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Work-Attributed Symptom Clusters (Darkroom Disease) Among Radiographers Versus Physiotherapists: Associations Between Self-Reported Exposures and Psychosocial Stressors

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Background *"Darkroom disease" (DRD) has been used to describe unexplained multiple symptoms attributed by radiographers to their work environment. This study determines the prevalence of symptom clusters similar to other unexplained syndromes among (medical radiation technologists (MRTs) as compared with physiotherapists (PTs), and identifies associated work-related (WR) factors.*

Methods *A mail survey was undertaken of members of the professional associations of MRTs and PTs in Ontario, Canada. Questions were included to determine the prevalence and frequency of symptom clusters including abnormal tiredness as well as WR headaches, and symptoms suggestive of eye, nasal, and throat irritation. For the purpose of this study, these are considered to be DRD symptom clusters. Individuals with doctor-diagnosed asthma were excluded from our analyses.*

Results *Overall, 63.9% of MRTs and 63.1% of PTs participated. Criteria for DRD were met by 7.8% of 1,483 MRTs and 1.8% of 1,545 PTs [odds ratio, OR 4.8 (confidence interval, CI 3.1–7.5); ($P < 0.0001$)]. Both occupations showed significant associations between responses reflecting psychosocial stressors and DRD. Those with this symptom cluster were more likely to report additional symptoms than those without, and MRTs with DRD symptoms reported significantly more workplace chemical exposures.*

Conclusions *Findings suggest excess symptoms consistent with DRD among MRTs versus PTs, and there were associations among those meeting our definition of DRD with self-reported irritant exposures and psychosocial stressors.* Am. J. Ind. Med. 45:513–521, 2004. © *2004 Wiley-Liss, Inc.*

KEY WORDS: radiographers; work-related symptoms; darkroom disease

Abbreviations: CI, confidence interval; DRD, darkroom disease; MRTs, medical radiation technologists; OAMRT, Ontario Association of Medical Radiation Technologists; OR, odds ratio; PPE, personnel protective equipment; SBS, sick building syndrome; WR, work-related.

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INTRODUCTION

Radiographers or medical radiation technologists (MRTs) have potential exposure to processing chemicals involved in developing and fixing films including sensitizers and irritants, such as glutaraldehyde, formaldehyde, sulfur dioxide (SO_2), and acetic acid [Gordon, 1989; Scobbie et al., 1996; Teschke et al., 2002]. The magnitude of the workforce is considerable, exceeding 5,000 in Ontario and about 10,000 in Canada. There have been reports of an unexplained medical syndrome, "darkroom disease" (DRD) among MRTs, [Gordon, 1989; Hewitt, 1993; Genton, 1998]. However, the prevalence of this syndrome and the associated factors are unclear. Several of the symptom clusters reported are similar to those of other medically unexplained syndromes [Kipen and Fiedler, 2002] with overlapping features, such as sick building syndrome (SBS) [Redlich et al., 1997; Hodgson, 2000]. SBS symptoms include mucous membrane irritation and psychosocial stress is an associated factor. MRTs are regularly exposed to multiple chemicals in processing and developing radiographs, which potentially can cause mucous membrane irritation, and may have episodic exposure to spills of these chemicals. One aim of this study was to assess whether work-related (WR) symptom clusters consistent with DRD in MRTs were more common than in physiotherapists (PTs) and whether they related to self-reported irritant exposures and other WR factors.

MATERIALS AND METHODS

We undertook a cross-sectional questionnaire mail survey to ascertain the prevalence of several health outcomes including multiple symptoms consistent with DRD among MRTs as compared with a control group of PTs. The proposal received ethics approval from the Office of Research Services, University of Toronto.

Subjects

Subjects were recruited from members of the two professional associations, the Ontario Association of Medical Radiation Technologists (OAMRT) and the Ontario Physiotherapy Association (OPA) as previously reported [Liss et al., 2003]. Within the OAMRT, we included in our sampling frame only the 2,761 radiological technologists (excluding radiation therapists, nuclear medicine technologists, and magnetic resonance imaging technologists). For the OPA, we excluded from the sampling frame a minority (about 10%) who had elected not to be approached for unsolicited mailings. A random sample of 3,000 was selected for mailing.

