

Field Study

Association between Use of Synthetic Metalworking Fluid and Risk of Developing Rhinitis-related Symptoms in an Automotive Ring Manufacturing Plant

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Abstract: Association between Use of Synthetic Metalworking Fluid and Risk of Developing Rhinitis-related Symptoms in an Automotive Ring Manufacturing Plant: Dong-Uk PARK, et al. Department of Environmental Health, Korea National Open University, Korea—The main objective of this study was to determine the association between synthetic metalworking fluid (MWF) and rhinitis-related symptoms. At a plant manufacturing piston rings for automobiles, we interviewed grinders (19) and manufacturing workers (142) in operations where synthetic or semisynthetic MWF is handled, and administrative office workers (44) regarding the principal symptoms of rhinitis (nasal stuffiness, runny nose, anosmia, nasal itchiness, rhinorrhea, headache, epistaxis, and post-nasal drip). In addition, we assessed the current exposure of workers handling MWF to MWF aerosols, fungi, and endotoxins. Logistic regression analysis was used to examine the association between MWF surrogates indicative of MWF exposure and each rhinitis-related nasal symptom. Odds ratios (ORs) and 95% confidence intervals were adjusted for sex, age, smoking habit, and duration of employment. Among grinders handling synthetic MWF, the frequency of complaints of the dominant symptoms was 66.7% for nasal stuffiness, 77.8% for anosmia, 77.8% for runny nose, and 50.0% for headache. These rates are quite high even allowing for the common occurrence of rhinitis in the general population. Twenty eight of 34 grinding and manufacturing workers (82.4%) sampled were exposed to MWF mist above the threshold limit of 0.2 mg/m³ listed as a notice of intended change by the American

Conference for Governmental Industrial Hygienists (ACGIH). The percentage of workers exposed to MWF mist >0.5 mg/m³ was 17.6%. Most workers were exposed to fungi levels >10³ CFU/m³. All exposures to endotoxins were <50 EU/m³. Logistic regression analysis found that use of synthetic MWF was significantly associated with excess risk of nasal stuffiness (OR 3.5), nasal itchiness (OR 2.0), and runny nose (OR 2.1). The use of semi-synthetic MWF had little or no impact on the risk of developing rhinitis-related nasal symptoms. Grinding workers handling synthetic MWF had an increased risk of nasal stuffiness (OR 7.9), anosmia (OR 23.2), nasal itchiness (OR 8.3), runny nose (OR 20.4), post nasal drip (OR 18.4), and headache (OR 7.4) compared to administrative workers. Synthetic MWF may play an important role in the development of the dominant symptoms of rhinitis. Further study is needed to establish the risk of rhinitis or rhinitis-related symptoms according to MWF type.

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Key words: Rhinitis, Synthetic metalworking fluids (MWF), Semisynthetic MWF, Metalworking fluid (MWF), Grinding operation

Workers using water soluble metalworking fluid (MWF) are exposed to a variety of chemical and biological agents that might be associated with the development of respiratory disease, including rhinitis. Many studies have focused on respiratory diseases such as occupational asthma, decrement of lung function, and hypersensitivity pneumonitis^{1, 5–9}. These studies reported prevalence of a few nasal symptoms in workers exposed to MWF, but other respiratory symptoms or diseases were mainly discussed. That is, there have been few reports of the prevalence of nasal symptoms among workers exposed to MWF. Furthermore, studies of the effects of

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occupational exposure on the development of rhinitis in workers who are handling MWF are sparse.

In a study by Rosenman *et al.*¹⁾, the percentage of workers exposed to MWFs who reported that they visited a doctor for sinus problems ranged between 29.4% (exposure to straight MWF only) and 48.1% (exposure to synthetic MWF only). In a study by Oudyk *et al.*²⁾ investigating the effects of exposure to MWFs on respiratory symptoms, 42% of 2,377 workers exposed to water soluble MWFs reported runny or plugged nose on a weekly or daily basis. Occasionally, nasal symptoms or problems have been noted among workers in plants manufacturing automobile parts using water soluble MWFs. Recently, Park *et al.*^{3,4)} investigated the association between nasal respiratory symptoms and exposure to water soluble MWFs in a plant manufacturing automobile engines and found no significant difference in symptoms between workers who did and did not handle MWFs.

