How much asthma is occupationally related?

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HOW MUCH ASTHMA IS OCCUPATIONALLY RELATED?

Asthma is a chronic inflammatory disorder of the airways characterized by variable airflow obstruction and airways hyperresponsiveness. Prominent clinical manifestations of asthma include cough, wheezing, and shortness of breath. Asthma is a multifactorial disease that has been associated with familial, allergenic, environmental, nutritional, socioeconomic, psychological, and occupational risk factors. Asthma prevalence and mortality have been increasing in both the United States and other countries over the past 20 years. It is currently estimated that 17 million people in the U.S. have asthma. A significant proportion of adult asthma in both the U.S. and in other countries may be related to occupational exposures.

A critical factor in determining how much asthma in adults may be related to occupational exposures depends on the definition of occupational or work-related asthma that is used. While there is a great deal of agreement in different case definitions of occupational asthma, there are also some critical differences that have become important factors in epidemiologic studies. The U.S. Centers for Disease Control and Prevention’s National Institute for Occupational Safety and Health (NIOSH) recently has published guidelines for surveillance of work-related asthma. This definition recognizes two different types: work-aggravated asthma, which occurs in subjects who have a history of symptomatic asthma or who have been treated for asthma within 2 years of entering the workplace, and who have experienced an increase in their asthma symptoms or use of medications since entering the workplace; and new-onset asthma, which occurs...
in people with either no history of asthma or a history of pre-existing asthma that was either untreated or asymptomatic for at least 2 years before entering the workplace. New-onset asthma is further broken down into two types: that which is related to persistent asthma symptoms following a high-level, one-time irritant exposure (reactive airways dysfunction syndrome [RADS]), and that which is related to either a known or unknown asthma inducer (with or without objective evidence that substantiates the work-relatedness of the asthma).

Current literature offers various definitions of what may be work-related or occupational asthma. While all definitions require that asthma, as marked by airflow limitation that reverses either spontaneously or in response to treatment, be present, and that this airflow limitation be related to the work environment, some definitions go on to limit occupational asthma to that which “develops after a period of symptomless exposure to a sensitizing agent at work,” implying that the worker had no previous asthma and that an allergic pathogenesis is important for the diagnosis. Other case definitions, however, also include a nonallergic mechanism that is related to exposures to levels of nonallergenic irritants, which some authors state need to be high dose (corresponding to the NIOSH section on RADS), but others say can be of a lower dose over an extended period of time (corresponding to the NIOSH section on unknown asthma inducers). The broadest definition of work-related or occupational asthma is “asthma derived from, worsened by, or encountered in an occupational setting,” a definition that includes subjects with pre-existing asthma that is worsened in the workplace.

Another problem in defining work-related asthma is trying to define airflow limitation in epidemiologic studies. Factors that typically enter into this definition include the presence of physician-diagnosed asthma; the presence of increased bronchial responsiveness, as determined by reactivity to a nonspecific agent; the presence of bronchial responsiveness to a specific allergen; and the presence of pulmonary symptoms such as wheeze, cough, or shortness of breath. Determinations of how much asthma is work-related can vary even within the same study, depending on which definition is used.

**METHODOLOGY**

Several techniques have been used to assess the incidence, prevalence, or risk of work-related asthma and, subsequently, its proportion to all adult asthma. In adults with asthma, 2–25% of cases are thought to be occupationally related. The present review includes studies published in English between January 1988 and June 1999 that attempted to determine what proportion of adult asthma is work-related. Three main methods were used: (1) the determination of asthma prevalence in populations exposed to occupational asthmogens versus that in unexposed populations; (2) active or passive surveillance of asthma in populations; and (3) the determination of the proportion of prevalent or incident asthma that may be related to occupational exposures. Each of these methodologies has benefits and shortcomings that influence the interpretation of the findings.