Questionnaire

The questionnaire was adapted, with input from the OAMRT, from those of Smedley et al. [1996], Wymer et al. [2000], and Dimich-Ward et al. [2003], who kindly provided their instruments. These questionnaires were used in previous surveys of radiographers and also incorporated PTs as the control group. We included questions common for both professions regarding demographics, dates of training and starting work, shifts, hours, respiratory, and other symptoms, questions regarding chemical sensitivity, psychosocial factors, and smoking history. Results of the lower respiratory symptom analyses have been previously reported [Liss et al., 2003]. The questionnaire for MRTs included questions regarding ventilation conditions, X-ray processing tasks, leaking processors, clogged drains, cleanup activities, and personal protective equipment (PPE) (for the past 12 months). The questionnaires also included items dealing with workplace psychosocial factors and musculoskeletal symptoms as well as burnout and health-related quality of life. The questionnaire was pilot tested with 15 MRTs, following which several awkwardly worded questions were revised. The covering letter indicated that this was a study of health and safety of various health professions and did not indicate a focus on DRD, or on MRTs. We conducted an initial mailing in late October 2000 with a reminder card 1 month later, followed by a second mailing in January 2001 to non-respondents with another reminder card 1 month after that. Questionnaire printing, distribution, and data entry was conducted by the Institute for Social Research, York University, Toronto.

Symptom Questions and DRD Definition

The questionnaire included the following questions addressing 18 different symptoms in addition to the lower respiratory symptoms which were previously reported [Liss et al., 2003]. We asked, on how many days in the past 12 months (choices: none, 1–7, 8–14, 15+), have you had the following symptoms (listed), and were they worse at work (no/yes)? The listed symptoms were: (a) fever or night sweats, (b) nausea, (c) dizziness or lightheadedness, (d) skin rash, (e) mouth soreness, (f) mouth ulcers, (g) palpitations, (h) ringing in the ears, (i) swelling or hives on skin, (j) sore, itchy or runny eyes, (k) persistent itchy or runny nose or sneezing (not including colds/flu), (l) sore throat, (m) pain on urinating, (n) headache, (o) blurred vision, (p) numbness or tightening of face, hands, or feet, (q) abdominal pain, (r) chemical taste in mouth. The questionnaire also enquired about the following: abnormal tiredness, problems concentrating, short memory, difficulty getting the meaning from reading newspapers or books (and whether worse at work, yes/no was also questioned). Additional separate questions were asked about musculoskeletal symptoms (not included in the present analyses).

The cluster of symptoms used in this study to define a "case" of DRD was the presence of three or more of the following five symptoms: (i) sore, itchy, or runny eyes (ii)

persistent itchy nose or sneezing (not including colds/flu), (iii) sore throat, (iv) headache (each of these symptoms worse at work and present 15+ days in the past year); and (v) abnormal tiredness in the past year, also worse at work. This symptom cluster was selected as being representative of the symptoms previously reported among those with ''DRD'' [Gordon, 1989; Hewitt, 1993; Genton, 1998]. Since some of the included symptoms, such as nose and eye symptoms could be associated with asthma, on an allergic basis, most analyses were performed with exclusion of doctor-diagnosed asthmatic subjects. Since glove use was common in the MRTs and a high proportion reported skin rashes, possibly related to this, skin symptoms were also not included in the current DRD definition.

