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Nonfatal Work-Related Inhalations: Surveillance Data From Hospital Emergency Departments, 1995–1996

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Background *Data from a stratified sample of hospital emergency rooms in the USA were used to describe nonfatal work-related inhalation injuries and illnesses during July 1995 to July 1996.*

Methods *Information was abstracted from emergency room records by the Consumer Product Safety Commission (CPSC) as part of the National Electronic Injury Surveillance System (NEISS) for all work-related injuries and illnesses regardless of product involvement.*

Results *There were an estimated 44,423 occupational inhalation cases nationwide, with an annual rate of 3.6 cases/10^4 workers/year. The rate for men (4.4 cases/10^4) was greater than that observed for women (2.6 cases/10^4), and the rates tended to decline with increasing age. An estimated 4.6% of the cases were hospitalized for further treatment. The highest rate by industry was 16.4 cases/10^4 for public administration (which included fire and police departments). Among non-firefighters, there were an estimated 6,470 cases nationwide in which respiratory symptoms or conditions were noted, which yielded an annual rate of 0.5 cases/10^4 (95% CI 0.3, 0.7). Chlorine compounds were a common agent for the cases with adverse respiratory outcomes.*

Conclusions *The NEISS data provide an efficient method to learn about the national frequency of work-related inhalation injuries and illnesses. The National Institute for Occupational Safety and Health (NIOSH) is exploring two ways to use these data: first, to routinely review the reports to conduct surveillance for work-related inhalation cases; and second, to consider working with CPSC to conduct follow-back interviews of selected cases in order to learn more about the circumstances of the exposure, prior training of the case, and outcome of the exposure.* Am. J. Ind. Med. 38:140–148, 2000.

KEY WORDS: occupational exposure; airborne contaminants; inhalations; emergency department; surveillance

INTRODUCTION

The respiratory tract is a common route of entry for harmful occupational exposures. For example, among work-related cases referred to a regional poison control center, 57% reported exposure by inhalation [Blanc et al., 1989]. Short-term exposures to airborne contaminants in the workplace can result in a range of acute and chronic respiratory effects. Based largely on case-reports and case

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series from occupational settings, the adverse respiratory outcomes include bronchiolitis fibrosa obliterans, pneumonitis, bronchiectasis, and reactive airways dysfunction syndrome (RADS) [Kass et al., 1972; Segev et al., 1983; Brooks et al., 1985a, 1985b; Epler et al., 1985; Boulet, 1988; Kraut and Lilis, 1988; Lerman and Kipen, 1988; Slutzker et al., 1989]. Also, studies in a particular industry (e.g., mills that produce pulp for paper) have reported the development of possible chronic changes in spirometry [Kennedy et al., 1991; Henneberger et al., 1996] and airway hyperresponsiveness among workers exposed to chlorine or other airborne irritants [Bhérer et al., 1994; Kremer et al., 1994; Malo et al., 1994]. In addition to damaging the respiratory tract, inhaled toxic substances can act as asphyxiants and/or have systemic effects [Weiss and Lakshminarayan, 1994]. For example, exposure to carbon monoxide is a common cause of asphyxiation, while inhaled pesticides can adversely impact the neurologic system.

Surveillance systems for occupational respiratory diseases that include acute inhalation injuries and their sequelae are currently implemented in the United Kingdom [Meredith and McDonald, 1994; Meredith et al., 1991; Ross et al., 1995; Sallie and McDonald, 1996] and Canada [Contreras et al., 1994]. The Sentinel Event Notification System for Occupational Risks (SENSOR) is a surveillance program in the United States coordinated by the National Institute for Occupational Safety and Health (NIOSH) that has attempted to identify cases of work-related injuries and illnesses, including occupational asthma and RADS [Levy et al., 1992]. However, this program is limited to a few states and does not include the full range of inhalation cases. There has been no nationwide study in the USA of workplace inhalation injuries and illnesses.

The primary goal of the present study is to describe nonfatal work-related inhalations that required treatment in hospital emergency departments in the USA and its territories during 1995–1996. The data are from a probability sample of hospital emergency departments and were collected as part of the National Electronic Injury Surveillance System (NEISS) conducted by the Consumer Product Safety Commission (CPSC). NEISS was selected, in part, because unlike many surveillance systems for occupational morbidity, the identification of cases is not limited to a particular region of the country, occupational group, or industry sector. In addition to describing the cases, another goal of this study is to evaluate the usefulness of these data for identifying and preventing occupational lung diseases.

