Occupational Asthma Surveillance Project
Grant #U60/CCU916057-03

Kaiser Permanente Center for Health Research,
Oregon Health Division,
And
Oregon Health and Sciences University
Portland, Oregon

Final Report
December 2001

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1. Introduction

This is the final report for the NIOSH project "Identify the Incidence of Occupational Asthma," referred to hereinafter as the "OCASTHMA" study. The report summarizes the work completed by the Kaiser Permanente Center for Health Research (CHR) and its subcontractor, the Oregon Health Division (OHD), from the initiation of the project on 9/30/98 through September 2001. The work of the second awardee on this project, Dr. Don Milton of Harvard University in Boston, is not covered in this report. Our project officer was Dr. Paul Henneberger.

2. Goals and Objectives

The overall goal of the project was to evaluate the incidence of work-related asthma in a defined population during a 12-month period. The population we evaluated consisted of working age members of the Northwest Region of Kaiser Permanente (KPNW), a large health maintenance organization (HMO) centered around Portland, Oregon.

In order to achieve this goal, we identified and accomplished the following specific objectives:

- develop and validate an algorithm for identifying individuals with prevalent asthma.
- develop and validate an algorithm for identifying individuals with new onset asthma.
- determine all "incident" cases of asthma in the target population during a 12-month period.
- determine an appropriate denominator population corresponding to the incident cases for purposes of calculating various "incidence" rates.
- calculate the incidence of occupational asthma in KPNW.
- conduct a detailed telephone interview of the incident cases.
- using established operational definitions developed in conjunction with NIOSH and the Boston group, determine which of these cases are occupationally related.
- calculate the proportion of all incident asthma cases that appear to be associated with workplace exposures.

The following objective was also addressed:

- Provide training for targeted primary and specialty care providers to increase their awareness of occupational asthma and the frequency with which they ask patients with adult onset asthma about their work-place exposures.

3. Methods

A detailed description of the study methods is provided in the draft manuscripts included in appendices 1 and 2. This information is briefly summarized below.

Study population

We investigated the burden of occupational asthma among the approximately 254,000 members aged 15-55 of the KPNW HMO. The KPNW membership has been shown in previous studies to be broadly representative of the larger Portland metropolitan area population from which the membership is drawn.

Identification of incident cases

We used the electronic clinical databases maintained by KPNW to develop an algorithm for identifying individuals with prevalent asthma, who by definition are not at-risk for developing new (i.e., incident) asthma. A manuscript summarizing the development of this algorithm and its validation has been submitted for publication and is included in appendix 1. Based on a manual review of 153 patient charts, we estimate that the final prevalence algorithm has a positive predictive value of 89%.

A second, main results paper that summarizes the rest of our methodology and presents the primary outcome data for the study has also been submitted (appendix 2). Table 1 of that paper summarizes the algorithm for identifying the at-risk population. In addition to excluding those with pre-existing asthma, we also excluded those with other medical conditions that might be confused with asthma. Table 2 of the main results paper (appendix 2) summarizes the algorithm for defining "incident" cases of asthma, all of whom were confirmed by chart review (97% of the 855 suspected cases were confirmed to represent incident asthma). It should be noted that what we are calling incident asthma in this report really represents a combination of true incident asthma and recurrence of previously dormant asthma.

We applied these two algorithms successively for each month of the year 2000, and aggregated the denominator person-months for each monthly at-risk population to compute an overall person-months of observation for the entire year. This was then used as the denominator to calculate incidence rates.

Occupational assessment

In order to assess the potential work-relatedness of asthma among the 828 confirmed incident cases, we developed, in conjunction with our project officer and investigators from the Boston performance site, a detailed telephone interview (summarized in appendix 3...the actual questionnaire was completed online using a computer assisted telephone interview protocol).

Using this telephone protocol, we attempted to contact by phone all 828 individuals with chart-confirmed incident asthma in order to assess the work-relatedness of symptoms and triggers and to gather information about potential workplace exposures. The former was assessed on a four-point scale (0-3) that counts whether: 1) the participant's chest symptoms or breathing troubles got better "on weekends, vacations, or other times when you are away from work," 2) the participant used less reliever medication "on weekends, vacations, or other times when you are away from work," and 3) the participant reported a trigger that was a problem at work.

Occupational exposures were assessed through a series of closed- and open-ended questions that asked about the work environment, ventilation in the work area, and the participant's particular job activities, including use of "tools, chemicals, or other materials" and exposure to "dust, smoke, gas, or chemical fumes" on the job. The questions were asked by lay staff who had been trained by an industrial hygienist (IH), and the responses were then independently reviewed by industrial hygienists from Portland and NIOSH who were blinded to the work-relatedness questions. Each of the industrial hygienists assigned every participant a three-point irritant score, a three-point sensitizer score, and a three-point indoor air quality score. These were then subjectively combined by each IH to yield a single three-point summary IH-score for the participant, and these overall IH scores were then averaged across hygienists to arrive at a single,

summary IH-rating scored as "0" (little or no asthmagenic potential), "1" (possible asthmagenic potential), or "2" (clear asthmagenic potential). An independent series of closed-ended questions was also included to identify potential Reactive Airways Disease Syndrome (RADS) cases.

The overall assessment of whether the participant's asthma was work-related was determined by the joint distribution of the summary work-relatedness and IH-scores (see table 3 of appendix 2). This matrix conforms to that developed by Milton et al. (*Am J Industrial Med* 1998; 33:1-10). Participants classified as having moderate to strong evidence of work-related asthma were considered to have work-related asthma.

The average interview lasted about 32 minutes, and all participants provided verbal consent before beginning. Our protocol included up to five separate attempts to contact participants. Respondents were not offered any monetary incentive in return for their participation.

Statistical methods

Incidence rates, expressed as number of incident cases per 10,000 person-years, were calculated as the total number of incident cases identified during the 12-month surveillance period divided by the total number of person-years of eligibility (sum of the at-risk populations for each month divided by 12) times 10,000. The same approach was used to calculate both overall incidence rates and subgroup-specific rates. Statistical analysis of the incidence data, including calculation of confidence intervals and comparisons of rates across subgroups, was conducted using Poisson regression analysis.

4. Summary of Results to Date

The overall rate of occurrence of new or recurrent asthma in this population was 41 per 10,000 person-years of observation. Rates were consistently higher for women than for men in each of four 10-year age groups, and no significant trend was observed with age (table 4, appendix 2). We completed questionnaires on 352 (47%) of the 828 incident cases (table 5, appendix 2).

Table 6 (appendix 2) shows the proportion of incident asthma cases that appear to be associated with workplace exposures using the Milton matrix. Overall, we estimate that 30% of all of the cases were work-related. This figure was consistently greater for men than for women (overall 40% for men and 26% for women). Using these figures, we project an overall incidence rate for work-related asthma of 12 per 10,000 person-years of observation and for non-work-related asthma of 29 per 10,000 person-years of observation (table 8a, appendix 2).

A manuscript in progress will discuss patterns of asthma by various occupation and industry groups. Preliminary data on the frequency distribution for incident asthma, subdivided into work-related and non work-related asthma for various groups of industries is shown in Table 1. Further, a trained Occupational Medicine Physician reviewed a small sample of cases (N=28) to determine how well the algorithm that combined the IH review and questionnaire performed. .

Table 1: Industry Code by Presence of Work-Related Asthma			
Industry Code, Job #1	Positive for occupational asthma		
Frequency Row Pct	No	Yes	Total
Not Employed	86 100%	0 0%	86
100-851:Ag,Forestry,Fishing	0 0%	2 100%	2
1500-1799:Construction	6 60%	4 40%	10
2200-3999:Manufacturing	13 42%	18 58%	31
4000-4899:Transportation	7 46.67	8 53.33	15
4900-4999:Electric,Gas,Sanitation	5 63%	3 37%	8
5000-5999:Wholesale & Retail	26 70%	11 30%	37
6000-6799:Finance,Insurance,RealEstate	17 85%	3 15%	20
70-79,84-89:Other Services	23 59%7	16 41%	39
8000-8099:Health Services	10 37%	17 63%	27
8200-8299:Educational Services	26 68%	12 32%	38
8300-8399:Social Services	5 31%	11 69%	16
9100-9799:Public Administration	13 57%	10 43%	23
Total	237	115	352

We also conducted a sensitivity analysis to determine the impact of minor changes to the Milton algorithm for defining work-relatedness. As shown in Table 7a (appendix 2), these figures may be subject to considerable misclassification error. For example, almost half of the individuals classified as having work-related asthma scored as a "1" on both the IH- and work-relatedness scales, which is the weakest of the "positive" combinations. If even half of these individuals were misclassified, the proportion of individuals classified as having work-related asthma would drop from 30% to 23%, and if we were to have classified this whole category as "weak" instead of "moderate" evidence, this figure would be reduced further to 16%. We suspect that these lower figures may be more accurate, because one of the categories of the work-relatedness scale seems to lack specificity. For example, while only 12% of participants reported that their

symptoms were better away from work and only 7% reported using their reliever medications less when they were away from work, 55% reported a work-related trigger. Furthermore, most of these latter individuals also reported that their trigger was also a problem away from work. When we recomputed the work-relatedness score, counting work triggers as positive only if they were a problem at work, the number of work-related cases dropped considerably (Table 7b, appendix 2), so that our estimate of the proportion of asthma that was work-related was reduced from 30% to 8.5%. Tables 8a and b (appendix 2) presents age and gender specific estimates of work- and non-work-related asthma using both the original Milton definition and the revised classification shown in Table 7b.

We worked with KPNW clinical staff to develop and implement a program that would increase the number of providers who discuss work-place exposure with their asthma patients. Specifically, we planned a drop-down screen on the electronic chart entry form such that when a provider (physician, nurse practitioner, or medical assistant) would check asthma as a condition for which the patients was being evaluated, there would have been a drop-down screen asking the provider if s/he had asked the patient if their asthma was related to their work. Initially there was positive interest in moving this forward, but subsequently there was a change that indicated that no such additions to the computer screens would take place. About 18 months into the project, it became clear that this objective would not be met.

5. Summary of Ongoing Work

As an ancillary objective to the study, we have geo-coded the addresses for all incident cases and randomly selected an incident-free at-risk comparison group. We hope to work with ATSDR staff to map these data against their point source pollutant database to determine if there exists an association between proximity to a hazardous waste site and the occurrence of asthma.

6. Publications and Presentations

Dr. Vollmer presented a poster summarizing the main outcomes of the study at the May 2001 meetings of the American Thoracic Society in San Francisco. The abstract was published in the American Journal of Respiratory and Critical Care Medicine. In addition, a manuscript has been submitted for publication (appendix 1), one will be submitted in January 2002 (appendix 2), and two others are in preparation.

Published abstract

"Incidence of Occupational Asthma (OA) in an Adult Managed Care Population" Vollmer, WM, O'Connor EA, Heumann MA, Breen VA, Villnave JM, Frazier EA, Buist AS, Henneberger, PK *Amer J Respir and Crit Care Med* 2001; 163 (5) A161

Submitted manuscript

"Electronic Surveillance of Asthma: Using Electronic Billing and Clinical Databases to Identify Prevalent Asthma" Elizabeth A. O'Connor, PhD, William M. Vollmer, PhD, Michael Heumann, MPH, E. Ann Frazier, PhD, Victor R. Breen, MD, Jacqueline Villnave, MHS CIH, A. Sonia Buist, MD (Appendix 1).

Manuscript to be submitted January 2002

"Incidence of Work-Related Asthma in a Health Maintenance Organization" (main outcomes paper) William M. Vollmer, Michael Heumann, Victor Breen, Elizabeth O'Connor, Jacqueline Villnave, E. Ann Frazier, A. Sonia Buist
(Appendix 2).

