

Work-Related Reactive Airways Dysfunction Syndrome Cases from Surveillance in Selected US States

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Learning Objectives

- Distinguish between reactive airways dysfunction syndrome (RADS) and other cases of work-related asthma (WRA) associated with a known asthma-inducing agent.
- Contrast the clinical features, severity, and course of RADS with those of other WRA related to an identified asthma inducer.
- Identify differences in outcome and disposition between RADS and other WRA.

Abstract

The objective was to elaborate the descriptive epidemiology of work-related cases of reactive airways dysfunction syndrome (RADS). Cases of work-related asthma (WRA) were identified in four states in the United States during 1993–1995 as part of the Sentinel Event Notification Systems for Occupational Risks (SENSOR). Information gathered by follow-back interview was used to describe 123 work-related RADS cases and to compare them to 301 other WRA cases whose onset of disease was associated with a known asthma inducer. RADS represented 14% of all new-onset WRA cases identified by the state SENSOR surveillance systems. RADS cases had significant adverse medical and occupational outcomes identified by follow-back interview. In particular, 89% still had breathing problems, 78% had ever sought emergency care and 39% had ever been hospitalized for work-related breathing problems, 54% had applied for worker compensation benefits, and 41% had left the company where they experienced onset of asthma. These values equaled or exceeded the comparable figures for those WRA cases whose onset was attributed to a known inducer. Work-related RADS represents a minority of all WRA cases, but the adverse impact of this condition appears to equal that of other WRA cases. (J Occup Environ Med. 2003;45:360–368)

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Reactive airways dysfunction syndrome (RADS) is characterized by the sudden onset of asthma symptoms after a single intense exposure to irritant chemicals.¹ In contrast, others experience asthma onset at varying amounts of time after initial exposure to sensitizing agents. Some of the population-based studies and surveillance programs that focus on work-related asthma (WRA) have enumerated and described cases of RADS or irritant-induced asthma. These include reports from the United States,^{2–5} Canada,^{6,7} the United Kingdom (UK),^{8,9} and South Africa.¹⁰ The largest RADS surveillance case series was based on data collected during 1993–1995 in the United States as part of the Sentinel Event Notification Systems for Occupational Risks (SENSOR).² The National Institute for Occupational Safety and Health (NIOSH) coordinates the state-based SENSOR programs and compiles information on cases from the participating states. During 1993–1995, SENSOR surveillance in four states identified 1101 people with WRA, including 210 with work-aggravated asthma and 891 with new-onset WRA. The new-onset cases included 301 (34%) with occupational asthma due to a known asthma inducer, 467 (52%) with occupational asthma due to an unknown inducer, and 123 (14%) with RADS.² The article based on the 1993–1995 SENSOR WRA cases did not include all the descriptive data collected by the four state programs. We used some of this additional information to further

elaborate the descriptive epidemiology of RADS and to compare features between the 123 individuals with RADS and the 301 other WRA cases whose symptoms developed after exposure to known asthma inducers. Features we examined included industry and occupation, personal and family history of allergies, agents, asthma-related use of emergency and hospital care, and cessation of exposure/change in employment status.

Methods

Case Identification and Follow-Up

Details on how SENSOR WRA cases were identified in Michigan, New Jersey, Massachusetts, and California have been published elsewhere.^{2,3,11,12} All four states have laws that require physicians to report occupational diseases, and these reports are the principal data source for WRA surveillance. Potential cases are also identified by actively soliciting hospital reports and discharge records and reviewing worker compensation claims. Michigan and New Jersey mandate reporting by hospitals. The state-based surveillance staff contact potential cases of WRA and ask them to complete standardized questionnaires. The questionnaires vary somewhat by state, with certain core questions that are common to all four programs and other questions that are unique to a subset of them. The information collected by all four states includes demographic characteristics, the pattern of asthma symptoms in relationship to work, the exposures at work that are associated with asthma symptoms, the industry and occupation of the affected person, individual and family history of allergies, and consequences of the suspected WRA (eg, care sought, whether they left work, and whether they applied for worker compensation benefits). This information is used by the state-based staff to determine which workplaces to target for intervention. Up to three

