Questionnaire Items That Predict Asthma and Other Respiratory Conditions in Adults*

Jun Bai, MPH; Jennifer K. Peat, PhD; Geoffrey Berry, PhD; Guy B. Marks, PhD; and Ann J. Woolcock, MD, FCCP

The International Union Against Tuberculosis and Lung Disease questionnaire is widely used in epidemiologic studies of adult asthma. We examined whether the symptom questions could be classified into groups that represent different “syndromes,” and whether some questions are better for predicting asthma than others. We analyzed questionnaire data from a population sample of 1,527 adults aged 18 to 55 years using factor analyses to classify the 17 respiratory symptom questions into four different groups that we termed asthma, cough, breathlessness, and urgent medical visit. The urgent medical visit was a subset of asthma. These four “syndromes” had good validity when measured against airway responsiveness to histamine, atopy to common allergens, lung function, smoking status, and body mass index. Questions that predicted asthma syndrome were those that asked about wheeze at rest or following exercise, asthma attack, chest tightness, and shortness of breath at rest. Questions about cough identified a different group of subjects who apparently did not have asthma. Questions of breathlessness did not aggregate with “asthma” or with “cough syndrome.” The identification of particular questions that measure different respiratory conditions is important for epidemiologic studies when short questionnaires or more precise definitions are required.

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Key words: adult; asthma; epidemiology; factor analysis; human; questionnaires

Abbreviations: AHR = airway hyperresponsiveness, a 20% fall or greater in FEV1 at < 3.9 μmol of histamine administered; BMI = body mass index; IUATLD = The International Union Against Tuberculosis and Lung Disease; UMV = urgent medical visit

Epidemiologic studies of adults rely on self-administered questionnaires to collect information about the presence and severity of asthma and other respiratory illnesses,1 because they are relatively inexpensive to administer and convenient both to researchers and to subjects in surveys of large and widespread populations. The International Union Against Tuberculosis and Lung Disease (IUATLD) questionnaire is widely used to collect information concerning wheeze, chest tightness, shortness of breath, and cough.2–6 As an epidemiologic tool for identifying people with asthma, it has been extensively evaluated in terms of its relation to airway hyperresponsiveness (AHR),3,7 clinically diagnosed asthma,8 and responses to other questionnaires.5 However, in some respects the information contained in the questionnaire is still not fully understood. Some common diseases and states, including bronchitis, obesity, hypertension, and heart disease, are associated with symptoms that are similar to those experienced by people with asthma.5 It seems likely that some items within the questionnaire identify people with these alternative conditions, whereas other questions would be more closely related to asthma. In addition, the issue of whether some questions are redundant, in that they do not collect further information but identify the same subset of respondents as other questions, has not been systematically examined. We have sought to examine these aspects of the construct validity of this questionnaire.

In 1991 and 1992, an abbreviated IUATLD questionnaire was administered to two large population samples of adults who were the parents of randomly selected schoolchildren living in two rural locations in New South Wales.4 The data were pooled and principal component analyses were used to identify items that were highly correlated with one another. The content of the derived principal components

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was examined to identify the clinical “syndromes” they represented. The nature of the syndromes was then validated against factors known to be associated with asthma and other respiratory illnesses and conditions, including AHR, atopy, lung function, smoking status, and body mass index (BMI).

Materials and Methods

Subjects

The studies were conducted in the two regions of New South Wales in October (spring) of 1991 and 1992 in Lismore and Wagga Wagga. Subjects, who were the parents of a randomly selected sample of schoolchildren aged 8 to 11 years, were asked to complete a questionnaire and to attend a location in the town center for lung function and allergy tests. The methods have been described in detail and are briefly summarized below.

Questionnaire

We used a shortened version of the IUATLD questionnaire. The 17 questions that asked for information about wheeze and tightness in the chest, asthma, cough, and shortness of breath were as follows, with the abbreviated identifier used in this report shown in parentheses.