The determinants of respiratory diseases such as occupational asthma and hypersensitivity pneumonitis have been widely studied in plants using MWFs^{1,5-9)}. However, the epidemiology of rhinitis is poorly understood. Few studies have evaluated the relationship between the development of rhinitis or rhinitis-related symptoms and risk factors in occupational environments that include MWFs. We believe that the lack of evidence linking exposure to MWFs or other work conditions to the development of rhinitis or rhinitis-related symptoms is due to the fact that rhinitis is considered a minor disease and common even in the absence of workplace exposure. Another important obstacle to a better understanding of the epidemiology of rhinitis is the absence of a standardized and well validated method for identifying the condition¹⁰⁾.

Although there is no general agreement regarding the definition of rhinitis for use in an epidemiological study, the most common signs and symptoms of chronic rhinitis are nasal stuffiness, rhinorrhea, post-nasal drip, nasal itchiness, and occasional headache^{11,12)}. Questions based on these symptoms have been used to define rhinitis in several studies^{10,13-16)}. Some of these symptoms were previously used to examine the prevalence of rhinitis in plants that use MWFs in the manufacturing of automobile parts. Park *et al.*³⁾ reported the prevalence of epistaxis and anosmia, including six of the symptoms described above, among workers manufacturing shafts for automobiles.

The main objective of this study was to assess the risk for development of rhinitis-related symptoms associated with the use of synthetic MWF. In addition, we identified the dominant rhinitis-related symptoms and report exposure to MWF aerosol and microbes including endotoxins.

Methods

Study plant and operations

The study plant manufactures piston rings for

automobiles. The plant has two main lines, casting and production, which are separately located and operated. In the casting line, the rings are roughly cast in molds. The rings are cleaned and finished on the production line, which consists of grinding, manufacturing, and quality control (QC) operations. The cast rings are initially sent from the casting line to the grinding operation, where the ring surfaces are roughly ground using synthetic MWF. The ground rings are immersed in cleaning solution to remove pollutants such as oil. All workers in the grinding operation handle synthetic MWF. After the initial grinding, the rings are sent to the manufacturing operation, where the inner, outer, upper, and lower parts of each ring are further finely ground. Synthetic MWF is used in both the grinding and manufacturing operations; the manufacturing operation also uses semisynthetic MWF. The three manufacturing operations also perform other tasks such as electroplating and acid rinsing. Workers involved in these operations work in the same room as workers using MWF and may have contact with automobile rings bearing residual MWF with potential exposure to MWF aerosol. The rings are inspected and assembled in the QC operation, which is in a separate location.

We selected operations for study based on the use of MWF and exposure to MWF. Workers from the grinding and manufacturing operations, where MWFs are handled directly or in the same room, were used for the case group. Administrative workers, who routinely work in an office area separate from but adjacent to the field operations, were used as a control group. The casting line and QC operations were not included in this study due to the absence of MWF use. Although we previously reported that 88% of 26 QC workers were diagnosed with rhinitis by a physician⁴⁾, the cause of rhinitis was not confirmed.

Questionnaire

All workers who were involved in the grinding (19) and manufacturing operations (142) were invited to participate in a questionnaire survey. Forty-four administrative office workers who had never been involved in manufacturing piston rings were also invited to participate. Workers with previous respiratory or rhinitis disease were excluded. The questionnaire was administered to 205 workers with the assistance of trained interviewers who work at the environmental health department of the plant.

The questionnaire was primarily designed to capture all information pertaining to rhinitis-related symptoms. Our questionnaire included eight questions relating to rhinitis or nasal problems (nasal stuffiness, anosmia, nasal itchiness, epistaxis, runny nose, post-nasal drip, rhinorrhea, occasional headache), which were used in other studies^{3,10-16)}. Subjects were asked if they experienced "a problem with these symptoms at work on

a weekly basis". Other questions pertained to current and past employment and possible exposure to respiratory irritants during previous jobs. Demographic information, including age and occupational history, were collected. All responses to questionnaires were collected at the subject plant when physical examinations for rhinitis were conducted with the consent of union workers. Questions that subjects did not answer were treated as missing values for the analysis.

