

Incidence of Work-Related Asthma in Members of a Health Maintenance Organization

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Objective: The objective of this study was to evaluate work-related asthma among health maintenance organization (HMO) members. Recent reports suggest that the incidence of work-related asthma may be much higher than Sentinel Event Notification Systems for Occupational Risks (SENSOR) data estimate. **Methods:** Using the HMO's electronic medical record, we identified 1747 persons with evidence of new or recurrent asthma. Interviews with 352 of them elicited information about workplace exposures, symptoms, and home environment. Industrial hygienists rated the potential asthmagenicity of the respondents' work environments. **Results:** Based on the industrial hygienist ratings and self-reported work-relatedness of asthma symptoms, we classified 33% of those interviewed as having potentially work-related asthma, suggesting an overall work-related asthma incidence/recurrence rate of 28 cases per 10,000. **Conclusions:** The contribution of occupation to the occurrence of adult onset asthma may be much higher than typically suggested in the literature. (J Occup Environ Med. 2005;47:1292-1297)

Estimates of the proportion of asthma that is work-related typically range from 5% to 15%.¹⁻³ Reasons for the differences in estimates relate both to varying definitions for work-related and occupational asthma and to limitations in the methodologies for assessing it.³ Guidelines of the U.S. Centers for Disease Control and Prevention National Institute for Occupational Safety & Health (NIOSH)^{4,5} for the surveillance of work-related asthma recognize two distinct subclasses: new-onset work-related asthma and work-aggravated asthma (ie, preexisting asthma that is made worse by exposures in the workplace).⁵ New-onset work-related asthma results from exposure to a sensitizer (in which case asthma symptoms may not occur until after many years of exposure) or an irritant (in which case asthma symptoms typically occur within 24 hours of a high-level exposure, but may occur only after repeated, low-level exposure).⁶ The term occupational asthma, as used in the literature, typically equates with new-onset work-related asthma,^{7,8} although some authors limit the term to sensitizer-induced new-onset asthma.^{9,10} Thus, this article uses the term work-related asthma.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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Relatively little population-based information about work-related asthma is available. In the United States, estimates of the average annual incidence of work-related asthma based on the Sentinel Event Notification Systems for Occupational Risks (SENSOR) have ranged

from five cases/10⁶ in Massachusetts¹¹ to 37 cases/10⁶ in Michigan.¹² The SENSOR data are assumed to be underestimates, however,⁵ and more refined estimates from Michigan suggest an incidence rate between 58 and 204 cases/10⁶.¹³ Outside the United States, estimates have ranged from as low as 21 cases/10⁶ in the United Kingdom to 191 cases/10⁶ in Finland.^{14–18}

Although NIOSH has published criteria for using its definition of work-related asthma,¹⁹ their use is limited from an epidemiologic perspective because the needed information is difficult to obtain. Recently, Milton and colleagues studied 79,204 health maintenance organization (HMO) members, aged 15 to 55, and estimated that 21% of incident asthma cases were work-related, an incidence of 71 per 100,000 in this population.²⁰ The Milton et al study is of particular interest because it used electronic medical records information, confirmed by chart review, to define asthma cases. It used a detailed interview, coupled with industrial hygiene evaluation, to assess both the work-relatedness of symptoms and the asthmagenicity of the work environment. The Milton protocol thereby attempts to address, in a reasonably rigorous manner, all three dimensions of the NIOSH definition.

This study evaluated all new cases of asthma occurring in 1 year among the working-aged members of a large HMO to determine the incidence of work-related asthma.

Materials and Methods

This study received Institutional Review Board approval. It was conducted in parallel with investigators from Harvard University as part of a joint award by NIOSH. The surveillance algorithm and the telephone questionnaire were developed collaboratively and were patterned after Milton's 1998 protocol.²⁰

Research Setting and Target Population

Kaiser Permanente Northwest (KPNW) is a large group-model HMO centered in Portland, Oregon, that provides comprehensive, pre-paid healthcare service. Its members' demographic characteristics correspond closely to the area population as a whole.^{21,22} We studied the approximately 255,000 members aged 15 to 55.

Most KPNW members receive coverage through work or are included in a household member's work-related coverage. The 50 largest employer groups contracting with KPNW belong to industries with known exposures to potential asthma triggers such as wood products, aluminum, electronics, and steel manufacturing.

Data Systems

Healthcare utilization data for this analysis were derived from administrative and clinical databases maintained by KPNW. These databases include information on inpatient admissions, emergency department services, general outpatient care, and medication dispensings from KPNW's outpatient pharmacies. Claims for services by non-KPNW facilities were also included.