**RESULTS**

Cross-sectional studies have been used to determine the relationship between occupational exposures and respiratory diseases, including asthma (Table 1). The methodology for these studies is reflected in the recently published reports of Kogevas, Monso, and Forastiere. The Kogevas study analyzed data from the European Community Respiratory Health Survey, which was undertaken in 12
## Table 1. Cross-sectional Surveys Attempting to Determine How Much Asthma isOccupationally Related

<table>
<thead>
<tr>
<th>Author</th>
<th>Setting</th>
<th>Number, Sex, Age</th>
<th>RR (OE)</th>
<th>RR Smoking</th>
<th>Attributable Risk</th>
<th>Asthma as Child</th>
<th>Definitions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krzyzanowski, 1988 (28)</td>
<td>France</td>
<td>8,692 Males 25–59</td>
<td>1.6 (1.4–1.8)</td>
<td>Male 1.9 Female 3.6</td>
<td>Male 13% Female 10%</td>
<td>Yes</td>
<td>Asthma—A, B WRA—H, I, J</td>
<td>1,2</td>
</tr>
<tr>
<td>Viegi, 1991 (53)</td>
<td>Italy</td>
<td>1,027 Males 18–64</td>
<td>2.0</td>
<td>Males 2.0 Female 3.3</td>
<td>Males 15% Females 14%</td>
<td>Yes</td>
<td>Asthma—A, C WRA—H, I, J</td>
<td>2</td>
</tr>
<tr>
<td>Xu, 1993 (54)</td>
<td>China</td>
<td>1,762 Males 40–69</td>
<td>1.6</td>
<td>Dusts 1.6 Fumes 1.4</td>
<td>Dusts 12% Fumes 5%</td>
<td>Yes</td>
<td>Asthma—A, D WRA—H, I, J</td>
<td>2,3</td>
</tr>
<tr>
<td>Ng, 1994 (38)</td>
<td>Singapore</td>
<td>2,378 age 20–54</td>
<td>1.7 (1.4–2.2)</td>
<td></td>
<td>33%</td>
<td>No</td>
<td>Asthma—A WRA—H, I, J</td>
<td>3</td>
</tr>
<tr>
<td>Kogevinas, 1996</td>
<td>Spain</td>
<td>1,275 Males 20–44</td>
<td>1.8</td>
<td>0.9 (0.7–1.1)</td>
<td>5.3%</td>
<td>No</td>
<td>Asthma—E, F, G WRA—H, I, J</td>
<td>3,4</td>
</tr>
<tr>
<td>Fishwick, 1997</td>
<td>New Zealand</td>
<td>739 Males 20–44</td>
<td>1.6 (0.8–3.0)</td>
<td></td>
<td>3.1%</td>
<td>No</td>
<td>Asthma—E, F, G WRA—H, I, J</td>
<td>3,4</td>
</tr>
<tr>
<td>Forastiere, 1998</td>
<td>USA</td>
<td>1,226 Males ≥ 55</td>
<td>1.8 (1.1–3.2)</td>
<td>2.3 (1.4–4.0)</td>
<td>15.1%</td>
<td>No</td>
<td>Asthma—A and E WRA H, I, J</td>
<td>3</td>
</tr>
<tr>
<td>Mouso, 1998 (37)</td>
<td>Spain</td>
<td>484 Males ≥ 18</td>
<td>1.9 (1.1–3.2)</td>
<td></td>
<td>20%</td>
<td>Yes</td>
<td>Asthma—D, C, or G WRA—H or K</td>
<td>3</td>
</tr>
<tr>
<td>Kogevinas, 1999</td>
<td>12 countries</td>
<td>7,375 Males 20–44</td>
<td>1.4 (1.1–1.7)</td>
<td></td>
<td>5–10%</td>
<td>No</td>
<td>Asthma—E, F, G WRA—H, I, J</td>
<td>3,4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8,262 Females 20–44</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key for Definitions:**