Assessment of current exposure to MWF aerosol and biological agents

Current exposure to MWFs was assessed on the basis that it is suitable for estimating the risk of acute or subchronic health effects such as rhinitis. Workers from the grinding and manufacturing operations were categorized on the basis of similar exposure in terms of the characteristics of the operation, environmental hazards and work practice into similar exposure groups (SEG). Workers representing each SEG by operation were randomly selected for assessment of exposure to environmental hazards that are known to be associated with the development of sinus-related disease or rhinitis-related symptoms. Exposures to MWF aerosols and biological agents (fungi and endotoxins) in the breathing zone of the representative production line workers were assessed in parallel. Airborne MWF mists from the breathing zone were measured using the sampling and analytical methods recommended by the National Institute for Occupational Safety and Health (NIOSH)¹⁷. The collected aerosol was resuspended in 10 mL sterile, non-pyrogenic water by orbital shaking (1,000 RPM for 15 min) at room temperature, and endotoxin concentrations were quantified using the Kinetic Turbidimetric Limulus Amoebocyte Lysate method (Pyrogent-5000, BioWhittaker, Walkersville, MD) of the American Society for Testing and Materials (E2144-01)¹⁸. Airborne microorganisms such as viable bacteria and fungi were collected and analyzed using the CAMNEA method, as recommended by Palmgren *et al.*¹⁹ We were not able to directly input exposure to MWFs and biological agents into the logistic regression models, but levels of exposure are compared with results reported from automobile plants using MWF and discussed with regard to their possible role in causing nasal symptoms.

Statistical analysis

The data were analyzed using descriptive statistics, the chi-square test, and logistic regression models with SPSS 12.0 Standard Version (SPSS Inc., Chicago, IL). Classifications of nasal symptoms were binary (present or absent). Surrogates for MWF exposure such as use of MWF (reference: no use MWF), type of MWF used (reference: semisynthetic MWF), and plant operations (reference: administrative office) were expressed

categorically. The chi-square test was used to examine whether general characteristics such as age, duration of employment, smoking status, and sex significantly influenced the development of nasal symptoms.

A standard logistic regression model was used to examine the association between MWF surrogates indicative of MWF exposure and each rhinitis-related nasal symptom. Odds ratios (OR) and 95% confidence intervals (CI) were estimated using logistic regression models adjusted for age, sex, duration of employment, and smoking status. The independent variables such as use of MWF, type of MWF used, and plant operation were further classified depending on the objective of the analysis. Use of MWF was characterized in three ways: a) 1=semisynthetic, 2=synthetic, and 3=no use of MWF (reference); b) 1=synthetic, 2=semisynthetic; and c) 1=use of MWF and 2=no use of MWF (reference). Plant operations were also further characterized in 3 ways: a) 1=grinding, 2=manufacturing, and 3=administrative workers (reference); b) 1=grinding and 2=manufacturing (reference); and c) 1=field operations including grinding and manufacturing and 2=administrative workers (reference).

Results

Worker demographics and relationship to nasal symptoms

Table 1 shows the distribution of study participants within each plant operation by sex, age, duration of employment, and smoking status. Age and smoking status were not significantly different between the three operations ($p>0.05$). All eight females were administrative workers.

Of the demographic variables, only smoking status was associated with the development of several nasal symptoms. In a model adjusted for duration of employment and age, a higher risk of rhinorrhea was found for current smokers (OR 30.5; CI 2.5–378) versus non-smokers, and a higher risk of stuffy nose (OR 2.8; CI 1.1–7.1) and post-nasal drip (OR 5.3; CI 1.0–26.4) was found for ex-smokers compared to non-smokers. A possible association between smoking and some rhinitis-related symptoms (rhinorrhea and stuffy nose and post-nasal drip) was found. This finding is similar to several previous findings. Oudyk *et al.*² found that ex-smokers and current smokers among workers handling MWF were found to be at a higher risk than non-smokers for developing a runny or plugged nose.