1. Have you had this wheezing in your chest in the last 12 months? (wheeze in last 12 months)
2. In the last 12 months, have you had an attack of wheezing that came on after you stopped exercising? (wheeze following exercise)
3. In the last 12 months, have you had a feeling of tightness in your chest? (chest tightness)
4. In the last 12 months, have you had a feeling of tightness in your chest on waking in the morning? (chest tightness on waking)
5. In the last 12 months, have you had an attack of asthma? (asthma attack)
6. In the last 12 months, have you ever had to spend a night in hospital because of breathing problems? (hospitalization)
7. In the last 12 months, have you visited a hospital casualty department because of asthma or breathing problems? (casualty department visit)
8. In the last 12 months, have you seen a doctor urgently because of asthma or breathing problems? (urgent doctor visit)
9. In the last 12 months, have you used a nebulizer to take asthma medicine at home? (recent nebulizer use)
10. Do you usually have a cough? (usual cough)
11. Do you usually cough first thing in the morning? (morning cough)
12. Do you usually bring up phlegm from your chest first thing in the morning? (cough with phlegm)
13. Do you cough in the morning on most days for as much as 3 months each year? (cough for 3 mo/yr)
14. In the last 12 months, have you been woken by an attack of coughing? (woken by cough)
15. In the last 12 months, have you had an attack of shortness of breath that came on when you were not exercising and without obvious cause? (shortness of breath at rest)
16. In the last 12 months, have you been troubled by shortness of breath when hurrying on level ground or walking up a slight hill? (breathlessness on exertion)

17. In the last 12 months, have you found it difficult to keep pace with other people of your own age when you walk? (breathlessness on walking)

Lung Function and Airway Responsiveness

A histamine bronchial challenge test was administered using the rapid method. Doses of histamine ranged from 0.03 to 3.9 μmol. For subjects who had a fall in FEV₁ of ≥ 20%, the dose of histamine that caused a 20% fall was calculated. All subjects with a ≥ 20% fall in FEV₁ at the maximum dose of histamine, 3.9 μmol, were classified as having airway hyperresponsiveness (AHR). Subjects who presented with an FEV₁ < 60% of predicted did not undergo histamine challenge but were given a bronchodilator challenge. Subjects with an increase in FEV₁ of ≥ 15% were considered to have a positive bronchodilator challenge and were also classified as having AHR.

Allergic Sensitization

Sensitization to common allergens was measured by skin prick test reactions to the forearm. The eight allergens tested were as follows: house dust; house-dust mites (Dermatophagoides pteronyssinus and Dermatophagoides farinae); cat dander; ryegrass; plantain; Alternaria tenuis; and cockroach. Histamine and glyceryl were used as positive and negative controls. A skin prick reaction was regarded as positive if the wheal size was ≥ 4 mm. Subjects were considered atopic if they had a positive reaction to any of the allergens in the testing panel.

Statistical Methods

Data were analyzed using a statistical package (SAS; SAS Institute Inc; Cary, NC). All of the 17 questions were answered by options of “yes” or “no.” These 17 variables were submitted to factor analyses using the principal components method of factor extraction with varimax rotation. An appropriate designation was assigned to each factor based on its content. χ² tests were used to determine the significance of differences in proportions between groups. For multiple comparisons, analysis of variance with Duncan’s post hoc test was used to assess differences in continuous variables between groups. Multiple regression was used to analyze the effect of each variable on continuous response-variable after adjusting for confounders. Logistic regression was used to determine the difference of AHR between groups after adjusting for confounders.

Results

The characteristics of the study samples have been described in detail. To summarize, 58% of the sample were female, 91% were in the age range 30 to 50 years, 19% were current smokers, 5% had AHR, and 46% were atopic. Table 1 shows the prevalence of positive responses to the 17 questionnaire items. When the principal component analysis was carried out separately for the two regions, the factor patterns were similar in each and to those given in Table 2 for the combined sample. The only differences were that “chest tightness on waking” had a higher loading on breathlessness than on asthma in Lismore, and “shortness of breath at rest” was almost
Table 1—The Prevalence of the Symptoms*

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheeze in last 12 mo</td>
<td>18.7</td>
</tr>
<tr>
<td>Asthma attack</td>
<td>9.2</td>
</tr>
<tr>
<td>Chest tightness</td>
<td>24.7</td>
</tr>
<tr>
<td>Recent nebulizer use</td>
<td>4.1</td>
</tr>
<tr>
<td>Wheeze following exercise</td>
<td>8.1</td>
</tr>
<tr>
<td>Shortness of breath at rest</td>
<td>12.7</td>
</tr>
<tr>
<td>Morning cough</td>
<td>11.2</td>
</tr>
<tr>
<td>Cough for 3 mo/yr</td>
<td>11.5</td>
</tr>
<tr>
<td>Cough with phlegm</td>
<td>11.8</td>
</tr>
<tr>
<td>Usual cough</td>
<td>11.6</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>0.5</td>
</tr>
<tr>
<td>Casualty department visit</td>
<td>1.3</td>
</tr>
<tr>
<td>Urgent doctor visit</td>
<td>3.2</td>
</tr>
<tr>
<td>Breathlessness on walking</td>
<td>9.2</td>
</tr>
<tr>
<td>Breathlessness on exertion</td>
<td>21.8</td>
</tr>
<tr>
<td>Chest tightness on waking</td>
<td>9.0</td>
</tr>
<tr>
<td>Woken by cough</td>
<td>21.6</td>
</tr>
</tbody>
</table>

*Total number of subjects is 1,527.