Occupational Asthma Surveillance Project
Grant #U60/CCU916057-03

Final Report
December 2001

Appendix 1

Electronic Surveillance of Asthma: Using Electronic Billing and Clinical Databases to Identify Prevalent Asthma

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Abstract

Electronic Surveillance of Asthma: Using Electronic Billing and Clinical Databases to Identify Prevalent Asthma

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As part of a National Institute for Occupational Safety and Health-funded study of the incidence of occupational asthma, the electronic databases of a large health maintenance organization were used to develop a computerized algorithm for defining prevalent asthma. The predictive values of eight distinct utilization profiles were validated by chart review to establish the final algorithm. Using a 12-month window for analysis, we estimated a prevalence of 4.1% among members aged 15-55, with the pharmacy and outpatient care databases accounting for 61% and 66% of this total, respectively. By extending the search of the outpatient care database, the estimated prevalence increased to 5.3%, with 81% of these accounted for by the outpatient care database. This analysis illustrates that electronic clinical information systems that provide disease-specific diagnostic data for outpatient visits, coupled with electronic pharmacy records, provide a powerful and accurate tool to study asthma-related health care utilization and for population-based disease management. [153 words]

Running title: Electronic surveillance of asthma
Keywords: asthma, surveillance, electronic medical records, epidemiology, prevalence

1. Introduction

Interest in population-based asthma management, particularly on the part of managed care organizations in the U.S., is growing. This interest has been kindled both by the increasing prevalence of asthma and by the recognition that asthma is a chronic condition that, for many, requires ongoing daily controller medication to maintain good disease control [1]. Despite the existence of national treatment guidelines [1], many patients with asthma continue to be under-treated and are therefore at greater risk for acute exacerbations that result in reduced quality of life, missed work or school, and expensive health care utilization (HCU) [2-4].

Central to the disease management process is the development of some form of asthma registry, ideally containing information on all members with asthma along with some indication of disease severity and current level of control [2]. The member information enables accurate tracking of the impact of disease management efforts, while the indication of severity and control enables medical providers to intervene most intensively with those most in need of help.

Implementation of such registries has historically been hampered by the lack of administrative databases containing diagnostic-specific encounter data. Medication databases are highly sensitive for asthma, but lack specificity, particularly if one is interested in developing a comprehensive registry [5]. Increasingly, however, large managed care organizations are adopting clinical information systems that provide diagnostic-specific outpatient utilization data. These databases offer great promise for the development of disease registries. As part of a National Institute for Occupational Safety and Health (NIOSH)-funded study to explore the incidence of occupational asthma, we used the computerized databases of a large health maintenance organization to develop a computerized algorithm for defining prevalent asthma and validated it against chart review. This paper summarizes our methodology, discusses operational difficulties, and summarizes data on asthma prevalence for the health plan.

2. Methods

2.1 Research Setting and Target Population

Kaiser Permanente Northwest Division (KPNW) is a large, group-model health maintenance organization centered in Portland, Oregon. KPNW provides comprehensive, prepaid health care service, including access to inpatient, outpatient, and emergency department (ED) services, to its approximately 430,000 members. The demographic and socioeconomic characteristics of its members correspond closely to those of the area population as a whole [6], and no evidence exists of a systematic selection of healthy individuals either into or out of the system [7]. Our analysis focused on the approximately 235,000 members who were aged 15-55 as of January 1, 1999, and who had continuous health plan eligibility from July 1998 through January 1999.

2.2 Data Systems

The health care utilization data used for this analysis were derived from a number of large administrative and clinical databases maintained by KPNW and briefly summarized below.

2.2.1 Inpatient Database

Both KPNW and its alliance hospitals use an automated inpatient scheduling system that serves as the basis for the discharge abstract. Primary and secondary discharge diagnoses are coded using the International Classification of Diseases, 9th revision (ICD-9) coding system.

2.2.2 Emergency Department Database

Data for emergency department and KPNW's hospital-based urgent care clinics are recorded in the ED database. Visits were categorized as either emergency or urgent care depending on the department of the staff member who saw the patient. We excluded "visits" for which the patient was triaged out of the emergency/urgent care center and aborted visits for which the patient was classified as "not seen" (e.g., the patient left against medical advice before being seen). Reason for visit is not entered as an ICD-9 code in this database, but instead is captured in an open text field. We used a previously developed search string that appears to work well for detecting asthma.

2.2.3 EpicCare (EPIC) Database

EPIC is KPNW's automated outpatient clinical information system. This computerized medical record database includes information on all clinic-based outpatient contacts, including telephone consults, occurring within KPNW. Diagnoses (coded using ICD-9) are determined by the provider by choosing from a predefined list, directly entering the ICD-9 code, or pattern matching text. Because EPIC does not distinguish between primary and secondary diagnoses, we considered all contacts with an asthma diagnosis in any of the first 10 diagnosis fields to be asthma visits. We excluded records (such as physician orders or chart notes made in the absence of a visit) that did not reflect "visits" in the usual sense of the term, although we did include telephone consults.

2.2.4 Outside Claims Database (OSCAR)

OSCAR is KPNW's automated claims processing system for recording covered services (generally inpatient and ED care) provided by non-Kaiser Permanente providers on a fee-for-service basis or under capitation contracts. The database also captures claims for emergency department use and hospitalizations that occur for out-of-area, non-contract facilities. Because any given health care encounter may generate several OSCAR billing records, each with its own primary diagnosis, we classified an encounter as an asthma visit if asthma was listed as the primary diagnoses on any of the ten largest billing records. Because outside hospitalizations are also included in the inpatient database, we used OSCAR to capture only outside ED care, most of which is not included in the ED database.

2.2.5 The Outpatient Pharmacy System (TOPS)

The TOPS database records all prescriptions dispensed by KPNW's outpatient pharmacies. About 90 percent of all prescriptions written by KPNW physicians are filled at KPNW pharmacies, including those for members without a prepaid drug benefit.

2.3 Validation Study

In developing our prevalence algorithm, we initially considered six possible criteria that might be used in defining asthma (Table 1). The criteria were selected to identify a broad segment of the

asthmatic population, but not necessarily to capture those with very mild asthma who do not require regular health care visits for their asthma and who use only a handful of inhaled beta-agonists per year. As expected, outpatient contacts and medication-based criteria were by far the most commonly met. Overall, 4.1% of participants met at least one of the criteria, which fits within the commonly reported range of prevalence estimates [8-11].

Based on the joint frequency distribution of these criteria and our own *a priori* assumptions, we identified eight utilization profiles (Table 2) that we thought might have particularly good (or poor) predictive profiles and randomly selected 10 to 20 charts from each profile for chart review to confirm the diagnosis. Trained medical records technicians reviewed the charts for 1997 and 1998 without knowledge of which group patients belonged to, and scored the charts as exhibiting definite, possible, or unlikely evidence of asthma (Table 3). A physician (VB) reviewed the charts of all patients rated as having possible asthma, and made a clinical determination as to whether they should be in the definite or unlikely categories. In addition, the physician checked the validity of the other medical records determinations by reviewing 10 each of those rated as "definite" and "unlikely." Among these latter two groups, the physician found only two charts where he disagreed with the medical records technicians' coding: one where the evidence of asthma was several years ago (which the medical records technicians did not find because we instructed them to look back only two years), and one where the physician believed the chart diagnosis of asthma was incorrect.

2.4 Statistical Methods

We used logistic regression analysis to evaluate the influence of age and gender on the prevalence of asthma.

3. Results

Table 2 summarizes the results of the chart review process. Our *a priori* most-probable profile (#1), accounting for 46% of all possible asthma patients, provided excellent predictive value (PV), with 21/22 (95%) of the charts reviewed classified as definite asthma. The next most common profile (#2), a single non-urgent outpatient asthma visit in EPIC with no acute care contacts and at most three beta-agonist dispensings, had a 90% predictive value (17/19 charts classified as definite asthma). This profile accounted for an additional 24% of possible asthma patients. Nebulizer treatment in the context of an ED or urgent care visit, even in the absence of other indicators (profile #4), was highly predictive (PV=100%), although nebulizer treatment without other corroborating factors (profile #7) was not (PV=27%). ED or urgent care contacts without nebulizer treatment or other corroborating factors (profile #6), which accounted for 7% of all possible asthmatics, had a predictive value of 80%. Isolated asthma hospitalizations (profile #5), while having poor predictive value (50%), accounted for only 0.1% of all possible asthma patients.

Based on these results, we decided to exclude from our prevalence algorithm only profile #7 (outpatient nebulizer treatment order with no other evidence of asthma). The predictive value of the resulting algorithm, computed as a weighted average of the predictive values in Table 2, is thus estimated to be 89%. Because the predictive value of a single EPIC visit was good and because so many asthma cases were found by looking in EPIC, we decided to search back an additional year in EPIC to define prevalent asthma. We identified an additional 2,769 members and therefore decided to add the additional year of EPIC search to our algorithm. Table 4 summarizes the resulting algorithm in its simplest format.

Table 5 shows the prevalence estimates that resulted from this final algorithm. The overall prevalence of asthma in this population was 5.3%, and was higher in women than in men (odds ratio = 1.7, 95% confidence interval = 1.6, 1.8). This gender differential persisted in each age group and increased over time, with the odds ratio increasing from 1.3 for the 15-24 year olds to 2.0 for those aged 45-55.

As illustrated by this analysis, no single database provides a complete enumeration of people with current asthma. For instance, using the pharmacy data alone, we would have identified only 5,909 (47%) of the 12,492 individuals who met any of our criteria for current asthma. Similarly, using the EPIC database alone, we would have identified 10,145 (81%) of these individuals. Had we not gone back two years with the EPIC database to define prevalent cases, we would have identified only 9,723 individuals with prevalent asthma, for an overall prevalence of 4.1%, and the pharmacy and EPIC databases would have accounted for 61% and 66% of this total, respectively.

4. Discussion

The increasing use of diagnostic-specific clinical information systems by large managed care organizations is expanding the opportunities for conducting true population-based asthma health services research. Traditionally, epidemiology researchers have had to rely on pharmacy-based algorithms, or on questionnaire-based surveys (perhaps augmented by clinical evaluation). The former were limited by the lack of specificity of pharmacy-based algorithms for defining mild asthma, while the latter were costly and subject to selection bias. The combination of pharmacy records plus clinical information systems offers a feasible, cost-effective solution for epidemiologists and health services researchers wishing to study asthma, as well as for organizations interested in population-based disease management.

These information systems become especially valuable when they can be linked with accurate denominator data, as will typically be the case for many health maintenance organizations in the U.S. and for certain types of governmental health care systems. Such linkage permits the calculation of prevalence, incidence, and more generally, rates of various types of health care utilization [12].

This analysis illustrates both the need to use multiple databases for a complete enumeration of cases and the impact of lengthening the timeframe for searching. Had we limited our focus to one year for each database, for example, the pharmacy database alone would have identified only 61% of the prevalent asthma cases, and the EPIC database alone would have identified only 66% of the total asthma cases. By extending the search of EPIC records to two years, we identified an additional 2,769 individuals who had not met any of the other criteria, thus increasing our estimate of current prevalence from 4.1% to 5.3% and increasing the proportion of prevalent cases identified by EPIC to 81%. The pharmacy data are still needed, however, to find the less severe asthmatics who require only periodic medication refills to maintain good control. One could similarly increase the yield from the pharmacy database by extending that search further back in time or by using less stringent criteria (e.g., two or more beta-agonist dispensings rather than the criterion of four or more used here). The problem with extending a search back too far in time is that, while it increases the yield from any given database and thus may limit the need to use multiple databases, the resulting prevalence estimate begins to resemble cumulative lifetime prevalence rather than current prevalence.

Interestingly, the outpatient and pharmacy databases missed a number of individuals who appear to have asthma. Those missed consist primarily of those individuals who were seen only in the ED or urgent care setting, but who were not seen in the general outpatient clinics and who did not meet the medication criteria. We suspect it may include those individuals who use the ED or urgent care services as convenience care. A total of 7.7% of the asthmatics identified in Table 2 fell into this category (profiles 4 and 6). Nebulizer treatment in this setting appears to be a very good indicator of asthma, increasing our confirmed asthma estimate from 80% (profile 6) to 100% (profile 4). The decision to include these individuals in the definition of asthma represents a tradeoff between sensitivity and specificity. In this case we decided that the increased sensitivity outweighed the loss of specificity. However, given the extra work to deal with the outside claims database, it is arguable as to whether the additional work is worth the gain.

Our finding that a single outpatient visit without the medication criteria and without concomitant acute health care utilization is still highly predictive of asthma (Table 2, profile 2), while consistent with a previous analysis of this issue in this population [13], may not be universal. Other investigators should understand the limitations of their own databases before beginning any investigation such as this.

The prevalence estimates based on our algorithm, including the male-female differential, are generally consistent with what has been reported in the literature [8-10, 14], including previous estimates of self-reported prevalence of asthma in this population [11]. Our one-year treated prevalence estimate of 2.7% (i.e., based solely on EPIC data and for only one year, data not shown) is higher than the previously reported annual treated prevalence of 1.7% that was estimated for this population for the period 1985-87 among individuals aged 15-64, and presumably reflects a continuation of the upward trend in prevalence that was reported in the previous paper [15].