Cross-sectional studies showed that children or adolescents with allergic rhinitis smoke more than others²⁰. In another study, it was found that a past history of smoking is more common among allergic patients than non-allergic patients. Tobacco smoking may increase allergic sensitization to haptens in occupational settings²². Several studies have indicated that smoking may cause several nasal symptoms such as stuffy nose, rhinorrhea,

Table 1. General characteristics of study subjects

Characteristics	Total (n=205)	Operation			p
		Office (n=44)	Grinding (n=19)	Manufacturing (n=142)	
Age, mean years \pm SD	40 \pm 9.2	36 \pm 10	39 \pm 11	40 \pm 8	>0.05 ^A
Duration of employment, mean years \pm SD	14.2 \pm 9.0	10.0 \pm 8.1	14.8 \pm 10.7	15.4 \pm 8.7	<0.05 ^A
Age, years					>0.05 ^B
<30	43 (20.9)	13 (29.6)	7 (36.8)	23 (16.2)	
30–39	67 (32.7)	14 (31.8)	4 (21.1)	49 (34.5)	
40–50	66 (32.2)	10 (22.7)	6 (31.6)	50 (35.2)	
>50	29 (14.2)	7 (15.9)	2 (10.5)	20 (14.1)	
Duration of employment, years					<0.05 ^B
<5	38 (18.9)	13 (29.6)	5 (26.3)	21 (14.8)	
5–10	39 (19.4)	14 (31.8)	4 (21.1)	21 (14.8)	
>10	128 (63.7)	17 (38.6)	10 (52.6)	100 (70.4)	
Sex					<0.05 ^B
Female	8 (4.0)	8 (18.2)	0	0	
Male	197 (96.0)	36 (81.8)	19 (100)	142 (100)	
Smoking status n=181 ^C					>0.05 ^B
Never	44 (24.3)	14 (31.8)	4 (21.1)	26 (18.3)	
Former	49 (27.1)	6 (13.6)	5 (26.3)	38 (26.8)	
Current	88 (48.6)	18 (40.9)	7 (36.8)	63 (44.4)	
Not answered	24 (11.7)	6 (13.6)	3 (15.8)	15 (10.6)	

Categorical values are expressed as n (%).

^AANOVA, ^B χ^2 analysis, ^C19 missing values.

Table 2. Exposure to MWF mists, endotoxins, and fungi according to plant operation

Operation	MWF mist (mg/m ³)	Endotoxins (EU/m ³)	Culturable Fungi (CFU/m ³)
Grinding (n=12)			
Mean	0.85	11.4	1.1 \times 10 ⁵
Range	0.05–7.65	6.1–44.3	19–5.4 \times 10 ⁵
Manufacturing (n=22)			
Mean	0.48	8.3	1.1 \times 10 ⁵
Range	0.18–1.38	3.8–19.4	7–2.7 \times 10 ⁶

and post-nasal drip in workers exposed to water soluble MWF. Adjustments were made for all general characteristics, including smoking status, when evaluating the association between MWF surrogates indicative of MWF exposure and each rhinitis-related nasal symptom.

Current exposure to MWF mist, endotoxins, and microbes

Twenty-eight of the 34 grinding and manufacturing workers (82.4%) were exposed to MWF mist higher than 0.2 mg/m³ for mineral oil mist (NIC) indicated as a notice of intended change by the American Conference for Governmental Industrial Hygienists²³. This NIC of

ACGIH is for mineral oil mist (straight MWF). NIC MWF mist exposure of workers in the grinding operation averaged 0.85 mg/m³, which is above the recommended exposure level (REL) of 0.5 mg/m³ for both oil and water-based MWFs²⁴. The percentage of workers exposed to MWF mist above the REL was 17.6%. Most workers were exposed to fungi levels above 10³ CFU/m³. All exposures to endotoxins were below the 50 EU/m³ limit of occupational exposure proposed by the National Health Council of the Netherlands²⁵. Exposures to other chemical agents including chromium and ethanalamines (data not shown) were far too low to adversely affect

Table 3. Number and percentage of rhinitis-related nasal symptoms according to MWF handling characteristics and operation