MATERIALS AND METHODS

Data Source

NEISS is an ongoing nationwide surveillance effort using a national probability sample of hospital emergency rooms, that is conducted by the CPSC to provide timely identification of unsafe products. NIOSH has worked in collaboration with the CPSC since the 1980s to collect information on all occupational injury and illness cases. The most prominent modification to NEISS for the surveillance of occupational injuries and illnesses was that all work-related cases are included, regardless of product involvement. NIOSH-sponsored NEISS activities were initiated in 1981 and then discontinued at the end of 1986. In July 1992, NIOSH established a new inter-agency agreement to obtain data on occupational injuries and illnesses from NEISS. At first, only certain age and industry groups were targeted for data collection. Then in July 1995, the agreement between NIOSH and CPSC was expanded to include occupational cases among workers of all ages and industries. The present study utilizes one year of NEISS data, from July 15, 1995, through July 14, 1996.

The 65 hospitals participating in NEISS were selected from a probability sample of all hospitals in the United States and its territories, stratified by hospital size (i.e., annual number of emergency department visits) and geographic area [Marker et al., 1988; US CPSC, 1992]. The NEISS data were abstracted from emergency department records by trained personnel using protocols and forms provided by the CPSC. The data abstracted for each case were based on the first visit to a hospital emergency department for a given incident, but not on follow-up visits related to the same incident. Additional details of the data collection have been previously described [Layne et al., 1994]. The cases selected for NIOSH were only those identified with work-related injuries and illnesses. There were a number of coded variables for each case that included information on standard demographic features (e.g., age, sex, race), the exposure incident (e.g., agent, locale), physician's diagnosis, and emergency room discharge status. Also, there were free-text variables for the patient's occupation and industry, and a two-line narrative description of the relevant incident used to supplement information from other variables and provide greater detail about the circumstances or etiology of the injury or illness.

Case Ascertainment

A case was defined as any individual who had an occupational injury or illness due to inhalation of a harmful substance. An occupational injury or illness was defined as being sustained during work performed for pay or other compensation, regardless of eligibility for workers' compensation [Jenkins et al., 1993]. The definition included persons injured or made ill at home or at a family business if they were being compensated for their services, or while performing volunteer work for an organization like a fire department, hospital, or charity group. An inhalation injury or illness was defined as any case involving inhalation of

harmful substance(s) from chemical, mineral or organic sources, that occurred in confined and non-confined spaces.

Work-related case listings were not considered if any one of the following were observed: (a) case was a duplicate listing, (b) sex or age was not indicated, (c) the patient died during transfer to the hospital or in the emergency room, (d) the patient was in the military. Selection among the remaining work-related cases was achieved in a two-step process which relied on the injury event and diagnosis variables, and the free-text comments. First, potential cases were selected whose injury event or diagnosis codes indicated that a harmful substance was inhaled, or whose comments included a keyword consistent with an inhalation event. Examples of keywords sought in the comments included fume, vapor, gas, inhalation, respiratory, and lung. Second, each potential case identified in the first step was reviewed and assigned to one of three categories. A case was classified as: (1) ''confirmed inhalation'' when (a) the injury event and/or diagnosis indicated inhalation of a harmful substance, or (b) when an inhalation incident was *clearly stated* in the comments; (2) ''possible inhalation'' when (a) the diagnosis did not clearly specify whether it was an inhalation or an ingestion, and the comments were not informative, or (b) an inhalation incident was *suggested* in the comments, but neither the injury event nor diagnosis were coded for inhalation; and (3) ''no inhalation'' when none of the above criteria was met. The review of all potential cases in Step 2 was accomplished by one researcher, with checks for consistency conducted on a random sample of the cases by another researcher.

Additional Data Coding and Recoding

The source-of-injury variable indicates which substance, object, or exposure directly produced the injury or illness. To quantify this variable for tabulated presentation, the two-line narrative description of the injury event was manually reviewed and assigned a code by one researcher. A random sample of cases was then selected and checked by another researcher.