In summary, electronic clinical information systems that provide disease-specific diagnostic data for outpatient visits, when coupled with electronic pharmacy records, provide a powerful and accurate tool for the study of asthma-related health care utilization as well as for population-based disease management.

Table 1. Potential criteria for defining prevalent asthma

Description[1]	Frequency of Occurrence	
	N	% of population[2]
(≥1 dispensing of either an inhaled corticosteroid or of cromolyn) *and* (≥1 dispensing of β-agonist inhaler)	5,074	(2.2%)
≥ 4 dispensings of β-agonist inhalers	2,717	(1.2%)
≥1 non-urgent outpatient contact for asthma	6,431	(2.7%)
≥1 emergency department or urgent care visit for asthma	1,863	(0.8%)
≥1 inpatient stay with primary discharge diagnosis of asthma	122	(0.1%)
≥1 order for nebulizer treatment in the outpatient setting	539	(0.2%)
Any of above	9,723	(4.1%)

1 all criteria were evaluated relative to the past year and are not mutually exclusive

2 frequencies are calculated relative to the population of 234,768 individuals aged 15-55 and having seven months of continuous health plan eligibility

Table 2: Health care utilization profiles used for validation study and results of chart review

Profile[1]	Number of Members Fitting Profile	Percent with Asthma, based on Chart Review	Number of Charts Reviewed
1. Four "high-probable" categories: ⇒ Two or more non-urgent care outpatient contacts for asthma ⇒ A single non-urgent care outpatient contact plus one or more ED, urgent care, or inpatient contacts for asthma ⇒ Any Industrial Medicine visit for asthma ⇒ Any asthma visit coupled with a positive hit on either of the two medication dispensing criteria	4,460	95%	22
2. Single non-urgent outpatient visit only	2,334	90%	19
3. Four or more β-agonists, with or without a nebulizer treatment order, but no asthma visits of any kind and no ICS dispensings	545	70%	26
4. ED or urgent care visit for asthma and nebulizer treatment order, but no other medication criteria met and no other types of asthma visits	25	100%	13
5. Hospitalization for asthma, but neither asthma medication criterion met and no outpatient asthma visits of any kind	11	50%	10
6. ED or urgent care visit for asthma, but no other types of asthma visits and no asthma medication criteria met	721	80%	20
7. Nebulizer treatment but no asthma visits of any kind and no other medication criteria met	99	27%	22
8. All other cases	1,528	80%	21

1 all criteria were evaluated relative to the past year and are mutually exclusive

Table 3. Criteria used in medical records review for validation study[1]

Definite Asthma

- two or more asthma health care visits
- a single visit for asthma with a chart notation indicating a prior history of asthma
- a single health care visit for active symptoms of asthma
- a single visit for an asthma exacerbation that responds to therapy, even if no prior history

Possible Asthma

- patient-reported history of asthma noted in chart, but no evidence of active asthma or treatment for asthma
- an uncorroborated ED diagnosis of asthma
- diagnosis of "rule out asthma" with no clear resolution

[1] all criteria evaluated for the past two years

Table 4. Description of the final prevalence algorithm[1]

Health CareUse in Past Year

- acute care visit for asthma
  - emergency department
  - urgency care
  - hospitalization with primary discharge diagnosis of asthma

Health Care Use in Past Two Years

- outpatient visit for asthma

Medication Dispensing in Past Year

- ≥4 dispensings of beta-agonist inhalers
- (≥1 dispensings of either an inhaled corticosteroid or cromolyn) *and* (≥1 beta-agonist inhaler dispensing)

[1] must meet any of the above criteria

Table 5: Prevalence of Asthma among Adult Members of Kaiser Permanente Northwest Division, Aged 15-55

	Age group (years)				
	15-24	25-34	35-44	45-55	Total
(n)	(53,121)	(48,037)	(62,624)	(70,986)	(234,768)
Men	5.2%	3.5%	3.4%	3.7%	3.9%
Women	6.6%	5.8%	6.4%	7.3%	6.6%
Total	5.9%	4.7%	5.0%	5.6%	5.3%

Acknowledgements

This work was supported by contract #U60/CCU916057 from the National Institute for Occupational Safety and Health (NIOSH).

References

1. National Asthma Education and Prevention Program, National Heart, Lung, and Blood Institute, National Institutes of Health. Guidelines for the Diagnosis and Management of Asthma. NIH 97-4051, 1. Asthma Expert Panel Report 2. Bethesda(MD): National Institutes of Health; 1997.

2. Cockcroft DW, Swystun VA. Asthma control vs. asthma severity. J Allergy Clin Immunol 1996; 98(6, Part 1):1016-1018.

3. Dales RE, Kerr PE, Schweitzer I, Reesor K, Gougeon L, Dickinson G. Asthma management preceding an emergency department visit. Arch Intern Med 1992; 152(10):2041-2044.

4. Dales RE, Schweitzer I, Kerr P, Gougeon L, Rivington R, Draper J. Risk factors for recurrent emergency department visits for asthma. Thorax 1995; 50(5):520-524.

5. Osborne ML, Vollmer WM, Johnson RE, Buist AS. Use of an automated prescription database to identify individuals with asthma. J Clin Epidemiol 1995; 48(11):1393-1397.

6. Freeborn DK, Pope CR. Promise and performance in managed care. 1st ed. Baltimore (MD):The Johns Hopkins University Press; 1994.

7. McFarland BH, Freeborn DK, Mullooly JP, Pope CR. Utilization patterns and mortality of HMO enrollees. Med Care 1986; 24(3):200-208.

8. National Heart, Lung, and Blood Institute (NHLBI). Data Fact Sheet. 1-3. Bethesda (MD): US Department of Health and Human Services. 1992

9. Centers for Disease Control and Prevention (CDC). Surveillance for asthma - United States, 1960-1995. Morbidity and Mortality Weekly Report 47[SS-1], 1-28. 1998.

10. Burt CW, Knapp DE. Ambulatory care visits for asthma: United States, 1993-94. Adv Data 1996; 275(277):1.

11. Janson C, Chinn S, Jarvis D, Burney PGJ. Physician-diagnosed asthma and drug utilization in the European Community Respiratory Health Survey. Eur Respir J 1997; 10(8):1795-1802.

12. Vollmer WM, Osborne ML, Buist AS. Uses and limitations of mortality and health care utilization statistics in asthma research. Am J Respir Crit Care Med 1994; 149(2 part 2):s79-s87.

13. Osborne ML, Vollmer WM, Buist AS. Diagnostic accuracy of asthma within a health maintenance organization. J Clin Epidemiol 1992; 45(4):403-411.

14. Dodge R, Burrows B. The prevalence and incidence of asthma and asthma-like symptoms in a general population sample. Am Rev Respir Dis 1980; 122(4):567-575.

15. Vollmer WM, Osborne ML, Buist AS. 20-year trends in the prevalence of asthma and chronic airflow obstruction in an HMO. Am J Respir Crit Care Med 1998; 157(4 Pt 1):1079-1084.

Occupational Asthma Surveillance Project
Grant #U60/CCU916057-03

Final Report
December 2001

Appendix 2

Incidence of Work-Related Asthma in a Health Maintenance Organization

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Key Words:

Word Count:

Supported by contract #U60/CCU916057 from the National Institute for Occupational Safety and Health (NIOSH)

Abstract (to be revised before submission)

Accurate information on the incidence of adult onset asthma and the role of occupation in asthma's development is limited. Although estimates of the magnitude of this problem are available from the Sentinel Event Notification System for Occupational Risks (SENSOR), they appear to underestimate the actual number of diagnosed cases. Recent reports suggest that the actual incidence of occupational asthma (OA) may be as much as 16 times greater than that estimated by the SENSOR data. As part of a NIOSH-funded study, we are investigating the burden of OA among the approximately 254,000 members aged 15-55 of the Northwest Region of the Kaiser Permanente (KPNW) health maintenance organization. Using a validated algorithm, each month during 2000 we reviewed KPNW's electronic inpatient, emergency department, and medication dispensing databases for the previous 12 months, and the outpatient databases for the previous two years to exclude members with evidence of prevalent asthma. From the remaining pool, we identified evidence of new or recurrent asthma, defined as people with both health care visits for asthma and orders for, or dispensings of, asthma medication. All cases so identified were confirmed by review of their medical record and contacted to complete a detailed telephone survey covering workplace exposures, symptoms, and home environment. The occupational data were reviewed by a minimum of two industrial hygienists to rate the potential asthmagenicity of the work environment. On the basis of these ratings and self-reported work-relatedness of asthma symptoms, incident cases were further classified as being occupationally related or not. We identified 829 confirmed cases of incident or recurrent asthma, corresponding to a rate of 41/10,000 members. To date we have attempted to reach all of these individuals and have completed questionnaires on 350 (46%) of them. Twenty-three percent were classified as having occupationally related asthma, suggesting an overall OA incidence/recurrence rate of 10/100,000.

Introduction

Estimates of the proportion of asthma that is work-related have varied from 2-36%, although most studies report figures in the range of 5-15%.[1-3] (Mannino,Occup Med, 2000, 15:359-368; Toren K, Scand J Work Environ Health, 1999, 25:558-563; Blanc, Chest, 1996, 110:3-4) Reasons for these differences relate both to disagreements about what is meant by occupational asthma, as well as by limitations in the methodologies used to assess it.[1,3] (Blanc, 1996; Mannino, 2000; Nordman H, Karjalainen A, Keskinen H. Incidence of occupational asthma: a comparison by reporting systems. Am J Ind Med 1999;Suppl 1: 130-133).

The U.S. Centers for Disease Control and Prevention's National Institute for Occupational Safety & Health (NIOSH) recently published guidelines for the surveillance of work-related asthma (WRA) that recognize two distinct subclasses: new-onset asthma and work-aggravated asthma (Jajosky et al, MMWR (CDC Surveillance Summaries), 1999, 48:1-20 ...this is ref 22 from Mannino 2000 article). These guidelines are followed by the four states that participate in NIOSH supported surveillance for WRA as part of the Sentinel Event Notification Systems for Occupational Risks (SENSOR). New-onset WRA results from exposure to either a sensitizer or an irritant. The former may not manifest itself until after many years of exposure to the sensitizing agent, while the latter typically occurs within 24 hours of a high-level exposure and is known as Reactive Airways Dysfunction Syndrome, or RADS. Also, some irritant-induced asthma occurs after repeated, low-level exposure and does not have the sudden onset characteristic of RADS (Brooks SM, Hammad Y, Richards I, Giovinco-Barbas J, Jenkins K. The spectrum of irritant-induced asthma: sudden and not-so-sudden onset and the role of allergy. Chest 1998;113:42-49). Based on definitions used by the SENSOR states, the risk pool for new-onset WRA is composed of those individuals who either have never had asthma or who have had asthma in the past but have neither experienced asthma symptoms nor been treated with asthma medications for two years prior to entering a new job. The risk pool for work-aggravated asthma is composed of those individuals who have had symptoms of, and/or medication for, asthma in the two years before starting a new job. Work-aggravated asthma occurs when exposures in the workplace cause an increase in asthma symptoms or an increased use of asthma medications among people with currently or recently active asthma. The term occupational asthma, as used in the literature, typically equates with new-onset asthma as described above[4,5] (Mapp, chapter 12 in Eur Respir Mon,1999, 11:255-285; Chan-Yeung & Malo, NEJM, 1995, 333:107-112), although some authors adopt the narrower perspective that it refers only to sensitizer induced new-onset asthma[6,7] (Chan-Yeung, 1990, 98:148S-161S), while still others use it to refer to all work-related asthma (Toren et al, Respir Med, 2000, 94:529-535). In this paper we take the latter perspective, using occupational asthma and work-related asthma interchangably, since we believe that this broader rubric best reflects the burden of occupation on asthma morbidity.

Although much has been published about occupational asthma, relatively little population-based information is available. One oft-cited example of the latter is Blanc's 1987 analysis of data from the U.S. Social Security Administration's Survey of Disability and Work,[8] (Blanc, Chest, 1987, 92:613-617) in which he noted that 15.4% of the 468 respondents who reported having asthma also indicated that "this condition [was] caused by bad working conditions, such as noise, heat, or smoke." Aside from the potential bias of having used a disability claims sample, the question used to assess the work-relatedness of the asthma has been criticized as being potentially leading and thus resulting in an overestimate.[9] (Siracusa et al, Amer J Ind Med, 1995,

28:411-423 Although NIOSH has published criteria for operationalizing its definition of work-related asthma,[11] (Matte et al, Chest, 1990, 98:173S-178S) their utilitiy is somewhat limited from an epidemiologic perspective since information to establish the lung function criteria are typically lacking from most medical records and since it may be difficult on interview to establish a temporal link with a known sensitizing agent in the workplace.