- **Asthma**
  - A—Physician diagnosed asthma
  - B—Lifetime history of severe asthma symptoms
  - C—Low pulmonary function
  - D—Lifetime history of asthma
  - E—Asthma symptoms in prior 12 months
  - F—Asthma medication in prior 12 months
  - G—Bronchial hypersensitivity

- **Work-Related Asthma**
  - H—Exposure to high dose of respiratory irritant
  - I—Exposure to unknown asthma sensitizer
  - J—Exposure to coffee
  - K—Improvement in symptoms away from workplace

**Comments:**

1. Excluded subjects where head of household was a manual laborer, rate ratio and attributable risk is for “wheeze”
2. Compared exposed subjects to unexposed subjects
3. Compared subjects with asthma to those without asthma
4. Part of European Community Respiratory Health Survey

**Notes:** Surveys use exposed-unexposed or case-control methodology. Relative risk = RR, occupational exposure = OE, work-related asthma = WRA.
countries: Australia, Belgium, Germany, Iceland, Ireland, Italy, New Zealand, Norway, Spain, Sweden, the United Kingdom, and the U.S.7 This study focused on young adults aged 20–44 years, and its design had two phases: the first phase dealt with an initial random population sample; the second phase included both a random subsample of the phase 1 population and a symptomatic phase 1 subsample. This type of design makes it impossible to determine from published data the prevalence of asthma in the population or in various subsets of the population. One feature of this study is that, in an effort to avoid bias, researchers coded either the current or former occupation that appeared to cause or worsen health problems.

The authors determined that asthma, defined as increased bronchial responsiveness and reported asthma symptoms or medication, was increased in certain occupational groups (farmers, cleaners, painters, and agricultural workers) and that occupational exposures caused or exacerbated asthma in 5–10% of young adults. A puzzling aspect of this study was the intercountry variation, with estimates of the attributable risk of asthma ranging from 2% in Australia and New Zealand (where the prevalence of asthma is high) to more than 10% in the U.S., Germany, and Iceland. Reasons for the low attributable risk of work-related asthma in Australia or New Zealand are unknown.

Many features of the Kogevinas study are shared by other cross-sectional studies (see Table 1), although there also are numerous differences between the studies. The relative risk of occupational exposures for asthma was remarkably consistent between the studies (1.4–3.3, with most around 1.8). Smoking was evaluated as an independent risk factor in several studies, and was increased in three,14,28,54 but not the fourth.27 Studies that included older adults tended to have higher attributable risks of asthma to occupational exposures than those that did not.16,55

A potential shortcoming of these studies is defining the “unexposed” control group. Exposures to agents which can cause or exacerbate asthma, such as tobacco smoke, are nearly ubiquitous both in and away from the work environment.23,52 This fact was noted in the differences between two studies: in one study service workers (including people potentially exposed to tobacco smoke) were an “exposed” group with an increased risk of asthma,38 while in another study service workers were included in the “unexposed” group.26 Furthermore, there is some evidence that subjects with increased airways responsiveness may quickly select themselves out of dusty occupations, without necessarily attributing this change to health concerns.39 Thus, it is possible that adults with asthma may have an occupational relatedness to their disease that is not readily apparent in a cross-sectional study, the result being an underestimate of the attributable risk of occupational exposures for asthma.

The second type of method used to determine how much work-related asthma is present applies surveillance systems. The surveillance systems described in publications are based either on physician reporting17,22,23,41,42 or claims to occupational disease registries.45,69 The physician-based reporting has been enhanced, in some instances, with hospitalization data or workers’ compensation claims.22,41 All of these systems require accurate physician diagnosis and accurate reporting. Only one of these systems, from Finland, also was able to collect data for all asthma incidence—thus allowing direct determination of the proportion of asthma that is work-related.42