Statistical Analyses

Proportions of categorical variables were compared between the two exposure groups with χ^2-tests and continuous variables with *t*-tests. Contingency tables were initially analyzed, with age stratified in three groups, gender, and smoking status (categorized as never, former, and current). The relative risk was estimated by the Mantel–Haenszel odds ratios (ORs). We subsequently used the OR from unconditional multiple regression analyses to estimate the risk between groups (e.g., between the professions for the various outcomes, for example, non-respiratory symptoms, psychosocial stressors, or DRD case definition), adjusting our models simultaneously for potential confounders such as age, gender, and smoking. Including the age term as either three groups or as a continuous variable yielded almost identical results; the latter are presented. Given that multiple comparisons with exposures and tasks were made, associations with exposures were considered to be ''of note'' or clinically important if the OR was (a) greater than 1.7; (b) the *P* value was <0.01; and (c) the prevalence of the variable in each group exceeded 0.5%. All statistical analyses were conducted in SAS Version 8 (2000). Analyses for DRD symptoms were performed with exclusion of subjects with doctor-diagnosed asthma, and statistical results were also analyzed with adjustments made for age, gender, and smoking. Comparison of the prevalence of DRD among MRTs versus PTs was also made with adjustment for the 12 item Physical Component and Mental Component Summary Scale Survey questions (SF12) which were included in the questionnaire [Ware et al., 1995, 1996].

RESULTS

Questionnaire Responses

Of the 2,761 and 3,000 questionnaires distributed to the MRTs and PTs, respectively, there were ''bad addresses/returned to sender'' responses for 15 and 24; and ''bad sample units'' (deceased, not working, out of country) for 0 and 6, respectively. Of the remaining 2,746 and 2,970 members, completed questionnaires were received from 1,754 and 1,875, yielding response rates of 63.9% among MRTs and 63.1% among PTs, respectively. We then excluded respondents who indicated that their work was totally administrative (34 MRTs and 27 PTs) or that they were currently on sick leave (1 MRT), leaving 1,719 and 1,848, respectively. Physician-diagnosed asthma was reported by 231 MRTs (13.4%) and 295 PTs (16%) who were excluded from these analyses. Age and years in practice were highly correlated among both MRTs ($r = 0.90$) and PTs ($r = 0.94$).

Comparison of DRD Outcomes and Unrelated Symptoms Between MRTs and PTs

Abnormal tiredness and the other individual symptoms which were included in our definition of DRD, reported to be worse at work and occurring at least 15 days in the previous 12 months, were more commonly reported by MRTs than by PTs ($P < 0.0001$ for each symptom), as shown in Table I. The most commonly reported of these symptoms in both groups was abnormal tiredness, in 39% of MRTs and 28% of PTs, followed in frequency by headache, nasal symptoms, eye symptoms, and sore throat. Our DRD definition was met by 7.8% of MRTs and 1.8% of PTs ($P < 0.0001$, OR 4.6 [confidence interval, CI 3.1–7.0]). Exclusion of current or ex-smokers did not significantly affect these percentages with three or more symptoms (8.3 and 1.9% for MRTs and PTs, respectively, $P < 0.0001$). The only interaction with smoking was observed at a marginally significant level for sore/itchy or runny eyes ($P = 0.047$).

Reporting of other symptoms which would not be expected to be worse at work, such as fever or night sweats, abdominal pain, and pain on urinating were reported by only 0.94, 1.55, and 0.26% of MRTs and 0.45, 0.78, and 0.19% of PTs, respectively, suggesting that there was no general trend to frequent over-reporting of symptoms by MRTs or PTs.

Other Symptoms and Factors Associated With DRD Symptom Clusters in MRTs

A number of psychosocial stressors and workplace exposures were reported significantly more frequently among the 116 MRTs who fulfilled our criteria for DRD compared with the other MRTs (Tables II and III). Age, gender, smoking history, and duration of work did not differ significantly and there were a similar number of processors in the workplace. However, those with DRD reported their job as being more hectic, requiring more physical effort, more repetitive, with less decision making, less help from supervisors and co-workers, and with more conflicting demands made by others. They were also more likely to report

TABLE I. Characteristics and Symptoms Consistent With DRD Among PTs and MRTs Without Doctor-Diagnosed Asthma