Estimates from national, provincial, and state-based surveillance programs provide information not only on the proportion of asthma that is attributable to occupation, but also on the incidence of occupational asthma in the general working (or in some cases working-age) population. These estimates cover a range of values. In the United Kingdom during 1992-1997, the estimated average annual incidence of occupational asthma was 38 cases/10^6, although rates by region were as high as 65 cases/10^6 in the West Midlands and as low as 21 cases/10^6 in the south east (McDonald JC, Keynes HL, Meredith SK. Reported incidence of occupational asthma in the United Kingdom, 1989-1997. Occup Environ Med 2000;57:823-829.) Rates in Canada cover a range of values depending on province and time period, from 25 cases/10^6 in Quebec during 1986-1988 (Meredith and Nordman, Thorax, 1996) to 92 cases/10^6 in British Columbia in 1991 (Contreras GR, Rousseau R, Chan-Yeung M. Occupational respiratory diseases in British Columbia, Canada, in 1991. Occup Environ Med 1994;51:710-712.). Investigations in Sweden during 1990-1992 estimated an incidence of 80 cases/10^6 (Toren K. Self-reported rate of occupational asthma in Sweden 1990-92. Occup Environ Med 1996;53:757-761). Rates in Finland tend to be some of the highest in the world, with values from 140 cases/10^6 during 1988-1992 (Meredith and Nordman, 1996) to 191 cases/10^6 in 1993 (Reijula K, Haahtela T, Klaukka T, Rantanen J. Incidence of occupational asthma and persistent asthma in young adults has increased in Finland. Chest 1996;110:58-61.)

From the state-based SENSOR surveillance programs for occupational asthma in the United States, rates have ranged from a low of 5 cases/10^6 in Massachusetts during 1988-1992 (NIOSH. Work-related lung disease surveillance report 1994. Morgantown, WV: US Dept of Health and Human Services (NIOSH) Publication No. 94-120, 1994) to a high of 37 cases/10^6 in Michigan during 1993-1994 (Rosenman KD, Reilly JM, Kalinowski DJ. A state-based surveillance system for work-related asthma. J Occup Environ Med 1997;39:415-425.) It is important to remember that the primary goal of SENSOR is to locate and improve hazardous workplaces, and the incidence figures based on SENSOR data are assumed to be underestimates (Jajosky et al, 1999). When capture-recapture analysis was applied to data from the Michigan SENSOR program during 1988-1995, it was estimated that the incidence of work-related asthma was probably in the range 58 to 204 cases/10^6 (Henneberger PK, Kreiss K, Rosenman KD, Reilly MJ, Chang YF, Geidenberger CA. An evaluation of the incidence of work-related asthma in the United States. Int J Occup Environ Health 1999;5:1-8.). These values were, respectively, 2.1 and 7.6 times the observed incidence of 27 cases/10^6. The results of the capture-recapture analysis are indirect estimates of the true incidence of work-related asthma, and population-based studies with aggressive case ascertainment are needed to provide direct estimates of the full extent of this problem.

A recent study by Milton and colleagues provided a model for attaining a direct estimate of incidence. The investigators conducted a 3-month prospective evaluation of 79,204 health maintenance organization members, aged 15-55, who were at-risk for asthma and estimated that 21.5% of 66 incident asthma cases were work-related.[12] (Milton et al, Amer J Indus Med, 1998,

33:1-10) This study is of particular interest since it was population-based; used electronic medical records information, confirmed by chart review; and used a detailed interview, coupled with industrial hygiene evaluation, in an attempt to assess both the work relatedness of symptoms and the asthmagenicity of the work environment. The protocol thereby attempts to address, in a reasonably rigorous manner, all three dimensions of the NIOSH definition. As part of a NIOSH-funded study of the incidence of work-related asthma, we adapted the Milton protocol to evaluate all new cases of asthma (including true incident cases as well as recurrence of pre-existing asthma) occurring over a one-year period among the approximately 235,000 working-aged members of a large health maintenance organization located in the Northwest United States.

Methods

This study, which received formal IRB approval, was conducted in parallel with investigators from Harvard University as part of a joint award by NIOSH. Investigators from the two institutions used similar, although not identical, protocols to assure maximum comparability of the final results. In particular, the surveillance algorithm and the telephone survey instrument were developed collaboratively and were patterned after a similar protocol used by Milton et al. in their 1998 study that effectively served as a pilot for the current work.[12] (Milton et al, 1998)

Research Setting and Target Population

Kaiser Permanente, Northwest Division (KPNW), is a large group-model health maintenance organization centered in Portland, Oregon. KPNW provides comprehensive, prepaid health care service, including access to inpatient, outpatient, emergency department, and occupational medicine services, to its approximately 430,000 members. The demographic and socioeconomic characteristics of its members correspond closely to those of the area population as a whole[13] (Freeborn DK, Pope CR. Promise and performance in managed care. 1st ed. Baltimore (MD):The Johns Hopkins University Press; 1994.), and no evidence exists of a systematic selection of healthy individuals either into or out of the system[14] (McFarland BH, Freeborn DK, Mullooly JP, Pope CR. Utilization patterns and mortality of HMO enrollees. Med Care 1986; 24(3):200-208.). Our analysis focused on the approximately 235,000 members aged 15-55.

The vast majority of KPNW members receive coverage through their work, or else are included as part of a household member's work-related coverage. Among the 50 largest employer groups contracting with KPNW are Intel, Oregon-Washington carpenters, the Teamsters, Tektronix, Longview Fibre Company, Precision Castparts, Reynolds Metal, Hewlett Packard, Mitsubishi Silicon America, Boeing, and Oregon Steel Mills, all of which belong to industries with known exposures to potential exposures related to occupational asthma, such as wood products, aluminum, electronics, and steel manufacturing.

Data Systems

The health care utilization data used for this analysis were derived from a number of large administrative and clinical databases maintained by KPNW and briefly summarized below.

Inpatient Database. Both KPNW and its allied hospitals use an automated inpatient scheduling system that serves as the basis for the discharge abstract. Primary and secondary discharge

diagnoses are coded using the International Classification of Diseases, 9th revision (ICD-9) coding system.

Emergency Department Database. Data for ED care are recorded in a separate database from that used for inpatient care. Reason for visit is not entered as an ICD-9 code, but instead is captured in an open text field. We used a previously developed search string that appears to work well for detecting asthma.

EpicCare (EPIC) Database. EPIC is KPNW's automated outpatient clinical information system. This computerized medical record database includes information on all clinic-based outpatient contacts, including telephone consults, occurring within KPNW. Diagnoses (coded using ICD-9) are determined by the provider by choosing from a predefined list, directly entering the ICD-9 code, or pattern matching text. Because EPIC does not distinguish between primary and secondary diagnoses, we considered all contacts with an asthma diagnosis in any of the first 10 diagnosis fields to be asthma visits. We excluded records (such as physician orders or chart notes made in the absence of a visit) that do not reflect "visits" in the usual sense of the term. Telephone consults were included for purposes of excluding prevalent cases of asthma, but not for the incidence algorithm.

Claims Database (OSCAR). OSCAR is KPNW's automated claims processing system for recording covered services (generally inpatient and ED care) provided by non-KP facilities. Any given health care encounter may generate several OSCAR billing records, each with its own primary diagnosis, so we classified an encounter as an asthma visit if asthma was listed as the primary diagnoses on any of the ten largest billings. Because outside hospitalizations are also included in the inpatient database, we only used OSCAR to capture outside ED care.

The Outpatient Pharmacy System (TOPS). The TOPS database records all prescriptions dispensed by KPNW's outpatient pharmacies. About 90 percent of all prescriptions written by KPNW physicians are filled at KPNW pharmacies, including those for members without a prepaid drug benefit.

Surveillance algorithm

Our surveillance algorithm was divided into two stages. Initially we identified the at-risk population by identifying and excluding individuals with prevalent asthma as well as individuals with other conditions whose diagnosis may be confounded with asthma. Table 1 summarizes the algorithm for defining at-risk members. Further details surrounding the predictive value of our prevalence algorithm have been published elsewhere.(O'Connor et al., submitted)

Once the at-risk population was identified, we used the algorithm in Table 2 to select potential incident cases. The algorithm captures only those individuals who present with an exacerbation of asthma severe enough to trigger a medication dispensing. However, because we wanted to exclude "rule-out" diagnoses, we required something more than just a single dispensing of a beta-agonist inhaler to fulfill the medication requirement. While we realize that the resulting algorithm may exclude some truly incident cases, it should also (appropriately) exclude some individuals with mild, intermittent asthma who were incorrectly included in the at-risk pool.

As is clear from tables 1 and 2, our algorithm attempts to exclude from the at-risk population those individuals with active asthma who require ongoing health care. It does not, however, exclude those with very mild asthma who have no outpatient care in the past two years and only minimal beta-agonist use, nor does it exclude those with old asthma that is no longer active. In this sense ours is a study of asthma incidence and recurrence, rather than true incidence alone. In order to assure that all participants were defined comparably, we divided our year-long surveillance period into twelve monthly periods and applied the algorithm independently to each monthly interval.

Case Validation

All potentially incident cases identified in this manner were then independently verified by medical record review by a trained medical records technician to confirm both the diagnosis and the incident nature of the encounter.

Assessment of Workplace Exposures and Work-Relatedness of Symptoms & Triggers

We next attempted to contact by phone all individuals with chart-confirmed incident asthma in order to assess the work-relatedness of symptoms and triggers and to gather information about potential workplace exposures. The former was assessed on a four-point scale (0-3) that counts whether: 1) the participant's chest symptoms or breathing troubles got better "on weekends, vacations, or other times when you are away from work," 2) the participant used less reliever medication "on weekends, vacations, or other times when you are away from work," and 3) the participant reported a trigger that was a problem at work. We attempted to ask questions in a neutral manner (e.g., do your chest symptoms change on weekends, vacations, ..., and if so, do they get better or worse away from work?), and information about triggers was assessed through both closed- and open-ended questions.

Occupational exposures were assessed through a series of closed- and open-ended questions that asked about the work environment, ventilation in the work area, and the participant's particular job activities, including use of "tools, chemicals, or other materials" and exposure to "dust, smoke, gas, or chemical fumes" on the job. The questions were asked by lay staff who had been trained by an industrial hygienist (IH), and the responses were then independently reviewed by industrial hygienists from Portland and NIOSH who were blinded to the work-relatedness questions. Each of the industrial hygienists assigned every participant a three-point irritant score and a three-point sensitizer score, which were then averaged across hygienists and combined to yield a single three-point summary IH-rating scored as "0" (little or no asthmagenic potential), "1" (possible asthmagenic potential), or "2" (clear asthmagenic potential). An independent series of closed-ended questions was also included to identify potential RADS cases.

The overall assessment of whether the participant's asthma was work-related was determined by the joint distribution of the summary work-relatedness and IH-scores as illustrated in Table 3. Participants classified as having moderate to strong evidence of work-related asthma were considered to have work-related asthma. We also defined as work-related asthma any cases of RADS that were associated with workplace exposures and occurred within 60 days of the index appointment.

The average interview lasted about 32 minutes, and all participants provided verbal consent before beginning the interview. Our protocol included up to five separate attempts to contact participants. These were conducted on different days and at varying times.

Statistical Methods

Incidence rates, expressed as number of incident cases per 10,000 person-years, were calculated as the total number of incident cases identified during the 12-month surveillance period divided by the total number of person-years of eligibility (sum of the at-risk populations for each month divided by 12) times 10,000. The same approach was used to calculate both overall incidence rates and subgroup-specific rates. Statistical analysis of the incidence data, including calculation of confidence intervals and comparisons of rates across subgroups, was conducted using Poisson regression analysis.

Results

Across the twelve-month surveillance interval we identified 855 suspected cases of new or recurrent asthma out of a total of 203,701 person-years (2,444,413 person-months) of observation. Of these, 828 (97%) were validated based on chart review. Thus, the overall rate of occurrence of new or recurrent asthma in this population was 41 per 10,000 person-years of observation. Table 4 summarizes the figures by gender and age. Rates were consistently higher for women than for men in each age group, and we observed no significant gender by age.