Table 2 lists six reports of occupational asthma incidence from five different countries. The range of estimates for the incidence of work-related asthma range from a low of 29 per million in the U.S. to a high of 193 per million in Finland. The recently published NIOSH report, which did not include incidence estimates and is not included in Table 2, did list the contribution of the different types of work-related
<table>
<thead>
<tr>
<th>Author</th>
<th>Setting</th>
<th>Incidence of WRA</th>
<th>Incidence of Asthma</th>
<th>Attributable Risk</th>
<th>Asthma as Child?</th>
<th>Definitions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gannon, 1993</td>
<td>UK, Targeted physician based surveillance</td>
<td>284 from 1989–91</td>
<td>43/10^5</td>
<td>1000–4000/10^{10}</td>
<td>1.0–4.3%</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Meredith, 1994</td>
<td>UK, Physician based surveillance</td>
<td>1954 from 1992–93</td>
<td>37/10^6</td>
<td>1000–4000/10^{10}</td>
<td>0.9–3.7%</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Toren, 1996</td>
<td>Sweden Self reported claims</td>
<td>1010 over 1990–92</td>
<td>Males 90/10^6</td>
<td>1000–4000/10^{10}</td>
<td>2.1–9.0%</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Reijula, 1996</td>
<td>Finland Disability claims</td>
<td>8,056 in 1993</td>
<td>Females 70/10^6</td>
<td></td>
<td></td>
<td>4.8%</td>
<td>Unknown</td>
</tr>
<tr>
<td>Rosenman, 1997</td>
<td>USA, State based surveillance</td>
<td>725 subjects</td>
<td>193/10^8</td>
<td>4000/10^6</td>
<td></td>
<td>0.8–2.2%</td>
<td>Yes</td>
</tr>
<tr>
<td>Provencher, 1997</td>
<td>Canada, Physician based surveillance</td>
<td>205 Males</td>
<td>Males 79/10^6</td>
<td>1000–4000/10^{10}</td>
<td>2.0–7.9%</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>82 Females</td>
<td>Females 42/10^6</td>
<td></td>
<td></td>
<td>1.0–4.2%</td>
<td></td>
</tr>
</tbody>
</table>

* Range of asthma incidence estimated from other studies

**Key for Definitions:**

**Asthma**

- A — Physician-diagnosed asthma

**Work-Related Asthma**

- B — Asthma believed to be due to work
- C — Exposure to high dose of respiratory irritant
- D — Exposure to unknown asthma sensitizer
- E — Exposure to known asthma sensitizer
- F — Report of work-related symptoms

**Comments:**

1. Part of SHIELD surveillance system
2. Part of Surveillance of Work-Related and Occupational Respiratory Disease (SWORD) system
3. Financial benefit to being diagnosed with persistent asthma (medications paid for)

**Notes:** WRA = work-related asthma
asthma to the total burden. The proportions varied by state, but overall only 27.3% of the cases had exposure to a known asthma inducer. This percentage can be contrasted with data from Finland, in which over 95% of the cases were due to known asthma inducers. The observed difference may be related to the requirement that work-related asthma in Finland be based on "the identification of a specific causative agent," whereas in the U.S. the main requirements in the state surveillance systems are that physician-diagnosed asthma be present and that there be an association between the symptoms of asthma and work.

The third grouping of studies comprises those attempting to determine how much incident, prevalent, or hospitalized asthma is occupationally related (Table 3). The proportion of asthma that is potentially work-related is estimated to be 13–26%. The question "Was asthma caused by bad working conditions?" was used in two of these studies; it has been criticized as being potentially leading, so some researchers believe that the results could be skewed. Of this group of studies, the most intriguing was the Milton study, which was based in a large health maintenance organization and was designed to determine the incidence of both new asthma (subjects who never before had asthma) and reactivated asthma (subjects who had not received treatment in the year prior to their being seen for asthma). Another interesting feature of this study was the use of a matrix including the work-relatedness of symptoms and the worksite exposure to classify the strength of evidence for work-related asthma as weak, moderate, or strong. Milton found that a similar proportion of people with new-onset (26%) and reactivated (19%) asthma had moderate to strong evidence that their asthma was work related. Methods that attempt to detect incident asthma and, in addition, determine the proportion of this asthma that is work related, such as reported by Milton, may more accurately determine the true proportion of asthma that is work-related.