agents are coded for each case, using a coding system that was developed for the Association of Occupational and Environmental Clinics (AOEC).¹³ The agent categories reported in the current analysis were based on the AOEC coding scheme. We created two inclusive agent categories: "cleaning materials" included bleach, cleaning materials not otherwise specified (nos), and metal polish; "diisocyanates" included toluene diisocyanate, methylene diisocyanate, naphthalene diisocyanate, hexamethylene diisocyanate, and diisocyanate nos. The self-reported information about jobs was coded using the 1987 Standard Industrial Classification for industry and the 1990 US Bureau of the Census codes for occupation. In addition to the interviews, individual medical records are routinely requested by the SENSOR programs in Michigan and New Jersey to look for objective physiologic evidence of asthma and the work-relatedness of the condition.

Case Definition and Classification

The SENSOR surveillance guidelines for WRA include three components: a general reporting guidance, a surveillance case definition, and a decision logic and case classification scheme.² The case definition for WRA requires a health care professional's diagnosis of asthma or a related diagnosis consistent with asthma and an association between symptoms of asthma and work. Cases are then divided into those with work-related exacerbations of a preexisting asthma condition (work-aggravated asthma) and asthma induced by workplace exposures (new-onset asthma). Individuals with work-aggravated asthma must have had symptoms of or treatment for asthma during the 2 years before entering a new work setting and then experienced increased asthma symptoms or increased use of asthma medications after entering that new

work setting. People who previously had asthma, then did not have asthma symptoms or treatment for asthma during the 2 years before entering a new work setting and finally developed WRA in that new work setting would be classified as new-onset cases. The individuals with new-onset WRA were further separated into two groups: RADS and occupational asthma. RADS was defined as the onset of new asthma symptoms within 24 hours after a single high-level inhalation exposure at work to an irritant gas, dust, fume, smoke, or vapor with the symptoms persisting for at least 3 months.^{1,2} This surveillance case definition is less dependent on objective findings than the usual clinical definition of RADS. In particular, the clinical criteria for RADS as noted by Brooks and colleagues include a positive methacholine challenge test and the fact that pulmonary function tests may reveal airflow obstruction.¹ Occupational asthma was defined as new-onset asthma where symptoms were related to work and the condition did not meet the RADS criteria. Occupational asthma was then subclassified according to whether the suspected agent was a known asthma inducer, in particular whether the agent had been documented in the medical literature to cause occupational asthma,¹⁴⁻¹⁶ and whether there were objective pulmonary changes in relation to work. For the current analysis, the 301 new-onset occupational asthma cases with exposure to a known asthma inducer provided a comparison group for the RADS cases and will subsequently be referred to as having "other WRA." As with the RADS case definition, it was not necessary for the other WRA cases to have pulmonary function evidence of asthma and work-relatedness.²

Data Management and Analysis

Data management and analysis were accomplished using SAS statistical software for personal computers.¹⁷ In order to test for statistical

significance, we used the χ^2 , continuity corrected χ^2 , and Fisher's exact test for categorical data and *t* test for continuous data.¹⁸ *P* values less than or equal to 0.05 were considered statistically significant unless otherwise noted.

Results

Source of Case Reports, Demographic Characteristics, Primary Industry and Occupation, and History of Allergies

The RADS cases were more likely to be identified by hospital discharge data and less likely to be reported by physicians than other WRA cases (Table 1). The two types of cases were very similar with respect to mean age, gender, race, and history of cigarette smoking but differed in their distribution by primary industry and occupation. By primary industry, the RADS cases were half as likely as the other WRA cases to be employed in manufacturing ($P \leq .05$) and more likely to be employed in other industries such as public administration ($P \leq .05$) and construction ($P \leq .05$) (Table 1). When state-specific data were examined (not shown), the difference in distribution by industry was evident for the states Michigan and New Jersey, but not for California and Massachusetts. By primary occupation, the RADS cases were less likely to be in the category of operators, fabricators, and laborers ($P \leq .05$) and more likely to be in the categories of technical, sales, and administrative support ($P \leq .05$) and service ($P \leq .05$). There was little difference between the two groups of cases in terms of personal and family history of allergies.