Table 5 summarizes the response rates to our telephone screening. We successfully interviewed 47% of the validated cases. The primary reason for non-response was our inability to reach a live person (as opposed to a recorded voice or no answer). In the 548 cases where we actually were able to reach someone, 387 (71%) agreed to the interview. Interestingly, 35 of these latter individuals denied having had a recent visit for breathing problems, despite our having documented evidence of such a visit. We truncated the interview in these instances, so that the remainder of this analysis focuses on the 352 individuals who acknowledged having breathing difficulties and completed the full telephone interview. Of these, 75 [21%, 95% confidence interval = (17%, 26%)] reported onset of symptoms within the past year, and thus presumably represent true incident asthma, as opposed to an exacerbation of pre-existing asthma. These results suggest that the true rate of occurrence of incident asthma in this population was 9 per 10,000 person years of observation. Compared with participants who completed the interview, non-respondents were slightly younger (36 vs. 38 years, p=.01) and were more likely to be male (43% vs. 28%, p<.001).

Table 6 shows the proportion of incident cases whose asthma we classified as being work-related. The data are expressed relative to the entire population, and not just to those who had jobs. Overall, we estimate that 30% [95% confidence interval = (25%, 35%)] of the asthma in this population is work-related, with estimates consistently (and significantly) higher for men than for women. These figures may be subject to considerable misclassification error, however. For example, almost half of the individuals classified as having work-related asthma were scored as a "1" on both the IH- and work-relatedness scales, the weakest of the "positive" combinations (table 7). If even half of these individuals were misclassified, the proportion of individuals classified as having work-related asthma would drop from 30% to 23%, and if we were to have

classified this whole category as "weak" instead of "moderate" evidence, this figure would be reduced further to 16%. We suspect that these lower figures may be more accurate, because one of the categories of the work-relatedness scale seems to lack specificity. For example, while only 12% of participants reported that their symptoms were better away from work and only 7% reported using their reliever medications less when they were away from work, 55% reported a work-related trigger. These latter individuals comprise xx% of those with a work-relatedness score of 1. Furthermore, most of the individuals who reported a work-related trigger also reported that their trigger was also a problem away from work. If we recomputed the work-relatedness score counting work triggers as positive only if they were a problem only at work, the proportion of asthma that was work-related was reduced to 8.5%. While this figure almost certainly reflects an overly conservative estimate, these calculations illustrate the sensitivity of the estimates in table 6 to even relatively modest changes to our classification algorithm.

Finally, table 8 combines the information from tables 4 and 6 to estimate the rates of occurrence of both work-related and non-work-related asthma in this population. Overall, we estimated the incidence of work-related asthma to be 12 per 10,000 person-years of observation. This figure tended to increase with age, particularly among women. The incidence of non-work-related asthma varied little by age and was consistently higher for women than for men.

Discussion

This population-based survey of the incidence and recurrence of work-related asthma in a young adult population estimated a higher contribution of occupation to adult onset asthma than has typically been reported, and at the same time illustrates the widely reported difficulties in the assessment of work-related asthma in field trials. We estimated that 30% of new-onset or recurrent asthma in the age range 15-55 years may be work related, with an "incidence" of work-related asthma in this age range of xx per 10,000 person-years of observation. . About 21% of this appears to represent new onset asthma, with the remaining 79% representing the recurrence of pre-existing asthma. A sensitivity analysis suggests that the figure of 30% work-related asthma may be fairly sensitive to relatively minor changes in the classification algorithm.

This study has several strengths. It was population-based. It made use of automated medical records information, available on all health plan members, both to exclude prevalent cases of asthma and to identify new/recurrent cases. It used IH review of detailed information about the workplace and work exposures, rather than simply the participant's industry and occupation, to classify the asthmagenicity of the work environment. It combined this information with self-reported work-relatedness of symptoms, medication use, and asthma triggers (all part of the NIOSH criteria for work-relatedness of asthma) to arrive at a final classification of whether a participant's asthma was work-related. In addition, because most individuals were interviewed within a few months of diagnosis, their recall of work tasks and exposures around the time of the diagnosis should have been reasonably accurate.

The study also has several potential limitations. First, while we are reasonably confident of our ability to identify prevalent asthma (O'Connor et al., submitted), we are less confident of our ability to identify incident asthma because, by definition, it represents an initial diagnosis for which there are typically not subsequent encounters to further validate the diagnosis. For this reason we used reasonably strict criteria to exclude likely "rule out" diagnoses (Table 2) and also

had a medical records technician review each suspected incident case. Nonetheless, 9% of those interviewed denied having had a recent health care visit for breathing problems. Second, while our IH assessment should represent a considerable improvement over traditional epidemiologic approaches, it clearly is no substitute for a detailed industrial hygiene investigation of the workplace, which is the "gold standard" for determining whether someone is exposed to an asthmagenic agent at work. In particular our raters, although centrally trained in the study protocol, often disagreed on their ratings of the asthmagenic potential of the workplace. Absolute agreement among the raters for the sensitizer and irritant ratings were 56% and 72%, respectively, and the weighted kappas were only .36 and .44. Third, our original work-relatedness score, as previously noted, may overestimate the presence of work-related triggers. Finally, we were able to complete full interviews on only 43% of those whom we attempted to reach. The remainder may differ systematically from those we did interview in terms of their work exposures. We do know that nonresponders were slightly younger on average, and were more likely to be male, than those who did respond.

Torén notes that estimates of the population attributable risk (PAR) associated with an exposure tend to vary according to one's definition of exposure, with narrow definitions being associated with lower PARs and broader definitions being associated with higher PARs[2] (ref Torén, Scand J Work Envir Hlth, 1999). We believe the algorithm we used, originally proposed by Milton et al.,[12] (Milton, 1998) represents a fairly rigorous attempt, from an epidemiologic perspective, to implement the case definition algorithm proposed by NIOSH[11] (Matte et al., 1990). It incorporates a careful IH review of the participant's work environment and information about the association of symptoms, medication use, and triggers with work. By contrast, some investigators have proposed job exposure matrices that essentially are based solely on one's occupation and industry;[15] (Kogevinas et al, AJRCCM, 1996, 154:137-143) on a combination of occupation, industry, and limited expert evaluation; (Kennedy et al., 2000) or on a single question asking whether the respondent believes his/her asthma is work-related.[8] (Blanc, Chest, 1987, 92:613-617) Such algorithms would seem to offer a much less precise occupational classification. At the other extreme, the surveillance systems used in Finland and Quebec use a very strict standard that includes clinical validation of the diagnosis[7,10] (Toren, Respiratory Med, 2000, 94:529-535; Meredith and Nordman, Thorax, 1996, 51:435-440). Regardless of the algorithm used, unless it adheres to accepted clinical norms it should not be used to attribute work-relatedness on an individual level. More accurately, such systems can be said to suggest the potential for work-relatedness.

This study also raises a number of interesting methodologic issues concerning the epidemiologic classification of work-related asthma. As noted previously, a strength of this algorithm is that it does attempt to implement all aspects of the NIOSH case definition algorithm. Had we used only the IH classifications, table 7 illustrates that 131 individuals (or 37% of the sample) would have been classified as having possible or clear asthmagenic exposures at work, and yet 32 of these individuals (24%) scored zero on the work-relatedness score and thus should have a very low likelihood of having work-related asthma. Even for the 60 individuals with an IH score of two, 15 (25%) still had a work-relatedness score of zero. Similarly, 51% of the 202 individuals with a non-zero work-relatedness score had an IH score of zero (50% for those with work-relatedness scores of 2 or 3). This suggests the likelihood that both systems used alone are subject to considerable misclassification, and that use of both together results in a substantially improved estimate. Even so, the fact that almost half of the suspected work-related cases fell

into the most marginal evidence category, the (1,1) cell in table 7, raises the likelihood that many of these individuals are still misclassified. Further studies comparing this algorithm against ratings based on a detailed clinical and workplace evaluation should be useful in identifying refinements to the algorithm that enhance its usability. Because of the time required to conduct the interviews, it would also be of interest to compare the IH scores using this methodology with those that would be obtained using more conventional systems based on job title and industry alone (with or without limited expert evaluation).

We also raised to possibility that the question about work-related triggers is nonspecific. While we think this is likely true, the alternative of requiring a trigger that is only present at work probably errs in the opposite direction. If someone is sensitized to an agent, we expect him to report responding to that same agent in more than one location, e.g., both at work and away from work. We cannot tell directly whether an individual's response to a particular agent occurred first at work or away from home. However, if someone has exposures at both home and work, it is usually the exposures at work that are considerably more intense and, therefore, are responsible for initiating the asthma. In a situation where we are not sure whether the same exposure at home or at work was the causative agent, the weight of evidence is typically on the side of the occupational exposure. For example, a person can grow up in contact with wheat and wheat products. Yet, as seen with studies of baker apprentices, it is not until they enter the workplace that they develop extreme allergies to wheat. In the same way, someone can have exposure to latex from balloons and the latex in their undergarments, but it is not until they enter a health profession and have repeated exposure to natural rubber latex gloves that they develop a latex asthma. Someone can grow up with pets, but it is not until they work as an animal handler that they develop asthma to animal dander. In each of these examples, the person being interviewed would report responding to the same agent at home and at work.

Finally, it is of interest to compare our findings with those of Milton et al.[12] (Milton, 1998), because we have essentially replicated their protocol on a larger scale and with a different population. Both studies report very similar estimates for the overall "incidence" of adult onset asthma (41 vs 37 per 10,000), although our estimate of new onset asthma (21%) was somewhat lower than the 35% figure reported by Milton. In terms of the proportion of asthma that is work-related, both studies are on the high side relative to what is typically reported in the literature (Milton et al. reported 21% versus our 30%, p-value = .20), although they are consistent with estimates from a recent study from Finland (29% for men and 17% for women). (Karjalainen A, Kurppa K, Martikainen R, Klaukka T, Karjalainen J. Work is related to a substantial portion of the adult-onset asthma incidence in the Finnish population. Am J Respir Crit Care Med 2001;164:565-568.) Even the revised estimates presented in our sensitivity analysis, while lower, were still generally higher than the typically reported range of 5-15%.[1-3] (Mannino,Occup Med, 2000, 15:359-368; Toren K, Scand J Work Environ Health, 1999, 25:558-563; Blanc, Chest, 1996, 110:3-4). Milton et al. recently reported in abstract form on initial results from a further study using their protocol and noted incidence figures that are almost twice those reported in their initial study of Boston area residents. Data on work-relatedness were not presented.[16] (ref to Milton et al abstract in AJRCCM, 2001)

In summary, this study of adult onset asthma among members of a large health maintenance organization in the northwest U.S. generally corroborates the findings from a similarly conducted analysis in the northeastern U.S. and suggests that the contribution of occupation to the

occurrence of adult onset asthma may be much higher than has typically been suggested in the literature. Particular strengths of the study included its population-based nature, the use of electronic medical records databases to identify incident cases, and a careful evaluation of the asthmagenicity of the workplace environment.

Acknowledgements

The authors would like to thank Dr. Paul Blanc for his careful review and comments on this manuscript. The views and opinions expressed herein are only those of the authors, however.

References (to be revised before submission)

1. Mannino DM. How much asthma is occupationally related? *Occup Med* 2000; 15(2):359-368.

2. Toren K. Challenges for the new century in the epidemiology of adult asthma. *Scand J Work Environ Health* 1999; 25(6):558-563.

3. Blanc PD. Occupation and asthma. Through a glass, darkly. *Chest* 1996; 110(1):3-5.

4. Mapp CE, Saetta M, Maestrelli P, Fabbri L. Occupational asthma. *European Respiratory Monograph 11*. ERS Journals Ltd, 1999: 255-285.

5. Chan-Yeung M, Malo JL. Occupational asthma. *N Engl J Med* 1995; 333(2):107-112.

6. Chan-Yeung M. Occupational asthma. *Chest* 1990; 98(5 Suppl):148S-161S.

7. Toren K, Brisman J, Olin AC, Blanc PD. Asthma on the job: work-related factors in new-onset asthma and in exacerbations of pre-existing asthma. *Respir Med* 2000; 94(6):529-535.

8. Blanc P. Occupational asthma in a national disability survey. *Chest* 1987; 92(4):613-617.

9. Siracusa A, Kennedy SM, Dybuncio A, Lin FJ, Marabini A, Chan-Yeung M. Prevalence and predictors of asthma in working groups in British Columbia. *American Journal of Industrial Medicine* 1995; 28(3):411-423.