	PTs	MRTs	OR (95% CI)*	*P* value
Number	1,545	1,483		
Age	40.3 ± 10	42.4 ± 10		<0.0001
% Female	84.6	88.2		0.0039
Smoking history (ex and current)	264 (17.1%)	528 (35.8%)		<0.0001
Symptomsworse at work and 15+ days in the past year (%)				
Sore, itchy, or runny eyes	3.3	8.5	2.8 (1.9–3.8)	<0.0001
Persistent itchy nose or sneezing (not including colds/flu)	4.2	10.8	2.9 (2.1–3.8)	<0.0001
Sore throat	1.2	3.9	3.4 (2.0–5.8)	<0.0001
Headache	9.7	17.5	2.0 (1.6–2.5)	<0.0001
Abnormal tiredness	27.8	39.1	1.7 (1.4–1.9)	<0.0001
DRD definitions				
Three or more of these symptoms (among all respondents)	1.8	7.8	4.6 (3.1–7.0)	<0.0001
Three or more of these symptoms (excluding smokers)	1.9	8.3	4.7 (2.9–7.5)**	<0.0001

PTs, physiotherapists; CI, confidence interval; MRTs, medical radiation technologists; DRD, darkroom disease.
*OR adjusted for age, gender, and smoking.
**Adjusted for age and gender.

TABLE II. Factors Associated With DRD Symptoms in MRTs and PTs Without Doctor-Diagnosed Asthma: Descriptors and Psychosocial Stressors

	MRTs with/without DRD	OR (95% CI)* [*P* value]	PTs with/without DRD	OR (95%CI)* [*P* value]
Number	116/1,367		28/1,513	
Age, years (mean ± SD)	42.2 ± 11.5/42.4 ± 10.1	[0.67]	37 ± 10.2/40.3 ± 10.5	[0.09]
Years of work as an MRT	18.6 ± 11.6/18.7 ± 10.4	[0.91]	12.7 ± 13.1/15.6 ± 10.4	[0.15]
% female	92.2/87.8	[0.16]	92.9/84.4	[0.22]
Ever smoked (%)	32.8/36	[0.48]	14.3/17.1	[0.69]
Work does not allow freedom to decide how to do job (%)	5.2/2.5	2.2 (0.9–5.5) [0.07]	7.14/0.53	15.6 (3.0—81.4) [0.001]
Job is repetitive (%)	47.4/27.8	2.3 (1.6–3.4) [<0.0001]	32.1/12.5	3.3 (1.5–7.4) [0.004]
Very hectic job (%)	67.8/47.7	2.3 (1.5–3.5) [<0.0001]	57.1/23.4	4.2 (2.0–9.0) [0.0002]
Not free from conflict demands made by others (%)	24.1/16	1.7 (1.1–2.6) [0.026]	35.7/9	6.2 (2.8–13.8) [<0.0001]
A lot of physical effort in job (%)	60.3/44.3	1.9 (1.3–2.8) [0.0013]	60.7/21.5	5.2 (2.4–11.3) [<0.0001]
Supervisor unhelpful in getting the job done (%)	17.6/7.6	2.5 (1.5–4.3) [0.0003]	25.9/4.5	7.4 (3.0–18.2) [<0.0001]
Co-workers unhelpful in getting the job done (%)	1.7/0.7	3.5 (0.7–17.0) [0.103]	0/0.75	na [0.65]
Work emotionally exhausting (%)	18.1/9.6	2.0 (1.2–3.3) [0.006]	35.7/5.46	10.3 (4.6–23.3) [<0.0001]
Feels burnt-out	27.6/9.1	3.7 (2.4–5.9) [<0.0001]	32.1/3.1	15.1 (6.4–35.6) [<0.0001]
Work is frustrating (%)	19/5.7	3.8 (2.3–6.5) [<0.0001]	10.7/1.74	6.5 (1.8–23.3) [0.004]
Always worn out at the end of a work day (%)	46.6/14.7	5.0 (3.4–7.4) [<0.0001]	35.7/8.6	5.9 (2.7—13.2) [<0.0001]
Often exhausted in morning at the thought of work (%)	17.2/4.2	4.7 (2.7–8.2) [<0.0001]	7.14/2.0	3.5 (0.8–15.7) [0.10]
Seldom has energy for friends and family (%)	2.8/0.9	3.7 (1.0–13.3) [0.034]	0/0.86	na [0.62]

*OR adjusted for gender, age, and smoking).