DISCUSSION

There is no easy answer to the question of how much asthma is occupationally related. The different answers to this question depend not only on how the terms "asthma" and "work-related" are defined, but also on how "occupation" is defined. For example, in the Kogevinas study housewives had an elevated odds ratio for asthma symptoms or medication (1.34, 95% confidence interval 1.11, 1.62). Housewives presumably are exposed to cleaning fluids and other potential asthagens at their "worksites." Similarly, environmental tobacco smoke, which has been shown to be an irritant that can exacerbate asthma, can be present at worksites, the home, and places where people shop or eat. Thus, the distinction between occupationally related asthma and environmentally related asthma can become blurred.

In this review, surveillance-based systems consistently had the lowest estimates for how much asthma may be work-related (Fig. 1). This finding is not surprising, because these systems typically rely on the voluntary reporting of a disease and probably require the most definitive proof that the asthma was work related. The two other methodologies estimate that 10–25% of asthma is work-related. This estimate, which may vary in different populations and in different areas, includes people with work-aggravated asthma, RADS, and occupational asthma with or without a known asthma inducer.

CONCLUSION

A significant proportion of both new and exacerbated asthma in adults is related to agents encountered in the workplace, with estimates ranging from 5% to
<table>
<thead>
<tr>
<th>Author</th>
<th>Setting</th>
<th>Number, Sex, Age</th>
<th>Incidence of WRA</th>
<th>Incidence of Asthma</th>
<th>Attributable Risk</th>
<th>Asthma as Child?</th>
<th>Definitions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanc, 1987 (4)</td>
<td>USA 1978 Disability Survey</td>
<td>468 respondents with asthma of 6,063</td>
<td>15.4%</td>
<td>Yes</td>
<td>Asthma—A</td>
<td>WRA—H</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Timmer, 1993 (48)</td>
<td>USA Hospital Discharges</td>
<td>94 subjects</td>
<td>3.1% Probable</td>
<td>Yes</td>
<td>Asthma—A</td>
<td>WRA—H, L, K</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Blanc, 1996 (5)</td>
<td>USA Community Survey</td>
<td>601 subjects, ages 18-50</td>
<td>8.5% Sens.</td>
<td>No</td>
<td>Asthma—A</td>
<td>WRA—I, J, K</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Milton, 1998 (36)</td>
<td>USA HMO Database</td>
<td>108 new asthma cases among 79,204 subjects</td>
<td>1300-10^6</td>
<td>26% New</td>
<td>No</td>
<td>Asthma—A, B, C, D</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Key for Definitions: **Asthma**

- A—Physician-diagnosed asthma
- B—Emergency department visit for asthma
- C—Hospitalization for asthma
- D—Asthma medication in prior 12 months

**Work-Related Asthma**

- H—Was asthma caused by bad working conditions?
- I—Exposure to known asthma sensitizer
- J—Exposure to high dose of respiratory irritant
- K—Exposure to unknown asthma sensitizer
- L—Report of work-related symptoms

Comments:

1. Attributable risk was 11.9% in Health Interview Survey data and 17.1% in the disability subset.
2. Subjects with exposures to known asthma sensitizers classified as “probable;” others classified as “possible.”

Notes: WRA = work-related asthma
Percent of Asthma that is Work Related

\begin{figure}
\centering
\includegraphics[width=0.8\textwidth]{asthma_work_related.png}
\caption{Estimates, derived from 23 written studies, of how much asthma may be work-related, depicting either the point-estimate (diamond) or range (line) of potentially work-related asthma. The numbers correspond to the references in the bibliography.}
\end{figure}

25%. While, historically, much attention has been given to sensitizing agents such as toluene diisocyanate, an increasing proportion of cases is related to nonspecific irritants and indoor air pollutants, many of which are encountered in both occupational and nonoccupational settings.

REFERENCES