10. Meredith S, Nordman H. Occupational asthma: measures of frequency from four countries. *Thorax* 1996; 51(4):435-440.

11. Matte TD, Hoffman RE, Rosenman KD, Stanbury M. Surveillance of occupational asthma under the SENSOR model. *Chest* 1990; 98(5 Suppl):173S-178S.

12. Milton DK, Solomon GM, Rosiello RA, Herrick RF. Risk and incidence of asthma attributable to occupational exposure among HMO members. *American Journal of Industrial Medicine* 1998; 33(1):1-10.

13. Freeborn DK, Pope CR. *Promise and performance in managed care*. first ed. Baltimore, Maryland: The Johns Hopkins University Press, 1994.

14. McFarland BH, Freeborn DK, Mullooly JP, Pope CR. Utilization patterns and mortality of HMO enrollees. *Med Care* 1986; 24(3):200-208.

15. Kogevinas M, Anto JM, Soriano JB, Tobias A, Burney PGJ. The risk of asthma attributable to occupational exposures. *American Journal of Respiratory Critical Care Medicine* 1996; 154(1):137-143.

16. Park JH, Gold DR, Spiegelman DL, Burge HA, Milton DK. House dust endotoxin and wheeze in the first year of life. *Am J Respir Crit Care Med* 2001; 163(2):322-328.

References

(these are from the original proposal)

1 Hoffman RE, Rosenman KD, Watt F, Stanbury M. Occupational disease surveillance: Occupational asthma. *MMWR* 1990; 39:119-123.

2. Guidelines for the diagnosis and management of asthma. National Heart, Lung and Blood Instituite, National Asthma Education Program Expert Panel report. *J Allergy Clin Immunol* 1991; 88:425-534.

3. Blanc P. Occupational asthma in a National Disability Survey. *Chest* 1987; 92:613-17.

4. Kobayashi S. Different aspects of occupational asthma in Japan. In: Frazier CA, ed. 1980 *Occupational Asthma.* New York: Van Nostrand Reinhold, 1980; 229-244.

5. Timmer S, Rosenman K. Occurrence of occupational asthma. *Chest* 1993; 104:816-820.

6. Reilly MJ, Rosenman KD, Watt FC, et al. Surveillance for occupational asthma--Michigan and New Jersey, 1988-1992. *MMWR* 1994; 43(no.SS-1):9-17.

7. (Note: this is the new citation #1) Rosenman KD, Reilly MJ, Kalinowski DJ. A state-based surveillance system for work-related asthma. *JOEM* 1997; 39:415-425.

8. Matte TD, Hoffman RE, Rosenman KD, Stanbury M. Surveillance of occupational asthma under the SENSOR model. *Chest* 1990; 98:173S-178S.

9. Chan-Yeung M, Malo JL. Occupational asthma. *The New England J Medicine* 1995; 333;107-112.

10. Chan-Yeung M. Occupational asthma. *Chest* 1990; 5:148S-161S.

11. McLarty J. Epidemiology and Occupational Asthma. In:Bardana EJ, Montanaro A, O'Hallaren MT. *Occupational asthma.* Philadelphia: Hanley & Belfus, 1992; 55-62.

12. Brooks SM, Weiss MA, Berstein IL. Reactive airways dysfunction syndrome (RADS). *Chest* 1985; 88:376-83.

13. Chan-Yeung M, Lam S. State of art: Occupational asthma. *Am Rev Respir Dis* 1986; 133:686-701.

14. Newman Taylor AJ, Longbottom JL, Pepys J. Respiratory allergy to urine proteins of rats and mice. *Lancet* 1977; 2:847-49.

15. NIOSH Criteria for a Recommended Standard: Occupational exposure to diisocyanates. US Department of Health, Education and Welfare. PHS CDC publication No. 78-215, Sept. 1978.

16. Forbes JD, Markham TN. Cutting and grinding fluids in chronic pulmonary airway disease. *J Occup Med* 1967; 8:421-423.

17. Robertson AS, Weir DC, Burge PS. Occupational asthma due to oil mists. *Thorax* 1988; 43:200-205.

18. Hendy MS, Beattie BE, Burge PS. Occupational asthma due to an emuslsified oil mist. *Br J Ind Med* 1985; 42:51-54.

19. Zacharisen MC, Kadambi AR, Schlueter DP, et al. The spectrum of respiratory disease associated with exposure to metal working fluids. *J Occup Environ Med* 1998; 40:640-647.

20. Vedal S, Enarson D, Kus J, et al. Symptoms and pulmonary function in western red cedar workers related to duration of employment and dust exposure. *Arch Environ Health* 1986; 41:179-184.

21. Marabini A, Dimich-Ward H, Kwan SYL, et al. Clinical and socioeconomic features of subjects with red cedar asthma. *Chest* 1993; 104:821-834.

22. Malo JL. The case for confirming occupational asthma. *J Allergy Clin Immunol* 1993; 91:967-970.

23. Milton DK, Solomon GM, Rosiello RA, Herrick RF. Risk and incidence of asthma attributable to occupational exposure among HMO members. *Am J Ind Med* 1998; 33:1-10.

23. Ertle AR, London MR. Insight into asthma prevalence in Oregon. American Lung Association of Oregon. Portland 1996.

24. Greenlick MR, Hurtado AV, Pope CR, Saward EU, Yoshioka SS. Determinants of medical care utilization. *Health Serv Res* 1968; 3:296-315.

25. Greenlick MR, Freeborn DK, Pope CR. Health care research in an HMO: Two decades of discovery. Baltimore: Johns Hopkins University Press, 1988.

26. Vollmer WM, Buist AS, Osborne ML. Twenty year trends in hospital discharges for asthma among members of a health maintenance organization. *J Clin Epid* 1992; 45(9):999-1006.

28. Vollmer WM, Osborne ML, Buist AS. Temporal trends in hospital-based episodes of asthma care in a health maintenance organization. *Am Rev Respir Dis* 1993; 147:347-353.

29. Vollmer WM, Osborne ML, Buist AS. 20-year trends in the prevalence of asthma and chronic airflow obstruction in an HMO. *Amer J Respir and Crit Care Med* 1998; 157:1079-1084.

30. Vollmer WM, Greenlick MR, Buist AS, Osborne ML. The Clinical Epidemiology of Asthma in an HMO -- Methodologic Considerations. In: *American Statistical Association--1989 Proceedings of the Section in Survey Research M*ethods. American Statistical Asso, Alexandria, 1990.

31. Osborne ML, Vollmer WM, Buist AS. Diagnostic accuracy of asthma within an HMO. *J Clin Epid* 45(4):403-411, 1992.

32. Burney P, Chinn S, Jarvis D, Luczynska C, Lai E, on behalf of the European Community Respiratory Health Survey. Variations in the prevalence of respiratory symptoms, self-

reported asthma attacks, and use of asthma medication in the European Community Respiratory Health Survey (ECRHS). *Eur Respir J* 1996; 9:687-695.

33. Osborne ML, Vollmer WM, Linton KLP, Buist AS. Characteristics of patients with asthma within a large health maintenance organization: A comparison by age and gender. *Amer J Respir & Crit Care Med* 1998; 157:12-128.

34. Vollmer WM, O'Hollaren M, Ettinger KM, Stibolt T, Wilkins J, Buist AS, Linton KLP, Osborne ML. Specialty Differences in the Management of Asthma: A Cross-sectional Assessment of Allergists' Patients and Generalists' Patients in a Large HMO. *Archives of Internal Medicine* 1997; 157:1201-1208.

35. Osborne ML, Vollmer WM, Buist AS. Use of an automated prescription database to identify people with asthma. *J Clin Epid* 1995; 18:1393-1397105.

36. Freeborn D, Pope C. Health status, utilization and satisfaction among enrollees in three types of private health insurance plans. *Group Health J* 1982; 3:4-11.

37. McFarland BH, Freeborn DK, Mullooly JP, Pope CR. Utilization patterns and mortality of HMO enrollees. *Med Care* 1986; 24:200-8.

38. Ng TP, Hong CY, Goh LG, Wong ML, Koh KT, and Ling SL. Risks of asthma associated with occupations in a community-based case-control study. *Am J Ind Med* 1994; 25:709-718.

39. Burney PG, Chinn S, Britton JR, Tatterfield AE, Papacosta AO. What symptoms predict the bronchial response to histamine? Evaluation in a community survey of the bronchial symptoms questionnaire (1984) of the International Union Against Tuberculosis and Lung Disease. *Int J Epidemiol* 1989; 18:165-173.

40. McWhorter WR, Polis MA, Kaslow RA. Occurrence, predictors and consequences of adult asthma in NHANES-I and follow-up survey. *Am Rev Respir Dis* 1989; 139:721-724.

41. (Note: new citation # 2) Jajosky RA, Harrison R, Reinisch F, Flattery J, Chan J, Tumpowsky C, Davis L, Reilly MJ, Rosenman KD, Kalinowski D, Stanbury M, Schill D, Wood J. Surveillance of work-related asthma in selected U.S. states using surveillance guidelines for state health departments – California, Massachusetts, Michigan, and New Jersey, 1993-1995. MMWR 1999; 48 (SS03); 1-20.

42. (Note: new citation #3) Blanc PD, Eisner MD, Israel L, Yelin EH. The association between occupation and asthma in general medicine practice. Chest 1999; 115(5); 1259-1264.

Table 1. Algorithm for identifying "at-risk" population

Inclusion Criteria

- aged 15-55 years as of the 1st day of the target month
- continuous health plan eligibility for the prior six months

Exclusion Criteria

HCU in past year

- outpatient or primary inpatient visit for any of the following
  - congestive heart failure
  - chronic obstructive pulmonary disease
  - bronchiectasis
  - chronic bronchitis
  - sleep apnea
- emergency department, urgency care, or primary inpatient visit for asthma

HCU in past two years

- outpatient visit for asthma

medication dispensing in past year

- ≥4 dispensings of beta-agonist inhalers
- (≥1 dispensings of either an inhaled corticosteriod or cromolyn) *and* (≥1 beta-agonist inhaler dispensing)

Table 2. Algorithm for identification of incident asthma cases[1]

Utilization Criterion
Any of the following health care contacts in the target month • ED visit for asthma • Inpatient stay with primary diagnosis of asthma • Outpatient clinic visit or urgent care clinic visit for asthma
Medication Criterion[2]
Any of the following dispensing patterns in the target or subsequent month • ≥2 dispensings of beta-agonist inhalers • ≥1 dispensing of any asthma medication other than beta-agonists inhalers

[1] In order to be identified as a potential case, the person must meet ***both*** the utilization and the medication criteria

[2] The following medications are considered when applying the medication criteria: beta-agonist inhaler, inhaled corticosteroid, cromolyn inhaler, theophylline, beta-agonist nebulizer, leukotriene inhibitor, prednisone, nebulization treatment

Table 3. Grid for assessing strength of evidence for work-relatedness of participant's asthma

		Work-Relatedness Score			
Summary IH Rating		**0**	**1**	**2**	**3**
0	little or no asthmagenic potential	No	Weak	Weak	Moderate
1	possible asthmagenic potential	Weak	Moderate	Moderate	Strong
2	clear asthmagenic potential	Weak	Moderate	Strong	Strong

Participants with moderate or strong evidence were classified as having occupational asthma

Table 4. Rate of occurrence of new and recurrent asthma among members of Kaiser Permanente, Northwest Region, aged 15-55, for the year 2000.

	Age (yrs)				
	15-25	26-35	36-45	46-55	total
Size of at-risk population (1000 person-years)					
Men	25	20	26	28	98
Women	25	22	28	30	106
Total	50	42	54	57	204
Validated cases of new or recurrent asthma					
Men	71	75	67	75	288
Women	103	117	156	164	540
Total	174	192	223	239	828
"Incidence" of new or recurrent asthma (per 10,000 person-years)					
Men	29	37	26	27	29
Women	40	53	56	55	51
Total	35	45	41	42	41

Table 5. Response rates to telephone screening

	Frequency	Percent[1]
Number of incident cases	829	
Number successfully interviewed	387	47%
acknowledged having asthma	352	43%
denied having asthma[2]	35	4%
Refused	161	19%
Unable to reach (passive refusal & no phone)	258	31%
Other	23	3%

[1] percentage of incident cases
[2] excluded from analysis

Table 6. Proportion of incident asthma that appears to be occupationally-related

	Age				
	15-25	26-35	36-45	46-55	Total
Men	33% (24)[1]	46% (26)	39% (18)	40% (30)	40% (98)
Women	11% (38)	27% (48)	25% (79)	33% (89)	26% (254)
Total	19% (62)	34% (74)	28% (97)	34% (119)	30% (352)

[1] denominator shown in parentheses

Table 7. Distribution of work-relatedness and IH scores

(7a)

		Work-Relatedness Score			
	Summary IH Rating	**0**	**1**	**2**	**3**
0	little or no asthmagenic potential	118	84	13	6
1	possible asthmagenic potential	17	49	4	1
2	clear asthmagenic potential	15	31	11	3

Participants in shaded areas classified as having occupational asthma. The (0,0) cell includes 86 individuals who reported no current job.