TABLE III. Work Exposure Factors Associated With DRD Symptoms Among MRTs Without Doctor-Diagnosed Asthma

	MRTs with DRD	MRTs without DRD	OR (95% CI)*	*P* value
Number	116	1,367		
Number of processors at work	3.1 ±3.3	3.1 ±2.8		0.98
Hours per week processing films	8.8 ± 9.7	7.0 ± 8.4		0.01
Darkroom processor is used in typical shift (%)	87	80	1.6 (0.9–2.9)	0.08
Not all machines have local exhaust (%)	62	48	1.8 (1.1–3.1)	0.02
Inadequate ventilation in the film processing area (%)	73.8	40.4	4.1 (2.6–6.5)	<0.0001
Processing machine leaks have ever not been cleaned up for more than a day (%)	34.4	18.2	2.5 (1.5–3.9)	0.0002
Floor drain at work has ever clogged (%)	83.8	67.3	2.5 (1.5–4.3)	0.0004
Need to free a film jam at least weekly (%) [pre-1995 %]	16.8 [27.7]	10.7 [23.5]	1.8 (1.1–3.1) [1.3 (0.8–2.0)]	0.03 [0.27]
Removes used chemicals from auto-machine (%)	27.5	17.1	2.0 (1.3–3.2)	0.004
Cleans up a processor chemical spill at least weekly (%)	66.1	40.2	3.0 (2.0–4.5)	<0.0001
Detects odor of film processing chemicals daily (%)	50.4	21.8	3.7 (2.5–5.5)	<0.0001
Job requires rapid and continuous physical activity (% strongly agreeing)	67.2	47.7	2.2 (1.5–3.3)	0.0001
Have concerns about processor and other chemicals at work (%)	78.1	42.5	4.8 (3.1–7.7)	<0.0001
Usually use gloves at work (%)	72.2	69.3	1.1 (0.7–1.7)	0.56
Gloves used are usually latex (%)	52.8	51.9	1.0 (0.7–1.6)	0.82
Rash when using latex gloves (%)	22.1	14	1.7 (1.0–2.9)	0.05
Itchy red eyes when using latex gloves (%)	19.5	5.7	4.1 (2.1–7.7)	<0.0001
Cough/wheeze when using latex gloves (%)	9.1	2.1	4.9 (2.0–12.3)	0.0007

*OR adjusted for age, gender and smoking).

physical and emotional exhaustion, frustration and burn-out (Table II). In contrast there was no difference between the groups in reporting that their job required them to learn new things, required a high level of skill, and required lifting heavy loads (data not shown). Both groups reported similar job security (52% with and 63% without DRD symptom clusters stated their job security was good, $P = 0.30$).

PTs with these symptom clusters, compared with those without, reported similar increases in responses to questions reflecting psychosocial stressors as seen in the MRT groups (Table II). Similarly, there was no significant difference in reported job security (55% with DRD symptom clusters and 68% without reported good job security, $P = 0.23$), similar to that reported by MRTs. Summary indices for both SF12 physical health (physical component summary score) and mental health (mental health summary score) [Ware et al., 1995] were significantly associated with DRD $P < 0.0001$. However, even after adjustment for both summary indices, individually and in the same model, the relative increased prevalence of DRD symptom clusters for MRTs compared with PTs did not change significantly. The OR was 4.5 [95% CI 2.8–7.0] after adjustment for physical and mental components of the SF12, as well as adjusting for age and gender (OR 4.7 [95% CI 2.8–7.8] when smokers were excluded).

MRTs with DRD were more likely to report factors expected to reflect greater workplace chemical exposures (Table III): less local exhaust of machines, and more frequent inadequate ventilation in the processing area, delayed clean-up of processing machine leaks, clogging of floor drains, need to free film jams (especially before 1995), personal clean-up of processor spills and daily detection of the odor of film processing chemicals. Both MRTs and PTs with DRD symptom clusters reported more concerns about chemicals at work (Tables III and IV). MRTs (but not PTs) with the symptom cluster were more likely to report eye, nose, lower respiratory, and contact hand symptoms in association with latex gloves use (Tables III and IV). In contrast, there was no difference between the MRT groups with and without DRD in reported frequency of mixing fixer or developing chemicals, loading and removing films, wet developing, removing used chemicals from automated machines, cleaning processors, and use of protective devices such as respirators, goggles, lead aprons (data not shown).

