST, Gold DR. Chronic caregiver stress and IgE expression, allergen-induced proliferation, and cytokine profiles in a birth cohort predisposed to atopy. *J Allergy Clin Immunol* 2004;113:1051–1057.
52. 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.