Equally correlated with breathlessness as with asthma at both Lismore and Wagga Wagga. Table 2 shows the final factor structure that was used in the remaining analyses. Four factors were identified. The first factor contained items for symptoms associated with asthma and accounted for 30.2% of the total variation (the variation was derived from the original principal component before rotation). The second factor contained items dealing with symptoms of cough and accounted for 13.6% of the total variation. The third factor, urgent medical visit (UMV) accounted for 9.5% of the total variation. The fourth factor, dealing with respiratory symptoms related to breathlessness (breathlessness), accounted for 6.6% of the total variation. One question, that is “woken by cough,” did not fit any group particularly well.

We divided the subjects into five groups, normal, asthma, cough, breathlessness, and UMV, based on their questionnaire responses. All of the subjects who had a positive reply to one or more of the symptom questions in the asthma factor, were classified as asthma regardless of their cough or breathlessness status. Subjects were classified as cough, if they had a positive reply to one or more of the symptom questions in cough factor, and were negative to asthma. Subjects were classified as breathlessness if they had a positive reply to one or more of the symptom questions in the breathlessness factor, and were negative to asthma and cough. Subjects who had one or more positive answers to UMV were classified as UMV. Over 95% of the subjects in the UMV group were also in the asthma group, that is, UMV was mostly a subset of asthma rather than an independent group. Subjects who had negative answers to all of the 16 questions (“woken by cough” excluded) were classified as normal. Of 1,527 subjects, 817 (53.5%) were classified as normal, 515 (33.8%) as asthma, 117 (7.7%) as cough, and 78 (5.1%) as breathlessness; 52 (10.1%) of 515 asthma were UMV.

Using the questionnaire-based classification, 76.7% of subjects with AHR were in the asthma group, 17.5% were in the normal group, 4.2% were in the cough group, and 1.7% were in the breathlessness group.

Figure 1 shows that the percentages of subjects

Table 2—Component Loadings (Correlations) Between Factors and Variables for the 17 Items in Principal Components Analysis (After Rotation)*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Factor 1 (asthma)</th>
<th>Factor 2 (cough)</th>
<th>Factor 3 (UMV)</th>
<th>Factor 4 (breathlessness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheeze in last 12 mo</td>
<td>0.75</td>
<td>0.15</td>
<td>0.06</td>
<td>0.11</td>
</tr>
<tr>
<td>Asthma attack</td>
<td>0.72</td>
<td>0.08</td>
<td>0.26</td>
<td>0.11</td>
</tr>
<tr>
<td>Chest tightness</td>
<td>0.67</td>
<td>0.16</td>
<td>0.00</td>
<td>0.25</td>
</tr>
<tr>
<td>Recent nebulizer use</td>
<td>0.62</td>
<td>0.02</td>
<td>0.24</td>
<td>-0.10</td>
</tr>
<tr>
<td>Wheeze following exercise</td>
<td>0.61</td>
<td>0.08</td>
<td>0.07</td>
<td>0.24</td>
</tr>
<tr>
<td>Chest tightness on waking</td>
<td>0.56</td>
<td>0.16</td>
<td>0.12</td>
<td>0.30</td>
</tr>
<tr>
<td>Shortness of breath at rest</td>
<td>0.54</td>
<td>0.14</td>
<td>0.06</td>
<td>0.43</td>
</tr>
<tr>
<td>Morning cough</td>
<td>0.07</td>
<td>0.91</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Cough for 3 mo/yr</td>
<td>0.10</td>
<td>0.85</td>
<td>0.04</td>
<td>0.15</td>
</tr>
<tr>
<td>Usual cough</td>
<td>0.12</td>
<td>0.81</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>Cough with phlegm</td>
<td>0.05</td>
<td>0.78</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>0.03</td>
<td>0.04</td>
<td>0.88</td>
<td>0.01</td>
</tr>
<tr>
<td>Casualty department visit</td>
<td>0.14</td>
<td>0.04</td>
<td>0.84</td>
<td>0.07</td>
</tr>
<tr>
<td>Urgent doctor visit</td>
<td>0.27</td>
<td>0.12</td>
<td>0.61</td>
<td>0.22</td>
</tr>
<tr>
<td>Breathlessness on walking</td>
<td>0.06</td>
<td>0.10</td>
<td>0.09</td>
<td>0.55</td>
</tr>
<tr>
<td>Breathlessness on exertion</td>
<td>0.27</td>
<td>0.14</td>
<td>0.06</td>
<td>0.77</td>
</tr>
<tr>
<td>Woken by cough</td>
<td>0.28</td>
<td>0.24</td>
<td>0.06</td>
<td>0.31</td>
</tr>
</tbody>
</table>