TABLE IV. Work Exposure Factors Associated With DRD Symptom Clusters Among PTs

	PTs with DRD	PTs without DRD	OR (CI)*	*P* value
Number	27	1,512		
Long periods of awkward body positions (%)	17.9	4.9	4.2 (1.5–11.4)	0.005
Job requires rapid and continuous physical activity (% strongly agreeing)	44.4	17.7	3.4 (1.6–7.4)	0.002
Have concerns about chemicals at work (%)	63.9	23.4	6.7 (3.0–15.1)	<0.0001
Usually use gloves at work (%)	25	17.3	1.4 (0.6–3.4)	0.43
Gloves used are usually latex (%)	37.5	19.1	2.3 (1.0–5.5)	0.05
Rash when using latex gloves (%)	12.5	5.0	2.3 (0.7–7.9)	0.2
Itchy red eyes when using latex gloves (%)	0	2.0	na	0.48
Cough/wheeze when using latex gloves (%)	0	0.9	na	0.64

*OR adjusted for age, gender, and smoking.

Additional symptoms were more common among those with DRD symptom clusters, both in MRTs and PTs (data not shown). The adjusted ORs for symptoms among MRTs with DRD versus those without these symptoms, and for PTs with versus without these symptoms, were respectively, for nausea OR 8.3 (CI 4.2–16.3) and OR 13.1 (CI 4.1–41.5); dizziness OR 8.2 (CI 4.9–14.0) and OR 14.8 (CI 5.1–42.4); and rash OR 2.3 (CI 1.2–4.5) and OR 3.1 (CI 0.9–10.5). Moreover, the ORs for MRTs with DRD were increased for cognitive symptoms and the magnitude of the OR for these symptoms was greater among MRTs than among PTs with versus without DRD symptoms. MRTs with versus without DRD more frequently reported problems concentrating, OR 3.8 (CI 2.6–5.7); short memory, OR 2.6 (CI 1.8–3.9); difficulty getting the meaning from newspapers or books, OR 2.6 (CI 1.6–4.1); and/or that relatives had told them they had a short memory OR 2.6 (CI 1.8–3.9). In contrast, for PTs with versus without DRD symptom clusters, the only significant association found for these symptoms was for problems concentrating, OR 3.0 (CI 1.4–6.5).

Lower respiratory symptoms among those without doctor-diagnosed asthma

Excluding those with doctor-diagnosed asthma, lower respiratory symptoms (adjusted for age, smoking, and gender) were also more common among MRTs than PTs, and were significantly more frequent among those with DRD. The magnitude of the ORs for those with versus without DRD symptom clusters was similar among MRTs and PTs (Table V).

Other symptoms

Among non-smokers, the following symptoms (which were not part of our symptom cluster definition) occurring at least 15 days in the previous year and worse at work, were more commonly reported by MRTs than PTs (OR > 1.8; $P < 0.01$; and reported by $>0.5\%$ of both professions): nausea (reported by 3.3/1.7%), dizziness (6.1/2.2%), and numbness (4.1/1.7%). Of note, the OR was greatest for the

TABLE V. Reporting of Lower Respiratory Symptoms in the Previous Year, Among MRTs and PTs* With and Without DRD Symptom Clusters Without Doctor-Diagnosed Asthma

	MRTs with DRD	MRTs without DRD	OR (CI)**	PTs with DRD	PTs without DRD	OR (CI)**
Wheeze (%)	27.8	9.2	4.0 (2.5–6.3)	14.3	4.1	4.0 (1.3–11.8)
Cough on exertion	22	6.5	4.1 (2.5–6.7)	18	2	10.2 (3.6–28.5)
Wheeze on exertion	20.1	6.0	4.3 (2.6–7.1)	3.6	1.7	2.3 (0.3–17.4)
Chest tightness on exertion	23.3	6.6	4.5 (2.8–7.4)	14.3	2.4	7.5 (2.4–23.5)
Woken by wheeze	6.9	1.8	4.0 (1.8–9.1)	0	0.9	na
Woken by dyspnoea	11.3	2.7	5.1 (2.6–10.0)	7.1	1.5	4.7 (1.0–21.0)
Wheeze with dust	13.8	5.4	2.9 (1.6–5.1)	7.4	2.2	3.6 (0.8–15.6)