Agents

Up to three agents could be reported for each case, and 20% of the persons with RADS and 12% of the other WRA cases had multiple agents with uncertainty about which

TABLE 1

Demographic Features, Primary Industry and Occupation, and History of Allergies for Work-Related RADS and for Other Work-Related Asthma Cases

Characteristic		RADS (n = 123)	Other WRA (n = 301)	
Source of case reports*	Physician reports†	72%	90%	
	Hospital discharge data†	25%	6%	
	Other		4%	
	Total	3%	100%	
Demographic features	Mean age (SEM)	42.2 (1.0)	41.7 (0.6)	
	Female	46%	52%	
	White	83%	79%	
	Ever smoke cigarettes	58%	58%	
Primary industry*	Services‡	33%	23%	
	Manufacturing†	29%	66%	
	Public administration†	15%	2%	
	Construction†	10%	2%	
	Wholesale/retail trade‡	7%	3%	
	Transportation, utilities	5%	2%	
	Other		1%	
	Total	2%	101%	
	Primary occupation*	Precision production, craft, repair‡	25%	18%
		Technical, sales, admin support†	21%	9%
Operators, fabricators, and laborers†		19%	55%	
Service†		19%	6%	
Managerial and professional specialty		15%	11%	
Farming, forestry, and fishing		1%	1%	
Total		100%	100%	
History of allergies		Ever told had allergies	43/116 = 37%	112/296 = 38%
	Family history of allergies	47/116 = 41%	97/292 = 33%	

* $p \leq 0.05$, by chi-square.

† $p \leq 0.05$, by continuity corrected chi-square or Fisher's exact test, comparing individual categories between RADS and other WRA cases.

‡ $0.05 < p \leq 0.10$, by continuity corrected chi-square or Fisher's exact test, comparing individual categories between RADS and other WRA cases.

was the primary causative exposure. Among those with multiple agents, some of the RADS cases were also exposed to sensitizers and some of the other WRA cases were also exposed to irritants. The state-based surveillance staff utilized data they gathered on exposure circumstances and the onset of symptoms to determine whether the reported cases were RADS or other WRA.

The majority of the reports from the state-based programs had a single agent indicated. For example, 82 (67%) of the 123 RADS cases had a single agent listed. Another 17 (14%) cases had multiple agents listed, and

the one agent identified as the most likely was counted. The final 24 (20%) cases had multiple agents listed with no clear indication of which was most likely, of whom 15 had two agents and 9 had three agents. At final count, there was a total of 156 agents considered for all 123 RADS cases. Similarly for the 301 other WRA cases, there was a total of 357 agents considered. In particular, 264 cases had one agent, 18 had two agents, and 19 had three agents. The seven most frequently reported agents for RADS and other WRA cases are presented in Table 2. The two lists, as expected, are en-

TABLE 2

The Seven Most Frequently Reported Agents for Work-Related RADS and for Other Work-related Asthma Cases

RADS		Other WRA	
Agents ^a	No. and % ^b	Agents ^a	No. and % ^b
1. Cleaning materials	18, 15	1. Diisocyanates	102, 34
2. Chemicals NOS ^c	10, 8	2. Lubricants nos ^d	46, 15
3. Chlorine	8, 7	3. Formaldehyde	24, 8
4. Solvents nos	8, 7	4. Natural rubber latex	22, 7
5. Acids, bases, oxidizers NOS	7, 6	5. Glutaraldehyde	19, 6
6. Smoke nos	7, 6	6. Epoxy resins	16, 5
7. Diesel exhaust	7, 6	7. Acrylates NOS	10, 3

^a The agent categories are based on a scheme developed by Hunting and McDonald (1995). We created two inclusive agent categories: "cleaning materials" included bleach, cleaning materials not otherwise specified, and metal polish; "diisocyanates" included toluene diisocyanate, methylene diisocyanate, naphthalene diisocyanate, hexamethylene diisocyanate, and diisocyanate nos.

^b For RADS, the percentages are of the 123 cases. For other WRA, the percentages are of the 301 cases.

^c NOS, not otherwise specified.

^d This category includes metal working fluids.

tirely different, with cleaning materials and chemicals nos leading the list for RADS, and the known sensitizers diisocyanates and lubricants nos leading the list for other WRA cases.