	Nasal stuffiness	Anosmia	Nasal itchiness	Epistaxis	Runny nose
Type of MWF Handled ^A					
None (n=128)	56 (43.8)	32 (25.0)	41 (32.0)	16 (12.5)	46 (35.9)
Semisynthetic (n=18)	9 (50.0)	5 (9.3)	7 (38.9)	2 (11.1)	8 (44.4)
Synthetic (n=54)	40 (74.1)	17 (31.5)	25 (46.3)	11 (20.4)	31 (57.4)
$\chi^2(p)$	14 (<0.01)	NS	3 (<0.20)	NS	7 (<0.05)
MWF Handled ^A					
No (n=128)	56 (43.8)	32 (25.0)	41 (32.0)	16 (12.5)	46 (35.9)
Yes (72)	49 (68.1)	22 (30.6)	32 (44.4)	13 (18.1)	39 (54.2)
$\chi^2(p)$	11 (<0.01)	NS	3 (<0.10)	NS	6 (<0.01)
Operation					
Administrative (n=44)	9 (22.5)	3 (7.5)	5 (12.5)	5 (12.5)	7 (17.5)
Grinding (n=18) ^B	12 (66.7)	12 (66.7)	7 (38.9)	4 (13.8)	14 (77.8)
Manufacturing (n=142)	84 (59.2)	39 (27.5)	61 (43.0)	20 (14.1)	64 (45.1)
$\chi^2(p)$	18 (<0.01)	22 (<0.01)	13 (<0.01)	NS	20 (<0.01)
Prevalence,%	52.5	27.0	36.5	14.5	42.5

Values are n (%) unless otherwise indicated.

NS=not significant at $p=0.25$. ^AFive missing values. ^BOne missing value.

Table 3. (continued)

	Postnasal drip	Headache
Type of MWF Handled ^A		
None (n=128)	14 (10.9)	39 (30.5)
Semisynthetic (n=18)	1 (5.6)	5 (27.8)
Synthetic (n=54)	12 (22.6)	17 (31.5)
$\chi^2(p)$	NS	NS
MWF Handled ^A		
No (n=128)	14 (10.9)	39 (30.5)
Yes (n=72)	13 (18.3)	22 (30.6)
$\chi^2(p)$	NS	NS
Operation		
Administrative (n=40)	1 (2.5)	6 (15.0)
Grinding (n=18) ^B	5 (27.8)	9 (50.0)
Manufacturing (n=142)	21 (14.9)	46 (32.4)
$\chi^2(p)$	8 (<0.01)	8 (<0.01)
Prevalence,%	13.6	30.5

Values are n (%) unless otherwise indicated.

NS=not significant at $p=0.25$. ^AFive missing values. ^BOne missing value.

workers' respiratory health. The humidity for the two operations ranged between 31.2% and 43.8%. Irritants such as ozone, chlorine, NO₂, and SO₂ that are known to be associated with an increase in healthcare visits for allergic rhinitis^{12, 26} were not detected. Exposures to MWF mist, fungi, and endotoxins were generally higher for grinding workers than for manufacturing workers (Table 2).

The amount of synthetic MWF used yearly at the plant between 2002 and 2006 ranged from 18.4–30.6 tons. In 2006, 164 kg semisynthetic MWF was used, a very small amount in comparison to synthetic MWF. According to the Material Safety and Data Sheets (MSDS), synthetic MWF was composed of mono-ethanolamine (5–15%), tri-ethanolamine (5–15%), glycerin (3–9%), carboxylic compounds (1–5%), boric acids (1–5%), benzotriazole (0.1–0.3%), and water (55–65%). It was not possible to obtain more specific information about the ingredients of the MWF.

Prevalence of nasal symptoms related to rhinitis

Except for nasal itchiness, all rhinitis-related symptoms were most frequent among the grinding workers who directly handle synthetic MWF. Table 3 presents the rates of rhinitis-related nasal symptoms according to MWF handling characteristics and operation. The dominant symptoms that grinding workers complained of were, 66.7% for nasal stuffiness and anosmia, and 77.8% for runny nose. Complaints of nasal itchiness were slightly more frequent among manufacturing workers (43.0%) than among grinding workers (38.9%). Except for epistaxis, the prevalence of nasal symptoms related to rhinitis was significantly higher among grinding and manufacturing workers than among administrative workers ($p<0.01$).