Information from the free-text variables on industry and occupation was used to assign codes according to the Standard Industrial Classification and Standard Occupational Classification of the U.S. Department of Labor [US DOC, 1980; US EOP, 1987]. While information for coding industry (i.e., type of business where individual worked) was reported for a majority of the cases, information for occupation (i.e., job title) was missing for about 29% of the cases. Therefore, we did not consider occupation in the analyses except for making the distinction between firefighter and all other.

There was concern that many records might not include which specific symptoms or conditions were associated with the inhalation events. Primarily based on the free-text comments, each case was evaluated as to whether there was mention of respiratory symptoms or diseases (e.g., cough, wheeze, shortness of breath, chest tightness, hypersensitivity pneumonitis), mucous membrane symptoms (e.g., burning of eyes, nose, or mouth), anoxia or general symptoms (e.g., headache, nausea, dizziness, unconsciousness), or no symptoms. This is similar to an approach used by Blanc and colleagues [1991] to summarize symptoms among inhalation cases reported to a regional poison control center.

Statistical Analysis

National estimates of nonfatal occupational inhalation injuries and illnesses that required emergency department visitation were computed using a statistical weight appended to each case record [US CPSC, 1994, 1996]. The weighting factor for each case was calculated as the inverse probability that the hospital emergency room in which they were treated was selected from the sampling frame. National estimates and confidence intervals were not calculated based on cells of less than 20 cases, nor for extrapolated estimates with a coefficient of variation $> 33\%$ [US CPSC, 1996]. With the larger and more stable estimates, standard errors used for the calculation of the confidence intervals were derived using the Taylor series method of SUDAAN V7.5.1, which provides a mechanism to incorporate the stratification and clustering of the sample design. Sex, age, and industry-specific rates were computed using the 1995 annual average data for civilian full-time employees from the Bureau of Labor Statistics' Current Population Survey as the denominator [US DOL, 1996]. We attempted to model hospital admissions using logistic regression, but were unable to implement this analysis due to small cell sizes.

RESULTS

A total of 541 cases of work-related inhalations (519 confirmed and 22 possible cases) were reported by the emergency departments during the 12 months from July 15, 1995 to July 14, 1996, leading to an annual national estimate of 44,423 cases (95% CI 35,984–52,862). The annual rate (based on the national estimate) was 3.6 inhalation cases per 10^4 workers. The distribution by sex, race, and age was nearly the same for both the actual cases observed and the national case estimates. Specifically, about two-thirds of the cases were male, and almost three-fourths were white (Table I). Age at the time of emergency care ranged from 16 to 74 years, with a mean of 35.1 and a median of 34 based on the national case estimates.

On average, females were slightly older than males, with mean ages of 36.6 and 34.3 years, respectively (mean difference = 2.3, 95% CI 2.0, 2.5). Table II presents national

TABLE I. Work-Related Inhalation Injuries and Illnesses by Demographic Characteristics—Number of Cases Observed and National Estimates, USA 1995—1996

	Cases observed		National case estimates		
Characteristic	**n**	**%**	**$\hat{N}$**	**95% CI**	**%**
Sex					
Female	176	32.5	15,040	± 3,895	33.9
Male	365	67.5	29,383	± 6,152	66.1
Total	541	100.0	44,423	± 8,439	100.0
Race					
White	400	73.9	32,927	± 7,752	74.1
Black	56	10.4	4,121	± 1,531	9.3
Other/Unknown	85	15.7	7,375	± 4,572	16.6
Total	541	100.0	44,423	± 8,439	100.0
Age					
16–24	114	21.1	9,618	± 2,309	21.7
25–34	158	29.2	12,869	± 2,867	29.0
35–44	156	28.8	12,406	± 3,071	27.9
≥ 45	113	20.9	9,530	± 3,289	21.5
Total	541	100.0	44,423	± 8,439	100.1

TABLE II. National Rates for Work-Related Inhalation Injuries and Illnesses by Sex and Age, USA 1995—1996