Surveillance Algorithm

Initially, we identified the at-risk population by excluding individuals with prevalent asthma and other diagnoses that might be confused with asthma. Table 1 summarizes this algorithm. Further details on the predictive value of our prevalence algorithm have been published elsewhere.²³

Using the at-risk population, we applied the algorithm in Table 2 to identify potential incident cases. We captured only individuals who presented with asthma severe enough to trigger a medication dispensing. However, to exclude "ruleout" diagnoses, we required more than one beta-agonist inhaler dispensing to

TABLE 1

Algorithm for Identifying the 'At-Risk' Population

Inclusion criteria

- Aged 15–55 years as of the first day of the target month AND
- Continuous health plan eligibility for the prior 6 months

Exclusion criteria (any one of the following):

- Healthcare utilization 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
- Healthcare utilization in the past 2 yr
- Outpatient visit for asthma
- Medication dispensing in the past year
- ≥4 dispensings of beta-agonist inhalers
- (≥1 dispensing of either an inhaled corticosteroid or cromolyn) and (≥1 beta-agonist inhaler dispensing)

fulfill the medication requirement. The resulting algorithm may exclude some truly incident cases, but it also should (appropriately) exclude some

TABLE 2

Algorithm for Identification of Incident Asthma Cases*

Utilization criterion

- Any one of the following healthcare contacts in the target month
- Emergency department visit for asthma
- Inpatient stay with primary diagnosis of asthma
- Outpatient clinic visit or urgent care clinic visit for asthma

Medication criterion†

- 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

*To be identified as a potential case, the person must meet *both* the utilization and the medication criteria.

†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.

individuals with mild, intermittent asthma who were incorrectly included in the at-risk pool.

As shown in Tables 1 and 2, our algorithm attempts to exclude from the at-risk population individuals with active asthma who require ongoing health care. It does not, however, exclude very mild asthmatics with no outpatient care in the past 2 years and only minimal beta-agonist use; and it does not exclude those with asthma that is no longer active. Thus, ours is a study of asthma incidence and recurrence rather than incidence alone. To assure that all participants were defined comparably, we divided our yearlong surveillance period into 12 months and applied the algorithm independently in each month.

All potentially incident cases thus identified were independently verified by medical record review by trained medical records technicians. Reviewers confirmed a provider diagnosis of asthma and prescription of either bronchodilators or steroids or instructions to refill an active prescription.

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

We attempted to telephone a subset of individuals with chart-confirmed incident asthma to assess the work-relatedness of symptoms and triggers and to gather information about potential workplace exposures. A work-relatedness score, ranging from 0 to 3, was defined as the sum of the following events: 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. 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 trained by an industrial hygienist (IH), and the responses were then independently reviewed by IHs from Portland and NIOSH who were blinded to the work-relatedness questions. Each of the two 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).

The overall assessment of whether the participant's asthma was work-related was determined by the joint distribution of the work-relatedness score and the summary IH score, 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 the one case of reactive airways dysfunction syndrome (RADS) that was associated with workplace exposures.

All participants provided oral consent before beginning the interview.

Statistical Methods

Incidence rates, expressed as number of incident cases per 10,000 person-years of observation, 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 12-month surveillance interval, we identified 1916 suspected cases of new or recurrent asthma of a total of 203,701 person-years of observation. Of these, 1747 (91%) were validated based on chart review. Thus, the overall rate of occurrence of new or recurrent asthma (both work-related and nonwork-related) in this population was 86 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 interaction. We attempted to contact 828 of the cases and successfully completed interviews on 387 (47%) of them. A further 35 denied having had a recent visit for breathing problems, despite our having

TABLE 3

Grid for Assessing Strength of Evidence for Work-Relatedness of Participant's Asthma

Summary Industrial Hygienist Rating	Work-Relatedness Score			
	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 work-related asthma.

TABLE 4

Rate of Occurrence of New and Recurrent Asthma Among Members Aged 15 to 55 of Kaiser Permanente Northwest for the year 2000

	Age (yrs)				Total
	15–25	26–35	36–45	46–55	
Size of at-risk population (1000 person-yr)					
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	160	148	164	155	627
Women	235	247	307	331	1120
Total	395	395	471	486	1747
"Incidence" of new or recurrent asthma (per 10,000 person-yr)					
Men	65	74	63	56	64
Women	92	111	109	111	106
Total	79	93	87	85	86

documented evidence of such a visit, and so were also excluded from the analysis. 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 [CI], 17–26%) reported onset of symptoms within the past year, and thus presumably represent true incident asthma, as opposed to recurrence of dormant asthma. These results suggest that the true rate of occurrence of incident asthma in this population (both work-related and nonwork-related) was 18 per 10,000 person-years of observation. Compared with participants who completed the interview, nonrespondents were slightly younger (36 vs 38 years, $P = 0.004$) and were more likely to be male (40% vs 28%, $P < 0.001$).

Table 5 shows the proportion of incident cases whose asthma we classified as being potentially work-related. The data are expressed relative to the entire population, not only to those who had jobs. Overall, we estimate that 33% (95% CI = 28–38%) of the asthma in this population was potentially work-related, with estimates consistently (and significantly) higher for men than for women. Had we required strong evidence (Table 3) to classify

asthma as work-related, only 4.5% of the 352 incident/recurrent cases would have been classified as work-related.

Finally, Table 6 combines the information from Tables 4 and 5 to estimate the incidence of work-related and nonwork-related asthma

in this population. The estimated incidence of work-related asthma in the population overall was 28 per 10,000 person-years of observation and tended to be higher among those aged 26 and older relative to those aged 15 to 25. The incidence of nonwork-related asthma varied little by age and was consistently higher for women than for men. Although not shown, the proportion of work-related cases did not differ for those judged to have true incident versus recurrent asthma.