Among workers who were involved in grinding or manufacturing rings, the frequency of symptom complaints was 60.0% for nasal stuffiness, 31.9% for anosmia, 42.5% for nasal itchiness, 48.8% for runny nose,

Table 4. Associations between MWF handling characteristics and operation, and nasal symptoms^A

	Nasal stuffiness	Anosmia	Nasal itchiness	Epistaxis	Runny nose
(1) Type of MWF I (reference: no use)					
Semisynthetic	1.3 0.5–3.7	1.1 0.3–3.4	1.3 0.46–3.82	0.9 0.2–4.2	1.4 0.5–3.9
Synthetic	3.5 1.6–7.5	1.1 0.5–2.4	2.0 1.0–4.1	1.8 0.8–4.3	2.1 1.0–4.2
(2) Type of MWF (reference: semisynthetic)					
Synthetic	2.6 0.8–8.4	1.1 0.3–3.8	1.7 0.5–5.2	2.6 0.5–13.9	1.5 0.5–4.7
(3) Use of MWF (reference: no use)					
Yes ^B	2.5 1.3–5.2	1.1 0.5–2.3	2.0 1.0–4.0	1.3 0.5–3.0	1.9 1.0–3.7
(4) Operation I (reference: administrative office)					
Grinding	7.9 1.9–32.5	23.2 3.8–141.6	8.3 1.7–40.9	2.3 0.5–11.0	20.4 4.1–101.4
Manufacturing	7.5 2.7–20.6	5.5 1.2–25.4	9.1 2.5–33.3	1.1 0.3–3.7	5.1 1.7–14.8
(5) Operation II (reference: manufacturing operation)					
Grinding	0.9 0.3–3.0	4.0 1.3–12.8	0.9 0.3–2.7	2.3 0.6–8.6	3.8 1.0–14.5
(6) Operation III (reference: administrative office)					
Field operations ^C	7.5 2.8–20.5	6.8 1.5–31.2	9.0 2.5–32.5	1.3 0.4–4.1	6.0 2.1–17.5

ORs and CIs were adjusted for age, smoking status, and duration of employment.

^AValues are OR and CIs. ^BWorkers who handled MWF directly. ^CField operations include grinding and manufacturing.

Table 4. (Continued^A)

	Rhinorrhea	Postnasal drip	Headache
(1) Type of MWF Handled (reference: no use)			
Semisynthetic	0.4 0.0–6.3	0.5 0.1–3.8	0.9 0.3–2.9
Synthetic	0.4 0.04–3.5	2.6 1.1–6.5	1.1 0.5–2.3
(2) MWF Handled (reference: semisynthetic)			
Synthetic	0.01 0.00–0.01	5.7 0.6–51.0	1.3 0.4–4.4
(3) MWF Handled (reference: no use)			
Yes	0.4 0.1–2.4	1.9 0.8–4.6	1.1 0.5–2.1
(4) Operation I (reference: administrative office)			
Grinding	3.5 0.1–125	18.4 1.8–189.6	7.4 1.7–32.4
Manufacturing	2.9 0.1–66.3	8.1 1.0–67.8	3.2 1.0–10.2
(5) Operations II (reference: manufacturing operation)			
Grinding	1.2 0.1–23.0	2.3 0.7–7.8	2.2 0.7–6.6
(6) Operations III (reference: administrative office)			
Field operation	3.0 0.1–66.6	9.3 1.1–77.6	3.7 1.2–11.4

ORs and CIs were adjusted for age, smoking status, and duration of employment.

^AValues are OR and CIs.

and 34.4% for headache. These can be regarded as the dominant symptoms among workers involved in manufacturing piston rings for automobiles (Table 3).

Risk for nasal symptoms related to rhinitis

Use of synthetic MWF was associated with increased risk of nasal stuffiness (OR 3.5; CI 1.6–7.5), nasal itchiness (OR 2.0; CI 1.0–4.1), and runny nose (OR 2.09; CI 1.04–4.20) compared to no use of MWF (model 1 in Table 4), while no symptom was related to use of semisynthetic MWF. In addition, there was no significant difference in risk between workers using synthetic and semisynthetic MWFs (model 2 in Table 4). This result indicates that the effects of synthetic and semisynthetic MWF on the development of rhinitis-related symptoms may not differ. However, to examine if adverse respiratory symptoms or diseases among fluid types differ significantly, future work with balanced subject cases will be necessary.