(7b)

		Revised Work-Relatedness Score			
	Summary IH Rating	**0**	**1**	**2**	**3**
0	little or no asthmagenic potential	195	16	8	2
1	possible asthmagenic potential	61	7	2	1
2	clear asthmagenic potential	42	11	6	1

Participants in shaded areas classified as having occupational asthma

Table 8. Estimated incidence of work-related and non-work-related asthma (per 10,000 person-years of observation) among members of Kaiser Permanente, Northwest Region, aged 15-55, for the year 2000.

Table 8a

	Age (yrs)				
	15-25	26-35	36-45	46-55	total
Work-related asthma					
Men	10	17	10	11	12
Women	4	14	14	18	13
Total	7	15	11	14	12
Non-work-related asthma					
Men	19	20	16	16	18
Women	36	38	42	37	38
Total	28	30	30	27	29

Table 8b. Using more stringent criterion for counting a trigger as work-related

	Age (yrs)				
	15-25	26-35	36-45	46-55	total
Work-related asthma					
Men	2	7	7	2	4
Women	1	2	2	6	3
Total	2	4	3	4	3
Non-work-related asthma					
Men	27	30	19	25	25
Women	39	50	54	49	48
Total	33	41	38	37	37

Occupational Asthma Surveillance Project
Grant #U60/CCU916057-03

Final Report
December 2001

Appendix 3

(August 24, 2000 version)

Community-Based Study of Adult-Onset Asthma

Telephone Interview

March 2000 – March 2001

Interviewers Initials __ __ __

Study ID Number __ __ __ __ __ __ __

Month/Year Identified as Case __ __ / __ __ / __ __ __ __

month day year

Interview Date __ __ / __ __ / __ __ __ __

month day year

A. Verify basic demographic data

A1. **Note gender. You do not need to ask this as a question.** 1 male
2 female

I'd like to begin by verifying your date of birth and address.

A2a. I show your birthday as __ __ / __ __ / __ __ __ __. Is that correct? 1 Yes
2 No

If no, enter correct date of birth A2b. __ __ / __ __ / __ __ __ __
month day year

B. Collect address information for the past year

B1a. I show your current home address as [*read address*]
Is this where you actually live, as opposed to a post office box or some other type of mailing address? 1 Yes
2 No

If no, enter correct address

B1ba. Street address and apt number _____

_____

B1bb. City _____

B1bc. State ___ B1bd. 5 digit zip code _____

(We cannot accept P.O. Boxes for geo-coding)

B2. When did you move to this address (month, year): __ __ / __ __ __ __

If moved to this location more than 1 year before date of interview, skip to section C. Else ask:

B2a. Where did you live before you moved to this location?
B2aa. Street address and apt number _____

_____

B2ab. City_____

B2ac. State ___ B2ad. 5 digit zip code _____

Repeat questions B2 and B2a for each new location until all residences lived in for the last year are recorded.

1. C. Respiratory Symptoms

As I mentioned, our records indicate that you were seen recently for some breathing problems.

C1. How old were you when you first developed these chest symptoms or breathing problems?

_____ years

C2. How soon prior to your visit on (date of clinic visit) did your chest symptoms or breathing problems begin to get worse?

A couple of days before your visit 1
One week before your visit..... 2
2-3 weeks before your visit 3
A month before your visit..... 4
More than a month before your visit 5

C3. Have you had wheezing or whistling in your chest at any time in the last 12 months? 1 Yes 2 No

C4. Have you had an attack of shortness of breath that came on following strenuous activity at any time in the last 12 months?

1 Yes 2 No

C5. Have you, at any time in the last 12 months, been woken by an attack of shortness of breath?

1 Yes 2 No

C6a. Do you usually cough first thing in the morning?

1 Yes 2 No

If yes,

C6b. Have you coughed like this most mornings for at least 3 months each year?

1 Yes 2 No

C7. Do you usually bring up phlegm from your chest first thing in the morning?
1 Yes 2 No

If yes,

C8. Have you brought up phlegm from your chest like this most mornings for at least 3 months each year?
1 Yes 2 No

C9. When you are near animals, feathers or dust (such as when vacuuming), do you ever. . .

		Yes	No
C9a.	start to cough?	[1]	[2]
C9b.	start to wheeze?	[1]	[2]
C9c.	Get a feeling of tightness in your chest?	[1]	[2]
C9d.	Start to feel short of breath?	[1]	[2]

C10. Which of the following statements best describes your breathing?

I never or only rarely have trouble with my breathing 1
I sometimes have trouble with my breathing 2
I often have trouble with my breathing 3
I always have trouble with my breathing 4

C11a. Are your chest symptoms or breathing troubles worse during some months of the year?
[1] Yes [2] No [8] Don't Know

C12a. Do your chest symptoms or breathing troubles change on weekends, vacations, or other times when you are away from work?
[1] Yes [2] No [8] Don't Know

If YES ask
C12b. Do your chest symptoms or breathing trouble get better or worse away from work?
[1] Better [2] Worse [8] Don't Know

C13. Do you use a prescribed inhaler or nebulizer that gives you quick relief from your chest symptoms or breathing troubles?
[1] Yes [2] No

IF yes ask
C14a. Does your use of your quick relief inhaler or nebulizer change on weekends, vacations or other times when you are away from work?
[1] Yes [2] No [8] Don't Know

IF yes ask
C14b. Do you use your inhaler or nebulizer more or less when you are away from work?
[1] More [2] Less [8] Don't Know

Now I am going to ask you to describe the particular things that seem to set-off your chest symptoms or breathing troubles, and to indicate whether these are primarily problems for you at work, at home, or elsewhere.

C15a. Is there anything that seems to set-off your chest symptoms or breathing troubles?
1 Yes
2 No

If YES, record in question C15b below. Record triggers below:

Now as you list these triggers I will need to ask after each one whether this occurred at work, at home or elsewhere. Let's begin.

C15b. Record subject responses in the drop down box and then categorize with the following radio buttons.

C15ba.	C15bb.		C15bc.		C15bd.	
Trigger	At work		At home		Elsewhere	
	Yes	No	Yes	No	Yes	No
Exercise	[1]	[2]	[1]	[2]	[1]	[2]
Temperature/humidity	[1]	[2]	[1]	[2]	[1]	[2]
Animals	[1]	[2]	[1]	[2]	[1]	[2]
Pollen	[1]	[2]	[1]	[2]	[1]	[2]
Mold	[1]	[2]	[1]	[2]	[1]	[2]
Respiratory infections	[1]	[2]	[1]	[2]	[1]	[2]
Dust	[1]	[2]	[1]	[2]	[1]	[2]
Perfume or strong odors	[1]	[2]	[1]	[2]	[1]	[2]
Cigarette smoke	[1]	[2]	[1]	[2]	[1]	[2]
Car and truck exhaust	[1]	[2]	[1]	[2]	[1]	[2]
Smoggy or sooty air	[1]	[2]	[1]	[2]	[1]	[2]
Other (specify):	[1]	[2]	[1]	[2]	[1]	[2]
Other (specify):	[1]	[2]	[1]	[2]	[1]	[2]
Other (specify):	[1]	[2]	[1]	[2]	[1]	[2]

C16. Is there anything else that seems to set-off your chest symptoms or breathing troubles?

1 Yes
2 No

If YES, record in question C15b above and repeat as many times as needed. (Answer saved to C15a.)

2. D. The next questions are about your employment.

(If necessary, complete this section on paper and refer to it as you ask the additional on-screen questions. Note responses in the table at the bottom of the page.)

Now I'd like to ask you some questions about any jobs that you have held over the past year. First I'll ask you to list all of the jobs you've held during this time, and then I'll go back and ask you some specific questions about each job.

D1. Counting your current position, what is the most recent job you have held in the last year? (If none, skip out of this section **GO TO SECTION E**)

D2. In what month and year did you start this job?

D3. In what month and year did you finish this job? (**list today's date if still employed**)

D4. Who is (was) your employer?

If the start date for the current job (D2) is within the past **one** year, ask

D5. Prior to your job as a (*job title*) for (*name of employer*), what was your next most recent position? (**If none, continue with current position then skip to SECTION E**)

(Go to Question D2 and repeat this series of questions for all jobs held in the **last year**).

Job title	Start date (mm/yyyy)	End date (mm/yyyy)	Employer

Now I would like to ask you some specific questions about each of these jobs.

D6. You indicated that you worked as a (*job title*) for (*employer*) from (*start date*) to (*end date*). What does this company do or manufacture? That is, what is its main product or service?

D7. On average, about how many hours per week do (did) you spend on this job? _____ hrs/wk

D8. Describe the place where you do (did) your job. This may be (have been) a building, shop, or office, or it may be (have been) some type of outdoor location. **[If respondent indicates they don't have a regular workplace ask them to describe the setting he or she spends most of his or her time]**
[Text box]

D9. Describe the ventilation in the place where you do (did) your job. **[if the respondent does not understand the term "ventilation" then rephrase the question as: "Describe the way the air moves in the place where you work"]**
[Text box]

D9a. Approximately how many hours of your working day do you spend in an office? This includes classrooms, libraries, courtroom, reception areas, etc
[Text box]

If the answer is more than one hour, ask the following (D9) series of questions:

D9ab. Can you describe this office for me?
[Text box]

If they answer that they move from location to location then skip the rest of the D9 series of questions

D9ba. Have you observed evidence of water damage or leaks, such as stained ceiling tiles or flooring, in the past year, in the office space?
[1] Yes [2] No

If yes ask
D9bb. Describe the evidence of water damage or leaks.
[Text box]

D9bc. Have you observed visible mold or fungus growth, in the past year, in the office space?
[1] Yes [2] No

If yes ask
D9bd. Describe the mold or fungus growth.
[Text box]

D9be. Have you observed an unusual odor, in the past year, in the office space?
[1] Yes [2] No

If yes ask
D9bf. Describe the unusual odor.
[Text box]

D9bg. Have you observed recent renovations or remodeling, in the past year, in the office space?
[1] Yes [2] No

If yes ask
D9bh. Describe the recent renovations or remodeling.
[Text box]

D10. Describe what you do (did) on the job.

[Text box]

D11. What tools, chemicals and other materials do (did) you use or come in contact with on the job? Let us take each item separately as additional information will be needed.

[Note answers in the box below. After each item ask, "Do (did) you use or come in contact with any other tools, chemicals, or materials on the job?"]

D11a. Tool, chemical, or other material used on the job	D11b. Do (did) you wear any form of breathing protection while using it?		D11c. Hours/week of use or contact with material
	Yes	No	
	[1]	[2]	
	[1]	[2]	
	[1]	[2]	
	[1]	[2]	
	[1]	[2]	
	[1]	[2]	
	[1]	[2]	
	[1]	[2]	

D12. In the last year, have there been any changes on this job such as new tools, chemicals or other materials that you use or come in contact with in your work place? (Describe the changes.)

[Text box]

D13. Are you ever exposed to dust, smoke, gas, or chemical fumes on this job? (This exposure may be related to the tools, chemicals, or other materials that you listed previously.)
Yes No

If No skip to Question D19

D14. Please describe the different processes or tasks that involve exposure to dust, smoke, gas or chemical fumes on this job (ALLOW RESPONDENT TO MENTION ONE OR MORE AT THIS POINT).

List process or task: A._____

B._____

C._____

D15. Now I am going to ask you a few questions about your exposure to (task A). How often are (were) you exposed to the dust, smoke, gas, or chemical fumes from this activity? Would you say,

All of the time 1
Some part of most days 2
At least once every week 3
At least once every month 4
or Rarely 5

D16. How close are (were) you to the exposure? Would you say,

Within arm's length 1
3-10 feet away 2
or More than 10 feet away 3

D17. Is (was) the exposure usually:

Mild 1
Moderate 2
or Severe 3

Go back and repeat D15, D16 and D17 for **each** process or task listed in D14.