	Female		Male		Total	
Age, years	**Rate[a]**	**95% CI**	**Rate[a]**	**95% CI**	**Rate[a]**	**95% CI**
16–24	3.5	1.4, 5.5	6.6	4.6, 8.6	5.1	3.6, 6.6
25–34	2.5	1.4, 3.6	5.2	3.7,6.7	4.0	2.9, 5.1
35–44	2.6	1.5, 3.8	4.5	3.2, 5.8	3.6	2.6, 4.6
≥ 45	2.3	1.3, 3.2	2.5	1.8, 3.3	2.4	1.7, 3.1
Total	2.6	1.9, 3.3	4.4	3.3, 5.4	3.6	2.8, 4.4

[a]Rate is per 10,000 employed persons, with the number of employed persons based on the Bureau of Labor Statistics' Current Population Survey.

inhalation rates by sex and age. Young men aged 16–24 had the highest rate with 6.6 cases per 10^4 workers, and rates in men declined with increasing age. The age-specific rates were consistently greater for men vs. women, but the extent of this difference varied across age groups. Male rates were about twice the female rates for those under 35 years, but then the contrast declined with advancing age. Similar age- and sex-specific rates were observed for both white and black workers (results not shown).

The distribution of work-related inhalation injuries and illnesses by industry type is presented in Table III, along with the corresponding rates. The highest percentage of inhalation cases occurred in the service (22.9%) and public administration industries (22.0%), with annual national estimates of 10,177 and 9,762, respectively. However, these two industries had very different rates. Service workers, including health care workers, had the lowest industry-specific rate at 2.0 inhalations per 10^4, while workers in public administration, including firefighters and police, experienced the highest industry-specific rate with 16.4 inhalations per 10^4. Within the services industry, the subcategory of health care workers accounted for 42.8% of the injuries and illnesses, and had a rate of 4.0 cases per 10^4 (95% CI 2.5, 5.5), which was only slightly higher than the overall rate of 3.6 per 10^4. Within public administration, firefighters and police considered as a separate group had a very high rate of 31.5 inhalations per 10^4 (95% CI 17.3, 45.7).

The second highest rate by major industry group was experienced by transportation/public utilities (4.9 cases per 10^4). The manufacturing industry accounted for the third largest number of cases and the third highest rate. The sub-

TABLE III. Numbers and Rates of Work-Related Inhalation Injuries and Illnesses by Industry Type—National Estimates, USA 1995–1996

Industry	$\hat{N}$	95% CI	%	Rate[a]	95% CI
Manufacturing	6,782	± 3,130	15.3	3.3	2.3, 4.3
Transportation/Public utilities	4,252	± 1,909	9.6	4.9	2.7, 7.1
Wholesale/Retail trade	5,471	± 2,477	12.3	2.1	1.4, 2.8
Services	10,177	± 3,134	22.9	2.0	1.4, 2.5
Health services	4,352	± 1,607	9.8		
Business and education svcs	3,122	± 1,543	7.0		
Public administration	9,762	± 3,973	22.0	16.4	11.5, 21.3
Executive and legislative	1,391	± 760	3.1		
Police/Correctional institutions	3,033	± 1,621	6.8		
Fire departments	4,206	± 2,456	9.5		
Other[b]/Unknown	7,979	± 2,703	18.0	[c]	
Total	44,423	± 8,439	100.0	3.6	2.8, 4.4

[a]Rate is per 10,000 employed persons, with the number of employed persons based on the Bureau of Labor Statistics' Current Population Survey.
[b]Includes the agriculture/forestry/fishing and construction industries (national estimates not provided since less than 20 cases were observed).
[c]Rate not calculated due to the cases classified as unknown.

industry categories of primary metals and chemical and allied products accounted for 23.8 and 13.2%, respectively, of the cases within the manufacturing industry. The wholesale/retail trades industry had the fourth largest number of injuries and illnesses, with eating and drinking establishments (29.9%) and food stores (24.9%) comprising the largest percentage of cases within this major industry division. The agriculture/forestry/fishing and construction industries accounted for 3.5 and 3.1% of all cases, respectively, but these categories are not shown in Table III as neither contained the required 20 cases to make extrapolated estimates.