Selected Occupations and Agents for RADS

It was noted in Table 1 that the RADS cases were more likely to work in technical, sales, and administrative support, and service occupations. Selected occupations and agents for RADS cases in these two occupational categories are presented in Table 3. These lists illustrate how people working in relatively "clean" jobs can still be at risk for RADS. For example, the category of technical, sales, and administrative support occupations includes RADS cases among secretaries, clerks, and telephone operators exposed to various chemicals. Also, people working in the service occupations of maids and janitors, cooks and food preparation workers, and health aides were among those with RADS, with cleaning materials as common agents for these jobs.

Consequences of WRA

Table 4 includes information about health care and compensation for the two groups of cases. Both types of cases were very likely to still have breathing problems at the time they were interviewed (89% RADS, 80% other WRA). As already noted, RADS cases were more often identified via hospital discharge data than the other WRA cases (Table 1). Over three quarters of the RADS cases had been to a hospital emergency department (ED) for work-related breathing problems versus about half of the other WRA cases ($P \leq .05$) (Table 4). This difference was almost entirely due to an excess in single ED visits by RADS cases (45%) versus the other cases (20%) ($P \leq .05$), while the two groups had almost the same percent of individuals who reported more than one ED visit (29% versus 27%, respectively). The RADS cases also were more likely to have been hospitalized for work-related breathing problems (39% versus 28%, $P \leq .05$) (Table 4). Approximately half of both types of cases had applied for worker compensation and the

proportion of applications decided was greater for RADS versus the other cases (64% versus 48%, respectively, $P \leq .05$). In both groups, 81% of those whose claims were decided had received an award (Table 4).

Cessation of Exposure to Suspected Agent

Over 70% of the cases in both groups were no longer exposed to the suspected agent (Table 5). Forty-one percent of both RADS and other WRA cases had left the company where they experienced onset of symptoms. Those who were no longer exposed but still working in the company where onset occurred had usually been reassigned to a different job, although other accommodations (eg, substitution of materials, new ventilation or respirator) were also reported.

Discussion

Benefits and Limitations of SENSOR Surveillance for WRA

The four states that identify cases of WRA as part of the SENSOR program conduct independent surveillance systems. However, the efforts of the four different state-based programs are coordinated by NIOSH so that a common set of variables are collected for each reported case. This coordination includes the use of the same case definition and classification scheme and a similar set of questions for follow-back interviews. It is likely that SENSOR data represent an underestimate of the total number of WRA cases due to incomplete recognition and reporting.² Still, the SENSOR program registers a large number of reports, and the current data represent the largest RADS surveillance case series in the medical literature. The SENSOR WRA surveillance case definition is based largely on symptoms. Tests such as spirometry and methacholine challenge are performed by treating clinicians for approximately half of the reported cases.² Pulmonary func-

TABLE 3
Selected Occupations and Agents Associated with Work-Related RADS

Occupations ^a	Agents ^a
Technical, sales, and admin support	
Radiologic & health technicians (3)	Nickel; petroleum fractions; smoke
Electrical technician	Diisocyanates
Drafting occupations	Soldering fumes
Chemical technician	Caustic acids
Building supplies sales person	Dry wall powder
Secretary (4)	Solvents NOS (2); glues; 2-butoxyethanol, Styrene-maleic anhydride resin, Isopropanol
Interviewer	Herbicides
Order clerk, record clerk (2)	Sulfur dioxide; solvents NOS
General office clerk (2)	Petroleum distillate; solvents NOS
Duplicating machine operator	Copier toner
Telephone operator (2)	Safrotin; chemicals NOS
Insurance adjuster	Ethyl acrylate
Government investigator (3)	Chemicals NOS (3) ^b
Social service eligibility clerk	Sewer cleaner chemicals
Teacher aide	Paint fumes
Administrative support occup. nec ^c	Solvents NOS
Service	
Fire inspector in forest service	Diesel fuel
Firefighter (2)	Smoke (2)
Police and protective services (3)	Diisocyanates; cleaning materials NOS (2)
Cooks (2)	Cleaning materials nos; sodium hydroxide
Misc. food preparation occupa. (2)	Chlorine; mixed bleach & other cleaning agent
Health aides except nursing (3)	Diazinon; cleaning materials nos; gasoline, diesel fuel, ethylene glycol
Maids, housemen, janitors, cleaners (9)	Ammonia; acids, bases, oxidizers NOS; petroleum fractions; bleach (2); muriatic acid; ethanalamines; ammonia, bleach, graffiti remover; ammonia, acid, cleaning materials NOS
Supervisor in casino	Indoor air pollutants

^a Numbers in parentheses indicate number of people with particular occupation or number of times agent was reported.