Three other models were created with different reference operations, as shown in models 4–6 of Table 4. Compared to office workers, grinding and manufacturing workers were at greater risk of developing all nasal symptoms except for epistaxis and rhinorrhea. Relative to manufacturing workers, grinding workers bore increased risk for developing anosmia (OR 4.0; CI 1.3–12.8) and runny nose (OR 3.8; CI 1.0–14.5). Compared to administrative workers, field workers, including grinding and manufacturing workers, demonstrated increased risk for developing all rhinitis-related nasal symptoms except for epistaxis and rhinorrhea (model 6 in Table 4). No variable significantly affected risk for developing epistaxis.

Discussion

Water-based MWFs including semisynthetic, emulsified, and synthetic MWFs that have been widely used in the automobile industry offer an excellent environment for microbes. There is an established association between exposure to MWFs and respiratory diseases such as asthma and hypersensitivity pneumonitis^{1, 5–9, 24, 27, 35}. In fact, occupational asthma and rhinitis are present concomitantly, with symptoms of rhinitis often developing before those of asthma^{16, 17, 28}. Little is known about the risk of rhinitis-related symptoms in plants manufacturing automobile parts, although several nasal symptoms have been reported in workers at such plants^{1–4, 27}.

Previous investigations of respiratory symptoms in workers handling MWFs revealed a few nasal symptoms such as nasal stuffiness, runny nose, consultation of a doctor for a sinus problem¹, and sinus trouble²⁷ that were only partly explained. That is, comprehensive rhinitis-related symptoms have rarely been reported in plants manufacturing automobile parts using MWF. Oudyk *et*

*al.*² observed an association between estimated MWF exposure and more frequent upper and lower respiratory symptoms with the exception of runny or plugged nose. They reported that neither average nor peak exposures were related to runny or plugged nose or shortness of breath. Until now, no study has examined the association between variables related to use of MWFs and the development of rhinitis or rhinitis-related symptoms. The present study was designed to identify the dominant nasal symptoms for rhinitis and examine the association between use of MWFs and development of rhinitis-related symptoms.

We found that there was a high prevalence of nasal stuffiness (60.0%), runny nose (48.8%) and nasal itchiness (42.5%) among grinding and manufacturing workers. Our previous results obtained from the same plant reported that 99 of 187 workers (52.9%) involved in grinding and manufacturing operations were medically diagnosed with rhinitis by an otolaryngologist⁴. The frequency of symptoms was higher than previously reported for workers in automobile manufacturing plants that use MWFs^{1–3}. Rosenman *et al.*¹ reported that 37.3% (emulsified MWFs), 42.9% (semisynthetic MWFs), and 48.1% (synthetic MWFs) of workers exposed to MWFs visited a doctor for sinus problems. The number of workers experiencing nasal stuffiness daily or weekly ranged from 25.1–42.9%. Oudyk *et al.*² reported that 42% of 2,935 employees working at a large automotive machining location complained of a runny or plugged nose daily or weekly. The prevalence of rhinitis-related symptoms among workers using MWFs in automobile plants is generally higher than that for workers in other occupational settings^{12, 29, 30}, even allowing for the common occurrence of rhinitis in the general population. Several studies^{1–3, 27} found that the dominant nasal symptoms were found to be stuffy nose, runny nose and nasal itchiness. These symptoms could be used to index rhinitis.