Public property ($\hat{N} = 23{,}077$, 95% CI ± 6,150;52.0%) was the most common locale of exposure incident, followed by industrial sites ($\hat{N} = 12{,}001$, 95% CI ± 4,318; 27.0%). Public property includes a variety of worksites, such as stores, office buildings, restaurants, and medical facilities. Unfortunately, the NEISS coding scheme does not subdivide the large public property category to provide more exact information on locale. While information on locale was missing for only 7.4% of workers other than firefighters, it was missing for 31.0% of the firefighters.

Table IV presents the distribution of sources of inhalation among non-firefighters. The information on sources was

TABLE IV. Sources of Work-Related Inhalation Injuries and Illnesses (excluding Firefighters)—Number of Cases Observed and National Estimates, USA 1995–1996

	Cases observed		National case estimates		
Source	n	%	$\hat{N}$	95% CI	%
Chemicals	186	39.4	16,582	± 4,463	41.2
Acids and ammonium compounds	29	6.1	2,801	± 1,513	7.0
Chlorine	23	4.9	2,119	± 1,372	5.3
CO, CO_2, engine exhaust	87	18.4	7,789	± 2,946	19.4
Chemical product/use	134	28.4	11,294	± 3,579	28.1
Bleach, incl. mixtures	35	7.4	3,121	± 1,641	7.8
Plastics, paints, resins, solvents, degreasers	31	6.6	2,600	± 1,683	6.5
Minerals and products	58	12.3	5,133	± 2,293	12.8
Fire smoke	80	16.9	6,124	± 2,160	15.2
Other/unknown	14	3.0	[†]		2.7
Total	472	100.0	40,217	± 7,607	100.0

[†] National estimate not provided since less than 20 cases were observed.

very complete, with data totally missing in less than 1% of the cases. Over two-thirds of the inhalations (69.3%) were due to chemicals or chemical products, while fire smoke and minerals and products accounted for 15.2 and 12.8% respectively (Table IV). The subcategory that included carbon monoxide, carbon dioxide, and engine exhaust was the most common source of inhalation among the subcategories, with an annual estimate of 7,789 cases (19.4% of the non-firefighter total). Another 8,041 cases (95% CI ± 2,765), or 20.0% of the non-firefighters, were attributed to several common irritants: acids, ammonium compounds, chlorine, and bleach. Chlorine compounds accounted for 5,240 (13.0%) of the cases, with 2,119 attributed to chlorine and 3,121 involving bleach. Cleaning agents other than bleach were identified as the source in another 3.9% of the cases. When inhalations due to bleach or other cleaning agents ($\hat{N} = 4{,}686$, or 11.7% of 40,217) were examined by industry subcategories, 24.7% occurred in food stores and eating and drinking establishments (both in the retail trades industry), comprising 38.6% of all sources of inhalation in these two industry subcategories. An additional 22.1% of inhalations involving bleach or other cleaning agents occurred in hospitals and other medical facilities, accounting for 23.8% of all sources of inhalation in these facilities.

To evaluate the usefulness of these data to describe the adverse effects of inhalation events, each of the non-firefighter cases was reviewed to determine whether specific symptoms or conditions related to the inhalation event were mentioned. About two-thirds of the records ($\hat{N} = 27{,}128$; 95% CI ± 6,503; 67.5% of 40,217) included a description of symptoms or conditions suffered by the patient. Over half of the records ($\hat{N} = 21{,}166$; 95% CI ± 5,541; 52.6%) mentioned anoxia or general symptoms such as headache, dizziness, or nausea. A smaller proportion of records specifically mentioned respiratory symptoms or diseases ($\hat{N} = 6{,}470$; 95% CI ± 2,374; 16.1%) and mucous membrane symptoms ($\hat{N} = 2{,}722$; 95% CI ± 1,239; 6.8%). There were 3,213 cases (95% CI ± 1,262; 8.0% of 40,217) whose records mentioned more than one of the three types of symptoms. Based on the number of non-firefighter workers nationwide, the annual rates for these three outcomes were 1.7 cases per 10^4 (95% CI 1.3, 2.1) for anoxia and general symptoms, 0.5 cases per 10^4 (95% CI 0.3, 0.7) for respiratory conditions, and 0.2 cases per 10^4 (95% CI 0.1, 0.3) for mucous membrane symptoms.