^b NOS, not otherwise specified.

^c NEC, not elsewhere classified.

tion tests performed in relation to work are even less frequent. For example, among all 562 case-patients reported to the Michigan and New Jersey SENSOR asthma programs during 1993–1995, only 5.2% had pulmonary function performed in relation to their work.¹⁹ These figures are an indication of usual medical practice in the United States. The less-stringent surveillance definition of RADS is likely to generate a number of false positives when held up to the standard of a clinical case definition that requires a positive methacholine challenge test or other objective findings.^{1,20} A single- or multi-site clinical study could

implement a protocol that would ensure objective test results for all subjects, but would likely rely on a narrower base for case selection than SENSOR.

RADS as a Percent of All New-Onset WRA Cases

RADS cases were more likely than other new-onset WRA cases to have been hospitalized for work-related breathing problems (Table 4) and identified via hospital discharge data (Table 1). Assuming that reporting by hospitals is more complete than voluntary reporting by physicians, underreporting was possibly less

common for RADS cases. Thus, RADS as a percent of all incident cases of WRA may have been overstated using these data.

Based on surveillance data from the United States, Canada, the UK, and South Africa, the estimates of what percent of new-onset WRA cases are due to RADS or irritant asthma range from 5% to 18% (Table 6). In the current analysis, RADS accounted for 14% (123/891) of new-onset WRA identified by the SENSOR programs in four states during 1993–1995.² RADS accounted for a somewhat smaller percent of all new-onset WRA cases in summaries of SENSOR data from earlier years and in a recent report from a surveillance system in California that shares some cases with the current data (Table 6). Earlier reports from the SENSOR program included data from Michigan and New Jersey during 1988–1992³ and from Michigan alone during 1988–1994,⁵ with estimates that RADS accounted for 8% and 10%, respectively, of new-onset WRA cases. Based on the Doctor's First Report system in California during 1993–1996, RADS accounted for 9% of the new-onset WRA cases who were interviewed and could be classified.⁴ Canadian researchers provided some of the smallest estimates, with 5% of WRA cases due to RADS based on data from the PROPULSE surveillance program in Quebec during 1992–1993⁶ and from the Worker Compensation Board in Ontario during 1984–1988.^{7,21}

Not all cases of WRA associated with irritant exposures fulfill the criteria for RADS, so we would expect the number of all irritant asthma cases to exceed the number of RADS cases. In fact, three estimates of irritant asthma or a combination of RADS and irritant asthma from surveillance systems in the UK and South Africa were less than, greater than, and about the same as the current estimate that 14% of WRA cases are attributable to RADS (Table 6). Based on data from the

TABLE 4
Consequences of Work-Related Asthma

	Work-Related RADS	Other WRA
Still breathing problems	89% (103/116)	80% (236/294)
Visited hospital emergency dept. for work-related breathing problems*	78% (85/109)	48% (136/282)
Number of times in ED:		
1*	45% (49/109)	20% (55/282)
>1	29% (32/109)	27% (76/282)
Data missing	4% (4/109)	2% (5/282)
Hospitalized for work-related breathing problems*	39% (41/105)	28% (77/279)
Number of times hospitalized:		
1	22% (23/105)	16% (44/279)
>1	10% (10/105)	8% (23/279)
Data missing	8% (8/105)	4% (10/279)
Applied for worker compensation	54% (66/122)	48% (145/301)
Percentage of applications decided*	64% (42/66)	48% (69/145)
Of those with applications decided:		
Awarded	81% (34/42)	81% (56/69)
Denied	19% (8/42)	19% (13/69)

* $P \leq 0.05$ by continuity corrected chi-square or Fisher's exact test.