Discussion

This 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 33% of new-onset or recurrent asthma in the age range 15 to 55 years may be work-related with

TABLE 5

Proportion of Incident Asthma That Appears to be Work-Related

	Age				Total
	15–25	26–35	36–45	46–55	
Men	33% (24)*	50% (26)	44% (18)	40% (30)	42% (98)
Women	11% (38)	31% (48)	29% (79)	36% (89)	29% (254)
Total	19% (62)	38% (74)	32% (97)	37% (119)	33% (352)

Males significantly greater than females based on logistic regression. No significant gender by age interaction.

*Denominator shown in parentheses.

TABLE 6

Estimated Incidence of Work-Related And Nonwork-Related Asthma (per 10,000 person-yr of observation) Among Members Aged 15 to 55 of Kaiser Permanente Northwest for the Year 2000

	Age (yrs)				Total
	15–25	26–35	36–45	46–55	
Work-related asthma					
Men	22	37	28	22	27
Women	10	35	32	40	31
Total	15	35	28	31	28
Nonwork-related asthma					
Men	43	37	35	34	37
Women	83	76	78	71	75
Total	64	58	59	53	58

an “incidence” of work-related asthma in this age range of 28 per 10,000 person-years of observation.

This study has several strengths. It made use of automated medical records information from a well-defined population and used industrial hygienist 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 latter 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 potentially 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, although we are reasonably confident of our ability to identify prevalent asthma,²⁴ 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 “ruleout” diagnoses and also had a medical records technician review each suspected incident case. Nonetheless, 9% of those interviewed denied having had a recent healthcare visit for breathing problems. Second, although our IH assessment should represent a considerable improvement over traditional epidemiologic approaches, it is no substitute for a detailed industrial hygiene investigation of the workplace, which is the “gold standard” for determining workplace exposure to an asthmagenic agent. Third, our original work-relatedness score, as previously noted, may overestimate the

presence of work-related triggers. Finally, we completed full interviews on only 43% of those we attempted to reach. Work exposures for the remainder may differ systematically from those interviewed. We do know that nonresponders were slightly younger on average and were more likely to be male.

We believe our algorithm, originally proposed by Milton et al,²⁰ represents a rigorous attempt, from an epidemiologic perspective, to implement the NIOSH case definition algorithm.¹⁹ 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. Still, it should not be used to attribute work-relatedness on an individual level. More accurately, it should be viewed as suggesting the potential for work-relatedness.

This study also raises a number of interesting methodological issues concerning the epidemiologic classification of work-related asthma. Had we used only the IH classifications, 142 individuals (40% of the sample) would have been classified as having possible or definite asthmagenic exposures at work, and yet 32 of these individuals (23%) scored zero on the work-relatedness score and thus should have a low likelihood of having work-related asthma. Even for the 58 individuals with an IH score of 2, 15 (26%) still had a work-relatedness score of zero. Similarly, 46% of individuals with a nonzero work-relatedness score had an IH score of zero (45% 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 52% of the suspected work-related cases fell into the most marginal evidence category, the (1,1) cell in Table 3, raises the likelihood that many of these individuals are still misclassified. Even if only half of these individuals

were misclassified, the proportion of individuals classified as having work-related asthma would drop from 33% to 24%. If we had classified this whole category as “weak” instead of “moderate” evidence, the proportion would be reduced further to 16%. We suspect that the lower figures may be more accurate, because one of the categories of the work-relatedness scale appears to lack specificity. For example, although 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 96% 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 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 would be reduced to 9%. Although this figure almost certainly reflects an overly conservative estimate, these results illustrate the sensitivity of the estimates in Table 5 to changes in our classification algorithm. 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).

Although the question about work-related triggers may lack specificity, the alternative of requiring a trigger that is present only at work probably errs in the opposite direction. If someone is sensitized to an agent, we expect him or her to report responding to that same agent in more than one location, eg, at work and away from work. In a situation in which 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 and yet, as seen with studies of baker apprentices, it is not until they enter the workplace that they develop extreme allergies to wheat. A person being interviewed in such a case 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,²⁰ because we have essentially replicated their protocol on a larger scale and with a different population. Our estimate for the overall “incidence” of adult-onset asthma is more than twice that reported by Milton (86 vs 37 per 10,000), although our estimate of the proportion of these cases that truly represent new-onset asthma is lower than Milton’s (21% vs 35%). In both studies, the proportion of asthma estimated to be work-related is high relative to typical reports in the literature (Milton et al reported 21% vs our 33%, P value = 0.09), although they are consistent with estimates from a recent study from Finland (29% for men and 17% for women).²⁵ Even the revised estimates presented in our sensitivity analysis, although lower, were still generally higher than the typically reported range of 5% to 15%. Milton et al²⁶ 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 (and hence more in line with the estimates reported here).

In summary, this study of adult-onset asthma among members of a large HMO in the northwest United States generally corroborates the findings from a similarly conducted analysis in the northeastern United States 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.

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