D19. I am now going to read you a list of materials or things that you may work with, or be exposed to, as a regular part of your job as [occupation]. You may have already listed some of these in response to a previous question. However I do have to ask these in order, without skipping, so that we ensure that everyone is asked the same question in the same manner.

	Category	Work with on job?	
		Yes	No
D19d.	2-part spray paints or spray foams that contain Di-isocyanates	[1]	[2]
D19e.	2-part glues or resins made from epoxy	[1]	[2]
D19g.	Soldering fluxes	[1]	[2]
D19h.	DUST from the following metals: platinum, nickel, cobalt, zinc, chromium, tungsten carbide, or aluminum	[1]	[2]
D19k.	Cutting oils or metalworking fluids	[1]	[2]
D19l.	Gloves made of natural rubber latex	[1]	[2]

If this is not the respondent's current job, ask

D20a. Why did you leave this job?

(Do not read responses, just note which is most accurate)

promoted 1
transferred 2
laid off 3
quit (non-health-related) 4
fired (non-health-related) 5

on workers compensation 7
quit because of health problems 8
fired because of health problems 9
still working in this job 10
other: _____ 11

D20b. (Other Text)

If the respondent reported more than one job, cycle through questions D6-D20 for each job worked in the last year. If the respondent had only one job during the last year, go to Section E.

D21. Do you have anything else to add regarding this job?

Use this question to enter any miscellaneous notes regarding this job you feel should be entered.

E. RADS Questions

Now I'd like to ask you a series of questions about large, one-time accidental exposures to smoke, gas, or fumes that you may have experienced in the past, either at home or on the job.

E1. Have you ever been exposed to smoke, gas, or chemical fumes, from a one-time spill, accident or fire (for example mixing ammonia and bleach in a closed area)?

1 Yes 2 No

If "NO" Skip to Question F1

E2. When did this first/next occur?

____ ____
Year Month

E3. What were you exposed to?

[Text box]

E4. How long did the exposure last? Was it...

Less than 1 hour.....1
1-8 hours.....2
9-24 hours.....3
or Greater than 1 day..4

E5a. Where did this (the exposure) occur?

Home 1
Work 2
or someplace else _____.. 3

E5b. (Other Text)

E6. Did you develop chest symptoms or breathing difficulty after this exposure?

[1] Yes [2] No

[IF NO, SKIP TO SECTION E9]

E7. How soon after the exposure did your symptoms occur? Would you say,

Immediately 1
Within 1 hour of exposure 2
Between 1 and 24 hours after exposure..... 3
1 -2 days after exposure 4
3 -7 days after exposure 5
or More than a week after exposure 6
Don't know 8

E8. How long did your symptoms last? Would you say,

Less than 1 week after exposure..... 1
Between 1 week and 3 months after exposure .. 2
or More than 3 months after exposure..... 3
Don't know..... 8

E9. Have there been any other one time spills or accidental exposures?

1 Yes
2 No

If YES, repeat questions E2 – E8 for each additional exposure reported. (E9 is stored in E1 under a new record.)

F. Home Environment

The next series of questions deals with your home environment.

F1. Which of the following best describes the building in which you live?

One family detached house..... 1
One family house attached to one
or more other houses..... 2
A building with 2 apartments 3
A building with 3 or 4 apartments..... 4
or A building with 5 or more apartments 5
A mobile home..... 6
A houseboat..... 7

F2. About when was the building you live in originally built? (Do not count remodeling, additions, or conversions.) Would you say,

1978 or later..... 1
1948-1977..... 2
or before 1948 3
Don't Know..... 8

F3. How many total rooms do you have? (Include kitchen but not bathrooms.)

_____ rooms

F4. What types of floor coverings occupy the floor space in the family/TV room and your bed room? (Mark all that apply)

		a. Family/ TV Room		b. Your Bedroom		
		Yes	No	Yes	No	
Wall-to-wall carpeting	F4aa.	[1]	[2]	[1]	[2]	F4ab.
Area rug	F4ba.	[1]	[2]	[1]	[2]	F4bb.
Exposed Wood Floors	F4ca.	[1]	[2]	[1]	[2]	F4cb.
Ceramic tiles	F4da.	[1]	[2]	[1]	[2]	F4db.
Linoleum/Vinyl tiles	F4ea.	[1]	[2]	[1]	[2]	F4eb.
Other _____	F4fa.	[1]	[2]	[1]	[2]	F4fb.

F4fc. (Other Text)

F5. Do you currently use a gas or propane cooking stove, range, or oven in your primary residence?

Yes 1
No 2
Don't Know 8

F6. In this residence does your stove, range, or oven use a continuously burning pilot light? **(May need to provide additional information)**

Yes 1
No 2
Don't Know 8

F7a. What is the primary means for heating your home? Would you say,

Forced Hot Air 1
Radiators 2
Space Heaters 3
Indoor wood or
Coal stoves 4
or Other _____ 5
Don't Know 8

F7b. (Other Text)

F8. During the past twelve months, have ANY of the following sources also been used to heat your home? (READ RESPONSE CATEGORIES AND MARK ALL THAT APPLY.)

		Yes	No	DK
F8a.	Wood or coal stove	[1]	[2]	[8]
F8b.	Fireplace	[1]	[2]	[8]
F8c.	Unvented kerosene heater	[1]	[2]	[8]
F8d.	Unvented gas heater or stove	[1]	[2]	[8]
F8e.	Coal stove	[1]	[2]	[8]
F8f.	Portable electric heater	[1]	[2]	[8]

F9a. Does your home or apartment have any air-conditioning?

Yes 1
No 2

IF YES ask

F9b. Which rooms have air conditioning? **(Mark all that apply)**

		Yes	No
F9ba.	All rooms (for example, central air-conditioning)	[1]	[2]
F9bb.	Living room	[1]	[2]
F9bc.	Family room	[1]	[2]
F9bd.	Your bedroom	[1]	[2]
F9be.	Other rooms	[1]	[2]

F10. In the past 12 months, have you used a dehumidifier in your home?

Yes 1
No 2
Don't Know 8

F11a. In the past 12 months, have you used a humidifier or vaporizer in your home? **(Include any humidifier built into the heating system.)**

Yes 1
No 2
Don't Know 8

If YES, ask:

F11b. What type of humidifier have you used? **(Mark all that apply.)**

		Yes	No	DK
F11ba.	Cool mist, spinning disk, or ultrasonic room humidifiers	[1]	[2]	[8]
F11bb.	Warm mist or steam room humidifiers	[1]	[2]	[8]
F11bc.	Console (evaporation from belt) room humidifiers	[1]	[2]	[8]
F11bd.	Unit attached to central heating system	[1]	[2]	[8]
F11be.	Water pans on radiator or stove	[1]	[2]	[8]

F12. In the past 12 months, has there been water damage to the building or its contents, for example from broken pipes, leaks, or floods?

Yes 1
No 2
Don't Know 8

F13a. During the past 12 months, has water ever collected on the basement floor?

Yes 1
No 2
Not Applicable (No Basement) 7
Don't Know 8

If YES ask

F13b. About how often has this occurred in the past 12 months?

Almost all the time 1
Frequently; on most rainy days 2
Occasionally; when it rained heavily ... 3
Rarely 4
Not Applicable 7

F14. During the past 12 months, has there been any mold or mildew on any surfaces inside your home (other than food)?

Yes 1
No 2
Don't Know 8

F15. Do you have any dogs, cats, other furry pets, or birds in your home? (**Mark all that apply**)

		Yes	**No**
F15a.	Dogs	[1]	[2]
F15b.	Cats	[1]	[2]
F15c.	Pet mice, rats, hamsters or gerbils	[1]	[2]
F15da.	Other furry pets: _____	[1]	[2]
F15e.	Birds	[1]	[2]

F15db. (Other furry pets Text)

F16. In the past 12 months, have you seen signs of rats or mice (other than as pets) inside your home? (**Mark all that apply**)

		Yes	No
F16a.	Rats	[1]	[2]
F16b.	Mice	[1]	[2]

F17a. In the past 12 months, did you or a professional exterminator use pesticides inside the home?

No 1
Yes 2
Don't know 8

F17b. If yes, how often _____?

F18. In the past 12 months, have you seen or noticed signs of cockroaches?

No 1
Yes, once 2
Yes, more than once 3
Don't know 8

F19. I am now going to read you a list of materials or things that you may come in contact with or be exposed to when you are not at work, either as part of routine chores in the home or as part of hobbies or home projects. You may have already listed some of these in response to a previous question. However, I do have to ask these, in order, without skipping, so that we ensure that everyone is asked the same question in the same manner.

	Category	Exposed to away from work?	
		Yes	No
F19d.	2-part spray paints or spray foams that contain Di-isocyanates	[1]	[2]
F19e.	2-part glues or resins made from epoxy	[1]	[2]
F19g.	Soldering fluxes	[1]	[2]
F19h.	DUST from the following metals: platinum, nickel, cobalt, zinc, chromium, tungsten carbide, or aluminum	[1]	[2]
F19k.	Cutting oils or metalworking fluids	[1]	[2]
F19l.	Gloves made of natural rubber latex	[1]	[2]

G. Tobacco Exposure

The next questions ask about exposures you may have had to tobacco smoke.

G1. Have you ever smoked cigarettes? ("No" means that you have smoked less than 20 packs of cigarettes or 12 ounces of tobacco in your lifetime, or that you have smoked, on average, less than one cigarette a day for a year during your lifetime.)

Yes 1
No 2
Unsure 3
Refused 9

If No, Unsure, or Refused, go to question G7. Only ask Question G2 if participant responds "Yes" above.

G2. Do you now smoke cigarettes (as of 1 month ago)?

Yes 1
No 2

If Yes, ask

G3. How many cigarettes do you smoke per day now? _____ cig/day

Go to G5

G4. If you have stopped smoking cigarettes completely, how old were you when you stopped? _____ years old

G5. How old were you when you first started regular cigarette smoking? _____ years old

G6. Over the years, what is the average number of cigarettes you smoked per day? _____ cig/day

G7. Have you ever smoked pipes or cigars? (Yes means more than 12 ounces of tobacco in a lifetime or one cigar a week for a year)

Yes 1
No 2

If Yes,

G8. Do you now smoke a pipe or cigar?

Yes 1
No 2

G9. Are there people in your household (other than yourself) who smoke regularly inside the home?

Yes 1
No 2

G10. How often do you smell cigarette smoke when you are at work? Don't count smoke exposure on entering or leaving buildings.

Everyday 1
More than one day per week but not everyday 2
Less than one day per week 3
Never 4

H. Medical History

We're almost done. You're doing great! The next questions are about your medical history.

H1. Has a doctor ever told you that you have:

Condition	You			Either of your parents		
		Yes	No		Yes	No
Asthma	H1aa.	[1]	[2]	H1ab.	[1]	[2]
Hay fever or allergies	H1ba.	[1]	[2]	H1bb.	[1]	[2]
Sinusitis	H1ca.	[1]	[2]			
Eczema or dermatitis	H1da.	[1]	[2]			
Acute bronchitis	H1ea.	[1]	[2]			
Chronic bronchitis, emphysema, or COPD	H1fa.	[1]	[2]			
Pneumonia	H1ga.	[1]	[2]			
Heart Disease	H1ha.	[1]	[2]			

I. Final Demographic Questions

Okay, we're almost done. Just four more questions!

I1a. What is your primary race? **(Read first four response categories and mark one answer)**

White 1
Black 2
Asian/Pacific Islander 3
American Indian/Alaskan Native 4
Other:(_____) 5
Don't Know 8
Refused 9

I1b. (Other Text)

I2. Do you consider yourself to be of Hispanic origin?

Yes 1
No 2
Unsure/Don't Know 8
Refused 9

I3. What is the highest grade of school that you have completed?

Never attended school 1
Grades 1-8 2
Grades 9-11 3
Grade 12 or GED (high school graduate) 4
Some college or technical school beyond high school 5
College graduate 6
Graduate or professional degree 7
Other _____ (recode) 10
Unknown 8
Refused 9

I3b. (Other Text)

I4. Which of the following best describes your total family income for the past year?

Under 14,999 1
15,000 to 24,999 2
25,000 to 34,999 3
35,000 to 49,999 4
50,000 to 74,999 5
75,000 to 99,999 6
100,000 or more 7
Don't know 8
Refused 9

That's it. You're done! Thank you once again for taking the time to answer all of these questions. I truly appreciate your help. Do you have any questions before I let you go?