TABLE 5
Cessation of Exposure to Suspected Agent

	Work-Related RADS	Other WRA
No longer exposed	78% (90/116)	71% (209/295)
Left company	41% (48/116)	41% (120/295)
Quit on MD advice, worker comp, disability, sick leave	20% (23/116)	25% (73/295)
Fired	4% (5/116)	6% (17/295)
Left work on own concern	5% (6/116)	4% (12/295)
Left company, no reason	12% (14/116)	6% (18/295)
Still work in company	20% (23/116)	22% (66/295)
Reassigned in company	11% (13/116)	19% (56/295)
New chemical in use, new ventilation or respirator	9% (10/116)	3% (10/295)
Reason not specified	16% (19/116)	8% (23/295)

SWORD surveillance program in the UK during 1994, RADS/irritant asthma cases represented 9% of the combined number of occupational asthma cases and RADS/irritant asthma cases.⁹ Among reports of occupational asthma from physicians in the West Midlands Region of the UK during 1989–1991, 18% were due to irritant exposures.⁸ In South Africa, occupational asthma induced by irritants represented 13% (30/225) of all asthma cases reported during 1996–1998. Compared to data from surveillance systems, two reports of clinical case series have identified higher percents of work-related

RADS and irritant asthma. From a university-based occupational and environmental clinic in Washington state, RADS accounted for 35% (18/52) of the new-onset WRA cases seen during 1981–1991.²² People identified with occupational asthma during 1978–1987 at a university-based clinic in Ontario included 9% (10/106) with irritant-induced asthma and another 15% (16/106) with possible irritant-induced asthma.²³

Atopy

The observation from the current analysis that RADS and other WRA

cases are equally likely to report a history of personal allergies (see Table 1) conflicts with findings from several clinic-based studies conducted in North America. For example, among people referred to a university hospital clinic in Ontario for possible WRA, atopy based on skin testing was evident for 61% (31/51) of those with sensitizer-induced occupational asthma and 20% (2/10) of those with irritant-induced occupational asthma.²³ In another study conducted in Indiana, 23% (5/22) of the occupational asthma patients versus 9% (2/23) of the RADS patients had evidence of atopy as determined from either self report or skin testing.²⁴ From a series of asthma patients evaluated at an occupational and environmental clinic in Washington, atopy was based on the patient's history of either an allergic disease or a positive skin test.²² The frequency of atopy was only 11% (2/18) for work-related RADS, 22% (6/27) for work-related sensitizer asthma, and 74% (14/19) for those with work-related exacerbation of asthma. These findings from clinical studies are consistent with the notion that people who are atopic are more likely to respond to sensitizing agents, whereas almost anyone regardless of atopic status will respond to overwhelming levels of irritant gases. There is even evidence that irritant-induced RADS cases with sudden onset of symptoms are less likely to be atopic than irritant-induced asthma cases for whom onset was not sudden.²⁵ In comparing these two groups of patients, Brooks and colleagues in Florida defined atopy as having one of the following: at least two positive skin prick tests, a positive RAST test, an elevated total serum immunoglobulin E concentration, personal history of allergic disease, or allergic disease in a close blood relative. Among the 38 patients with new-onset irritant-induced asthma, 52% (12/23) of those with sudden-onset RADS versus 87% (13/15) of those with not-so-sudden onset had atopy.²⁵ Per-

TABLE 6

Percentage of Work-related Asthma Attributed to RADS or Irritant Asthma, from Surveillance in Four Countries