An examination of the causal agents among cases that mentioned respiratory symptoms or diseases was difficult given the relatively small number of cases for most of the categories. Chlorine compounds (i.e., a combination of the chlorine and bleach categories in Table IV) were common, accounting for 22.5% of the respiratory cases. While carbon monoxide, carbon dioxide, and engine exhaust was the most common single source for all cases with 19.4% of all inhalation injuries and illnesses, it was noted in only 3.5% of the respiratory cases.

Hospitalization was required for 4.6% of all work-related inhalation cases ($\hat{N} = 2{,}029$, 95% CI ± 1,323) and 4.8% of the non-firefighter cases. Among non-firefighters, the hospitalized cases were similar to other cases in age (median age of 34 years for both groups), but were somewhat more likely to be male (72.5% vs. 63.0%) and white (95.6% vs. 72.7%). Of hospitalized cases (excluding firefighters), the source of inhalation with the greatest percentage was carbon monoxide, carbon dioxide, and engine exhaust, which comprised 53.6% of all cases. The records of hospitalized cases were more likely to mention specific symptoms or conditions than were those of the non-hospitalized cases (78.8% compared to 66.9%, respectively), and also more likely to mention anoxia or general symptoms such as headache, dizziness, or nausea (69.1% compared to 51.8%, respectively).

DISCUSSION

We reported an estimated total of 44,423 work-related inhalation injuries and illnesses using a national probability sample of hospital emergency departments in the USA during the 1 year period, July 15, 1995 to July 14, 1996. This yielded an average annual rate of 3.6 cases per 10,000 employed persons. This is very similar to the average annual rate of 3.4 inhalation cases per 10,000 employed persons that was observed when NEISS data collected in 1982–1986 were evaluated using methods similar to the current study (unpublished data).

Toxic materials that are inhaled can act as irritants, asphyxiants, and/or systemic toxins [Weiss and Lakshminaraya, 1994], and examples of each were observed in the current study. Common respiratory irritants noted in Table IV include acids, chlorine gas and bleach, and ammonium compounds, and accounted for 20.0% of the inhalation sources among non-firefighters. The source category of carbon monoxide, carbon dioxide, and engine exhaust represents common asphyxiants and accounted for another 19.4% of the non-firefighter cases. Non-cyanide pesticides commonly have systemic effects on the neurologic system, but pesticide exposure was uncommon in this cohort. Neurologic effects could also be associated with exposures to various chemical products, including plastics, resins, paints, varnish, solvents, and degreasers (6.5% of the non-firefighter cases as listed in Table IV).

The current study identified chlorine compounds as common causal agents for cases with respiratory problems. Chlorine was also identified as the most common specific cause of inhalation accidents by the SWORD project in the UK for the years 1989–1991 [Meredith and McDonald, 1994]. From a study of irritant inhalation cases identified in a regional poison control center in California, chlorine gas

and bleach mixtures were the most frequently reported exposure [Blanc et al., 1994]. These findings are a testimony to the irritant capabilities of chlorine and its widespread use.

It is possible that NEISS over-samples or under-samples certain industries. For example, health service workers might be more inclined to seek care and/or have easier access to hospital emergency departments than workers in other industries, resulting in an over-representation in the NEISS sample. In this study, the small number of cases identified in the chemical industry did not provide an adequate sample size for extrapolation to the national level or more detailed analysis. This finding is not consistent with the results from the surveillance of work-related and occupational respiratory diseases (SWORD) in the United Kingdom where chemical processors had the highest injury rates [Sallie and McDonald, 1996]. On the other hand, Blanc et al. [1994] demonstrated that prior chemical safety training was significantly protective against closed space inhalation. Such training, as well as availability of non-hospital emergent care within the chemical industry, may be responsible for the small number of cases. While the agriculture/forestry/fishing industry accounted for only 3.5% of all cases, this might be an underestimate since the greater distances that many rural residents must travel to reach the nearest hospital might discourage use of emergency medical departments [McKee et al., 1990].