*All respiratory symptoms were significantly more frequent among MRTs than PTs.
**OR adjusted for age, smoking, and gender.

symptom ''chemical or metallic taste in the mouth,'' reported by 5.2% of MRTs and 0.2% of PTs WR and occurring at least 15 days in the previous year, with unadjusted OR 27.1 (CI 8.5–86.8), representing the strongest association observed between the two professions.

DISCUSSION

The present study is the largest review of radiographers to assess work attributed symptom complexes consistent with DRD. These symptom clusters were significantly more common among MRTs than among PTs, occurring over four times as often, consistent with previous reports of ''DRD'' [Genton, 1998]. It is unlikely that the increases in WR symptoms by MRTs reflected universal symptom over-reporting by MRTs. This is because the frequency of symptoms included to detect over-reporting, such as abdominal pain, hives, blurred vision, skin rash, and fever/night sweats, which have not been reported to be part of DRD symptoms, were similar in both groups and were very low in prevalence. Moreover, we found that MRTs were not more likely to meet outcomes used previously by Kipen et al. [1999] and Kreutzer et al. [1999] to identify those possibly having multiple chemical sensitivities/idiopathic environmental intolerance (data not shown), also indicating that it was unlikely that MRTs were over-reporting.

The DRD symptom clusters reported by 1.8% of PTs clearly were not due to exposure to darkrooms or darkroom chemicals. However, the symptom cluster we selected for this study definition is non-specific and might be expected to occur in a small proportion of any workforce. The symptom cluster is also very similar to definitions used for SBS, in settings such as office buildings [Mendell, 1993; Hodgson, 2000; Hodgson, 2002]. We found significant associations among both MRTs and PTs between these self-reported symptoms and self-reporting of factors reflecting psychosocial stresses at work. There is recognized psychosocial stress in health care workers which may relate to staff cut-backs despite increasing patient numbers, and pressure for MRTs to complete radiological procedures within a timely manner. In the clinic setting, MRTs may be required to perform administrative duties in addition to their technical tasks (Ontario Association of Medical Radiation Technologists, personal communication). The presence of these factors in the workplaces could not be objectively assessed in this study. The differences recorded between those with and without DRD symptoms could be explained either by the environmental exposure differences in the two groups, or by differences in perception of the symptomatic workers (which might have caused both increased reporting of psychosocial stressors and DRD symptom-reporting or an increase in perception might have resulted from DRD), or by a combination of both factors. Of note the increased ORs for DRD among MRTs persisted after adjustment for physical and mental health summary scales, suggesting that the environmental exposures truly did contribute to the increased prevalence of the symptom clusters in the MRTs.

Some additional non-respiratory symptoms, not included in our DRD symptom definition, such as nausea, dizziness, rash, and numbness, were reported more commonly by MRTs. The ORs for these were particularly increased among those who fit our criteria for DRD, both among MRTs and PTs to a similar extent, suggesting that these might be considered part of the same syndrome. Some symptoms were increased disproportionately among MRTs with the DRD symptom cluster rather than by PTs with the symptom cluster, such as cognitive symptoms which may have reflected a more specific environmental or psychosocial influence in MRTs with DRD.

Differences in reported exposures to chemicals at work were not objectively assessed in this study among MRTs, both with and without DRD symptoms. Therefore, reporting bias cannot be excluded as a possible explanation for our results. However, findings indicate an association between self-reported indicators of increased exposure to workplace chemicals and symptoms among MRTs. Several of the DRD symptoms, notably nose and eye symptoms could potentially be triggered by mucous membrane irritant effects. Of interest, our previous assessment of asthma among the MRTs in this study also showed an association between indicators of respiratory irritant exposures criteria used in our study questionnaire for asthma. Although workplace measures were not performed specifically for subgroups with and without DRD symptoms, a small sample of workplaces (not selected for the presence or absence of DRD) underwent an exposure assessment with findings of very low concentrations of glutaraldehyde. Geometric mean acetic acid and sulfur dioxide levels, although generally within allowable threshold limit values, were significantly higher in darkrooms of MRTs with WR asthma symptoms than among other darkrooms (Doherty J, et al., personal communication).