Reference	Country (State, Province, or Region)	Years	Surveillance Program (How Cases Identified) ^a	% RADS or Irritant Asthma
Current analysis	United States (California, Massachusetts, Michigan, New Jersey)	1993–1995	SENSOR (MD, HDD, WCC)	14% RADS (123/891)
Reilly et al, 1994	United States (Michigan and New Jersey)	1988–1992	SENSOR (MD, HDD, WCC)	8% RADS ^b (42/498)
Rosenman et al, 1997	United States (Michigan)	1988–1994	SENSOR (MD, HDD, WCC)	10% RADS ^b (69/672)
Reinisch et al, 2001	United States (California)	1993–1996	Doctor's First Reports (MD)	9% RADS (27/290) ^c
Provencher et al, 1997	Canada (Quebec)	1992–1993	PROPULSE (MD)	5% RADS (14/301) ^d
Chatkin et al, 1999; Tarlo et al, 1995	Canada (Ontario)	1984–1988	Ontario Worker Compensation Board (WCC)	5% RADS (12/235)
Ross et al, 1995	United Kingdom	1994	SWORD (MD)	9% RADS/irritant asthma (93/1034) ^e
Gannon et al, 1993	United Kingdom (West Midlands Region)	1989–1991	SHIELD (MD)	18% irritant asthma
Hnizdo et al, 2001	South Africa	1996–1998	SORDSA (MD, PR, OHN)	13% irritant asthma (30/225) ^f

^a Abbreviations for how cases identified: MD reports from physicians, HDD hospital discharge data, WCC worker compensation claims, PR reports from provincial representatives, OHN reports from occupational health nurses.

^b The cases from the Michigan SENSOR program that are included in the article by Reilly et al. (1994) are also included in the article by Rosenman et al. (1997). Some of the cases from Rosenman et al. (1997) were included in the current analysis.

^c The 290 cases of WRA were the new-onset cases who were interviewed and could be classified. These cases included 24 RADS and 28 other WRA cases from California that were included in the current analysis.

^d There were 287 cases of occupational asthma and 14 cases of inhalation accident/RADS. The combination of these two groups equals 301 cases, and $14/301 = 5\%$ RADS.

^e There were 280 cases of work-related inhalation accidents reported to SWORD in 1994. Based on an earlier study, the researchers estimated that about one third of the inhalation cases were either asthma or RADS, chiefly due to chemical irritants (Ross et al, 1995). Thus, about $1/3 \times 280 = 93$ RADS/irritant asthma cases. With the RADS/irritant asthma cases and other occupational asthma cases combined ($93 + 941 = 1034$), the RADS/irritant asthma cases represented 9% of the total ($93/1034 = 9\%$).

^f There were 195 cases of occupational asthma with latency and 30 cases of asthma induced by irritants. Thus, the percentage with asthma induced by irritants was $30/225 = 13\%$.

haps our use of allergy history as the only criterion for atopy failed to adequately discriminate who is truly atopic and, as a result, we did not detect the difference between RADS and other asthma cases that was observed in the clinical studies. Misclassification of RADS and other irritant-induced WRA cases could also yield the findings for atopy, although there is no evidence that such misclassification occurred.

Persistence of Breathing Problems, Medical Care, and Worker Compensation

The findings of this analysis highlight the seriousness of work-related RADS and how its adverse impact on the individual is similar to that of

other cases of WRA that were predominantly due to sensitizers. For example, breathing problems were still present in at least 80% of both types of cases (Table 4). This finding is consistent with the results of other occupational asthma studies. In particular, 80% of all occupational asthma cases from the Ontario Worker Compensation Board were still symptomatic at the time of their main assessment.⁷ From another study based on worker compensation claims in Ontario, 73% (8/11) of work-related irritant-induced asthma cases had no clearing of symptoms.²¹ Consistent with the abrupt onset of RADS, these cases were more likely to have ever used emergency and hospital services. This contrast was

especially apparent in reports of a single ED visit for work-related breathing problems. The fact that the RADS and non-RADS cases reported almost the same percent of multiple ED visits could mean that the two groups are similar with respect to one or several factors: distribution of cases by underlying disease severity, environmental exposures, and pharmacologic control of asthma.