*The bold figures are the item highest loadings under the factors to which they belong.
with AHR and atopy were significantly higher in asthma groups (both p < 0.001), especially in the group of asthma with UMV. The percent of subjects with AHR and atopy in the normal, cough, and breathlessness groups was not significantly different (both p > 0.05).

There were significant differences in percent predicted FEV₁ between the asthma and the normal group and between the cough and the normal group (both p < 0.05) (Fig 2). After adjusting for smoking status, the difference in mean percent predicted FEV₁ between the cough and the normal group was no longer significant (p = 0.07), but the difference between the asthma and the normal groups was still highly significant (p < 0.001). This suggests that the lower percent predicted FEV₁ in subjects in the cough group, but not in the asthma group, was explained by smoking. There were significantly more current smokers in the cough group than in the asthma, breathlessness, and normal group (p < 0.001) (Fig 3).

Within the asthma group, the UMV and non-UMV subjects were very different in terms of AHR (Fig 1) and lung function. A total of 34.6% of the UMV subjects had AHR compared with 16.0% in the non-UMV subjects (p < 0.001). The mean percent predicted FEV₁ for the UMV subjects was 85.7% compared with 97.8% for the non-UMV subjects (p < 0.001). These results suggest that the UMV group included subjects with more severe asthma.

Within the asthma group, 34.6% of the subjects reported one or more of the four cough symptoms. Compared with subjects with asthma symptoms alone, those who also had cough were similar in terms of prevalence of AHR (19.3% vs 15.2%, p > 0.05) and atopy (61.0% vs 52.3%, p > 0.05).

The percentage of subjects with obesity (defined as a BMI > 30 kg/m²) differed among the symptom groups (p < 0.001) (Fig 4). A statistical analysis of Duncan grouping showed that the differences of mean BMI were significant between the group with breathlessness and asthma symptoms and the groups of asthma symptoms without breathlessness, normal, and cough subjects (all p < 0.05). The mean BMI did not differ between the group with breathlessness

Figure 1. Percentage of subjects with AHR and atopy in each of the symptom groups (error bars represent the 95% confidence interval).

Figure 2. The comparison of mean percent predicted FEV₁ for symptom groups (error bars represent the 95% confidence interval).

Figure 3. Percent of current smokers in each symptom group (error bars represent the 95% confidence interval).

Figure 4. Percent obese (BMI > 30 kg/m²) in each symptom group (error bars represent the 95% confidence interval).
and asthma and the group with breathlessness symptoms only (p > 0.05). Table 3 shows that subjects with obesity were more likely to report breathlessness symptoms and some asthma-like symptoms, were more likely to be diagnosed as having asthma, and were more likely to use asthma medication, but there was no difference of AHR and atopy between subjects with and without obesity. This suggests breathlessness and asthma-like symptoms may be attributable to other causes in these obese subjects.

**Table 3—Comparison Between Subjects With Obesity (BMI > 30 kg/m²) and Without Obesity**

<table>
<thead>
<tr>
<th></th>
<th>Nonobesity</th>
<th>Obesity</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%)</td>
<td>1,352 (88.5)</td>
<td>175 (11.5)</td>
<td></td>
</tr>
<tr>
<td>AHR, %</td>
<td>7.8</td>
<td>9.2</td>
<td>0.53</td>
</tr>
<tr>
<td>Atopy, %</td>
<td>46.4</td>
<td>46.9</td>
<td>0.90</td>
</tr>
<tr>
<td>Ever diagnosed asthma, %</td>
<td>17.5</td>
<td>25.3</td>
<td>0.01</td>
</tr>
<tr>
<td>Wheeze in last 12 mo, %</td>
<td>17.2</td>
<td>29.7</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Asthma attack, %</td>
<td>8.3</td>
<td>16.0</td>
<td>0.001</td>
</tr>
<tr>
<td>Chest tightness, %</td>
<td>23.8</td>
<td>32.0</td>
<td>0.02</td>
</tr>
<tr>
<td>Recent nebulizer use, %</td>
<td>3.7</td>
<td>6.9</td>
<td>0.049</td>
</tr>
<tr>
<td>Wheeze following exercise, %</td>
<td>7.1</td>
<td>13.7</td>
<td>0.001</td>
</tr>
<tr>
<td>Chest tightness on waking, %</td>
<td>8.5</td>
<td>12.9</td>
<td>0.06</td>
</tr>
<tr>
<td>Shortness of breath at rest, %</td>
<td>11.5</td>
<td>22.1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Breathlessness on exertion, %</td>
<td>19.9</td>
<td>36.2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Breathlessness on waking, %</td>
<td>7.6</td>
<td>21.3</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Woken by cough, %</td>
<td>21.3</td>
<td>23.1</td>
<td>0.59</td>
</tr>
</tbody>
</table>