The high prevalence of rhinitis symptoms in workers within the automobile industry may be closely related to exposure to water soluble MWFs such as synthetic or semisynthetic MWFs, which include microbes, their toxins, and other metallic elements. We found a high prevalence of rhinitis despite the fact that current worker exposure to MWF aerosol was below 0.5 mg/m³. Exposure to MWF mist was found to be generally higher than exposures reported in several other studies identifying cases of hypersensitivity pneumonitis^{5, 9}, cross-shift decrement²⁷, or a high prevalence of respiratory symptoms in automobile plants^{1, 9}. Our findings confirm the NIOSH contention that non-malignant respiratory diseases like rhinitis can develop even with exposure below the REL (0.5 mg/m³)²⁴, although we did not test for the association between MWF aerosol concentration and rhinitis-related symptoms. Additional research is needed to explore the relationship

between MWF aerosol exposure and non-malignant respiratory diseases, including rhinitis.

Although the prevalence of nasal symptoms has been reported to an extent, little is known about the relationship between exposure to water soluble MWF and the development of rhinitis.

We also found that the use of MWFs (compared to no use of MWF) and employment in operations where MWFs are handled (compared to administrative employment) were associated with excess risk of nasal stuffiness, nasal itchiness, and runny nose. Logistic regression analysis indicated that workers using synthetic MWF are at significantly increased risk for developing nasal symptoms such as nasal stuffiness (OR 3.5; CI 1.6–7.5), nose itching (OR 2.0; CI 1.0–4.1), runny nose (OR 2.1; CI 1.0–4.2), and post-nasal drip (OR 2.6; CI 1.1–6.5) compared to office workers who are not exposed to MWF. Grinding and manufacturing workers were at much higher risk than administrative workers for developing most nasal symptoms. In particular, grinding workers directly handling synthetic MWFs were more likely to develop nasal symptoms than were office workers who were never exposed to MWF in the same plant. This finding indicates that use of synthetic MWFs may increase the risk of developing rhinitis-related problems. However, the use of semisynthetic MWF may have little or no impact on the risk of developing such problems. We found no significant difference in risk of nasal symptoms for workers using semisynthetic versus synthetic MWF.

Although we found that synthetic MWFs play an important part in the development of rhinitis-related symptoms, it is not clear whether the prevalence of rhinitis-related symptoms is distinctly different among different types of MWFs. To compare the risk of rhinitis-related symptoms associated with different types of MWFs, more samples and additional types of MWFs such as straight and water soluble MWFs should be included. Unfortunately, we could not examine the effects of straight and soluble MWFs on the development of rhinitis-related symptoms. Also, the effect of semisynthetic MWFs on the development of rhinitis-related symptoms could not be determined due to limitations such as the low number of subjects handling it¹⁸⁾, the short duration of use (a couple months) and co-exposure to synthetic MWFs.

Based on our results, the questions included in our questionnaire, or similarly simple questions regarding nasal problems might be useful for clinicians and epidemiologists seeking to assess rhinitis resulting from MWF use. Information on the use of MWFs such as MWF type and intensity of exposure should also be considered in determining the risk of rhinitis.

Rhinitis may appear as the first manifestation of a common allergic airway disease, eventually leading to the onset of asthma^{17, 31–34)}. Based on the etiology of

rhinitis, a concise questionnaire for nasal symptoms may be sufficient for identification, determination of comorbidity with other manifestations of occupational asthma, and classification of the severity of symptoms. In addition, a questionnaire for nasal symptoms could be used to recognize the onset of asthma and to prevent development of asthma in plants that use MWF. Our results could help to inform the causes and risks of rhinitis in automobile part manufacturing plants that use MWFs.

A major limitation of this study is that the relationship between exposure levels and the development of rhinitis-related symptoms was not examined. In order to determine the quantitative association of exposure to MWF mist, either estimation of retrospective exposure or sufficient current MWF samples may be required. Our results may serve as a basis for this future work.

Conclusions

The prevalence of nasal symptoms in a plant manufacturing piston rings for automobiles was higher than all rates previously reported for automobile plants and other occupational settings. The dominant symptoms exhibited by grinding and manufacturing workers were nasal stuffiness, nasal itchiness, and runny nose. In addition, use of synthetic MWF was significantly related to the development of rhinitis-related symptoms. We conclude that employment in a grinding operation that uses synthetic MWF is associated with significantly higher risk for stuffy nose, anosmia, nasal itchiness, runny nose, and headache. Further study is necessary to examine whether there are differences in the level of risk for rhinitis-related symptoms associated with each of the four different MWF types.

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