People in the current analysis with work-related RADS were as likely as the other WRA cases to apply for and receive worker compensation benefits (Table 4). The figures of 54% for RADS and 48% for other WRA who had applied for worker compensation compares to 41% of

new-onset cases of occupational asthma who had filed a claim among the WRA cases identified in California via the Doctor's First Report.⁴ Approximately 28% (34/122) of RADS cases and 19% (56/301) of the other WRA cases had been awarded worker compensation benefits. Indeed, the sudden-onset of RADS after a dramatic high-level exposure might facilitate justification of compensation. These figures compare to findings from a clinic-based case series in which 27% (19/71) of patients diagnosed with occupational asthma were receiving workers' compensation.²²

Some differences between RADS and other WRA cases might be due to the way in which these two types of cases were identified by state SENSOR programs. As noted in Table 1, more of the RADS cases were identified from hospital discharge data. The lag time since hospital care could be as long as several years, and interviews with these people were conducted longer after onset than with cases reported by physicians. The longer period of time since diagnosis could account for some of the increased prevalence of ED and hospital visits observed for RADS cases (Table 4). This might also explain why the percent of cases who had applied for worker compensation and been decided were greater for the RADS cases versus the others (64% versus 48%, respectively). In addition, the percent of RADS cases who had ceased exposure might have been artificially inflated relative to other WRA cases due to the suspected longer period of time between diagnosis and interview.

Change in Employment or Exposure Status

Whether the patient has left employment or has had to modify their work to avoid exposure are indicators of the adverse impact of WRA. The current analysis revealed that 41% of all RADS and other WRA cases had left the company where

they experienced asthma onset (Table 5). Findings from other studies indicate that adults with asthma frequently experience disease-related disruption of employment, and this is especially true for those diagnosed with occupational asthma. For example, among asthma patients treated at a pulmonary clinic, 36% reported a change in work duties, reduction in pay, or change in job or work status over a 5-year period.²⁶ From a study of 601 people with asthma treated by pulmonary or allergy specialists, 7% had complete work disability and another 10% had partial work disability.²⁷ Using the Doctor's First Reports in California to study cases of WRA, 20% were not able to perform their usual work and 33% were able to perform modified work.⁴ Based on the data from the 1978 Social Security Disability Survey, asthma limited the ability to work for 36% of those with occupational asthma and 24% of those with nonoccupational asthma.²⁸ From a study of people with adult-onset asthma, the percent who had changed jobs since their first asthma attack was 55% for those without occupational asthma, and 73% and 89% for those with occupational asthma and probable occupational asthma, respectively.²⁹ Among people with irritant-induced WRA, 75% (9/12) were off work or doing other work.²¹ In another investigation, most patients with occupational asthma were unemployed: 67% (12/18) for sensitizer-induced asthma; 71% (5/7) for RADS; and 100% (5/5) for other irritant-induced asthma.³⁰

Cessation of exposure is sometimes achieved by changes in work assignments, agents, or exposure levels in the same company. In the current analysis, in addition to the 41% of WRA cases who had left employment, another 20% of the RADS cases and 22% of the other WRA cases were still working for the same company but were no longer exposed (Table 5). Based on cases of occupational asthma identified for worker compensation in On-

tario, 63% had left work and another 15% were at the same workplace but out of the usual exposures.⁷ The SWORD surveillance system in the UK determined that 72% of the cases with occupational asthma were no longer exposed at diagnosis.⁸ The reasons for cessation of exposure included: 15% moved from exposure; 4% agent removed; 15% changed employer; 21% unemployed; 9% long-term sick leave; and 8% retired.⁸ From the study of the Doctor's First Reports of WRA in California, 64% of the cases were no longer exposed.⁴ The reasons for no more exposure were: 12% job change; 25% stopped using the substance; 5% engineering controls or personal-protective equipment; 10% fired or laid off; 15% left job due to physician's advice; 7% left job due to own concerns; and 25% other reasons.

Summary

RADS is a significant workplace health problem. Based on surveillance data from four states in the United States, RADS cases represent only 14% of new-onset WRA cases. However, the adverse impact of work-related RADS equals or exceeds that of other WRA cases as indicated by persistence of symptoms, use of emergency medical and hospital services, applications and awards for worker compensation, and the need to change jobs to avoid harmful exposures. We hope this paper will contribute to the prevention of WRA by alerting workers, managers, and clinicians to the seriousness of work-related RADS and to the industries and occupations in which cases occur. Such awareness might stimulate efforts by workers and managers to control exposures in the workplace that could initiate RADS and efforts by clinicians to recognize, treat, and report this work-related condition. SENSOR surveillance for WRA is ongoing and will continue to be a vital source of information about RADS and other types of WRA.

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