Different surveillance systems of respiratory diseases have been used to estimate the number of work-related inhalation injuries and illnesses in the United States and other countries, but none of them provides a complete census of cases. The present study based on hospital emergency room patients underestimates the total number of work-related inhalation cases due to people seeking treatment in other medical venues. An investigation conducted by the National Center for Health Statistics in 1975 found that 36% of work-related injuries are treated in emergency rooms. [Ries, 1978]. Unpublished analyses of data from the 1998 Occupational Supplement of the National Health Interview Survey reveal that a similar percentage of all occupational injuries which require medical treatment beyond first aid are initially treated in hospital emergency departments. A study comparing treated vs. reported toxic exposure found that only 26% of the inhalation cases presented to a hospital emergency department were referred to their regional poison control center [Harchelroad et al., 1990]. On the other hand, Blanc et al. [1994] noted that only 54% of work-related inhalation cases reported to a poison control center were identified through an emergency department visit.

There is evidence that systematic review of emergency room records provides a more complete count than surveillance based on physician reports. In the current study of hospital emergency room cases in the United States, the rate for respiratory effects of inhalation events was 0.50 cases per 10^4. Lower overall rates for acute inhalation were reported in other industrialized nations based on voluntary reports of occupational respiratory diseases by physicians. Specifically, the SWORD project in the UK and a similar surveillance system in Canada estimated that 3 and 2 inhalation injuries occurred per million working population per year, respectively [Meredith et al., 1991; Contreras et al., 1994]. These figures are an order of magnitude less than the estimate from the current study. However, the different surveillance systems probably capture different types of cases. Hospital emergency care is likely to capture respiratory cases regardless of the severity of the acute event and of the secondary complications. In contrast, cases with chronic respiratory symptoms following an acute inhalation are more likely to be referred to physicians for ongoing care. Based on cases of occupational inhalation referred to a regional poison control center, Blanc et al. [1994] reported that the presence of continuing respiratory symptoms was not associated with emergency care. This suggests that surveillance based solely on hospital emergency department records would not identify many severe occupational inhalation cases that require ongoing care.

A more complete count and characterization of work-related inhalation injuries and illnesses could be achieved with a surveillance system that coordinated reports from hospitals, physicians, clinics, poison control centers, and company-based or company-contracted medical services. This could provide not only an increase in the sensitivity of the surveillance system, but also information concerning the severity of the cases as derived from the medical records of subsequent visits for treatment. However, the necessary level of cooperation from participating organizations and access to personal identifiers needed to link data among different sources makes such a comprehensive surveillance system unlikely in the United States.

In the present study, NIOSH collaborated with the CPSC to obtain specific descriptions of the inhalation event as well as the patient's industry classification at the time of the visit to the hospital emergency department. This surveillance system has the advantage of providing readily accessible information on occupational inhalations, reducing the potential for non-participation and poor recall. The inherent limitation is the failure to capture cases referred to private physicians and other medical facilities. When assessing the quality of the NEISS data, we found that the information for exposure incident and work-related variables was adequately complete except for incident locale among firefighters and patient's occupation. More detailed information for firefighter injuries, however, is available from the National Fire Incident Reporting System (NFIRS), maintained by the United States Fire Administration of the Federal Emergency Management Agency. Although information on the causal inhalant was generally available from the description of the exposure incident, it was necessary to manually review these comment fields to code each case.

This, however, demonstrates the value of automating narrative information in public health surveillance systems as the findings were an integral component of this research effort. Additional information on the severity of the acute episode is needed in order to identify cases that would potentially develop respiratory sequelae. Severity criteria other than hospitalization have to be defined, based on clinical symptoms, inhalant characteristics, and underlying respiratory disease.

Despite limitations, NEISS data from hospital emergency departments appear to be a useful source of information for surveillance of work-related inhalation injuries and illnesses in terms of accessibility to and quality of data. At least two applications of the data are currently being evaluated by NIOSH. First, an ongoing surveillance system could be used as a sentinel to identify industries that experienced inhalation cases, and causal agents that are most frequently encountered. Second, follow-back interviews of the selected cases may be appropriate to describe in more detail (1) the circumstances of the inhalation events in the workplace, e.g., work history, work activity directly involved with the incident, misuse or dysfunction of equipment, and length of exposure; (2) existence of safety training and use of protective devices, e.g., respirator use and ventilation; and (3) medical care received before visiting the hospital emergency rooms. A better understanding of the high-risk populations for inhalation injuries and illnesses in the workplace is needed to target and implement preventive measures.

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