**Discussion**

By using factor analysis, we found that 16 questions identified four separate respiratory conditions, that is asthma, cough, breathlessness, and a subset of asthma that experienced UMV. These identified groups had good validity against the other physical characteristics that were measured. In this study, the regrouping of symptom questions was derived from original data and based on the internal relationship of the questions. Questions were compared by their item correlations to their factor. The similarity of the factors extracted for the two regions separately provided confirmation of their validity, although there were some slight differences discussed below that suggested some ambiguity on the most appropriate factor with which to associate three of the questions.

Physiologic features of asthma include AHR to various bronchoconstrictor stimuli, including chemical substance, such as histamine and methacholine, atopy to some allergens, and reduced lung function. The impairment in lung function is greater in persons with more severe asthma.

In this study, we demonstrated that the symptom questions in the asthma group identified subjects with a significantly higher percentage of AHR and atopy, and a lower mean percent predicted FEV₁ than subjects in the normal, cough, and breathlessness groups. The questions of “wheeze in last 12 months,” “asthma attack,” “chest tightness,” “recent nebulizer use,” “wheeze following exercise,” and “shortness of breath at rest” all contributed to asthma. The first three questions had the strongest correlations with this factor and are thought to be most useful for future epidemiologic surveys. The questions of “wheeze following exercise,” “chest tightness on waking,” and “shortness of breath at rest” had moderate correlations with the breathlessness factor (Table 2). It was also noted that the last two of these three questions were almost as strongly correlated with breathlessness as with asthma when the analyses were carried out separately in the two regions. This suggests that these questions may be as appropriately associated with the breathlessness factor as with the asthma factor.

Cough is a common symptom that can be caused by various respiratory diseases such as bronchitis, asthma, and also by heart failure. We found that the cough group identified subjects with a similar prevalence of AHR and atopy to the normal group. However, the cough group included a higher proportion of current smokers and of subjects with reduced lung function. Our analyses also suggested that the decrement in lung function was related to smoking in the cough group but not in the asthma group. The cough group comprised four questions: “morning cough,” “cough for 3 months per year,” “usual cough,” and “cough with phlegm.” While some asthma subjects reported these symptoms, subjects with cough who did not have a positive response to any of the asthma questions were not different from the normal in terms of the presence of AHR, atopy, and impaired lung function. Therefore, it may not be appropriate to use these questions as indicator symptoms for adult asthma.

The UMV group was a subset of the asthma group, and was more likely to include those with more severe asthma.

Subjects with obesity often have shortness of breath and physical limitation. Our study shows subjects responding positively to the breathlessness questions did not have abnormal lung function, AHR, or atopy but tended to be obese. It seems likely that their symptoms are related to obesity but other disease states such as heart disease cannot be excluded, since the symptoms of breathlessness are common in some heart diseases such as left ventricular failure. The cause of the symptoms in the group that we labeled as breathlessness was not clear, but was apparently different from that of the asthma group. The two questions comprising the breathlessness group are “breathlessness on walking” and
“breathlessness on exertion.” The question “woken by cough” did not load strongly on any factor and hence could be omitted from the questionnaire in future studies of adult asthma.

In this study, we examined the construct of validity of a questionnaire that is commonly used in epidemiologic studies of adult asthma. Our description of the relation between groups of questions and clinical conditions will facilitate a more informative interpretation of questionnaire responses. The identification of more and less valuable questions for particular purposes will allow the construction of shorter sets of questions for specific purposes.

References
1 Burney P, Chinn S. Developing a new questionnaire to measuring the prevalence and distribution of asthma. Chest 1987; 91(suppl):79s–83s