Nevertheless it is possible that acetic acid, sulfur dioxide, or other volatile chemicals such as formaldehyde or glutaraldehyde might account for irritant and/or odor-related nasal and eye effects, causing DRD symptoms. This would be consistent with the hypothesized mechanism of DRD-like syndromes or SBS in other settings, that volatile organic compounds [Sundell et al., 1993; Ten Brinke et al., 1998] or bioaerosols [Teeuw et al., 1994; Menzies et al., 2003], may be specific triggers for discomfort and health symptoms that are then exaggerated by work stress and/or thermal discomfort, as recently reviewed [Hodgson, 2002; Kipen and Fiedler, 2002]. Similarly, preceding/underlying stress has been shown to lead to more severe upper respiratory symptoms induced by viral infections as reported by Cohen et al. [1991], and stress or perceived risk can affect symptom reports related to chemical odorous or irritant

responses as reviewed by Dalton [2003]. A recent study by Menzies et al. [2003] showed a reduction of building-associated symptoms of mucous membrane irritation by use of ultraviolet germicidal lights in a double-blind study, with greatest improvement among atopic individuals and non-smokers, suggesting that symptoms, at least in part, were related to mucous membrane irritation from microbial contamination.

Atopy was also not assessed objectively in this study, but it is of note that those with DRD symptoms reported more nasal, eye and lower respiratory symptoms on exposure to natural rubber latex gloves. Although this was still reported by a minority of those with DRD symptoms (less than 20%, and less than 10% for lower respiratory symptoms), nevertheless, it suggests the possibility of underlying allergic or non-allergic rhinitis or conjunctivitis as a risk factor for increased mucous membrane symptoms in response to low levels of irritants, such as reported to chlorine by Shusterman et al. [1998]. This might account for a relative increase in SBS symptoms in atopic workers described by Menzies et al. [1997] in buildings and by our findings with DRD symptoms in this study. The finding of a similar relative increase in the likelihood of having lower respiratory symptoms suggestive of asthma among those with DRD symptoms but without physician-diagnosed asthma might be due to increased awareness of respiratory symptoms, or may be due to undiagnosed asthma as a component of, or predisposing factor to DRD symptoms. This study could not distinguish between these possibilities.

The very high relative risk for reporting WR chemical or metallic taste by MRTs as compared with PTs (OR over 27) has also been reported by others [Genton, 1998], and may have been related to the presence of one or more of the processing chemicals used by the MRTs. Which chemical(s) may have caused this is unknown since exposures include acetic acid, sulfur dioxide, formaldehyde, glutaraldehyde, and other chemicals [Teschke et al., 2002]; however, our exposure assessment suggests that acetic acid or sulfur dioxide may be causative agents (Doherty J, personal communication).

In contrast to the findings relating to DRD symptoms, as noted above, MRTs were no more likely to meet criteria for multiple chemical sensitivity than PTs. They do not consider themselves ''unusually sensitive'' or require modifications of lifestyle including diet, home, or clothes (data not shown). Nevertheless, it is possible that there may be some survivor bias in our findings as we would not have identified individuals who were more chemically sensitive and who had left the workplace due to their symptoms.

In conclusion, MRTs have an excess of symptoms consistent with DRD. There were significant associations between these symptom clusters and self-reporting of increased psychosocial stressors and increased workplace exposure to expected mucous membrane irritants among MRTs with these symptoms, which may be primary or secondary to the etiology of this syndrome. The prevalence of 7–8% of MRTs meeting our criteria for DRD in the previous year has significant health implications for this workforce. Changes to processing-free radiography, with digital films, may offer the opportunity to follow these workers in the future to provide further understanding as to the role played by darkrooms and their chemicals in the etiology of these symptoms.

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