A Survey for Rhinitis in an Automotive Ring Manufacturing Plant

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Abstract: We report findings regarding otolaryngologist-confirmed rhinitis, current exposure to MWF aerosols, fungi, and endotoxins for workers in a plant manufacturing automobile piston rings. Questionnaire data showed that 61.5% of 187 workers exhibited rhinitis-related symptoms. Rhinitis was confirmed in 99 of 115 workers whom were medically examined. Otolaryngologist-confirmed rhinitis was present in 10 of 19 grinding workers (52.6%), 67 of 142 production workers (47.2%), and 22 of 26 quality control (QC) workers (84.6%). These rates are much higher than the rates of rhinitis-related symptoms in automobile plants and other occupational settings and quite high even allowing for the common occurrence of rhinitis in the general population. We found that rhinitis could develop even in workers exposed to less than 0.5 mg/m³ MWF aerosol. The average exposure to fungi exceeded 10×10^3 CFU/m³, a level higher than that reported for other automobile plants. Although we were unable to identify significant risk factors for rhinitis using only the physician-confirmed rhinitis cases, this study concludes that exposure to MWF aerosol, which would include microbes and metals, could contribute to a high occurrence of rhinitis in grinding and production workers. Forty-nine workers (63.6%) of 77 rhinitis patients in grinding and production operations were determined to handle synthetic MWF directly. For QC workers, for whom the prevalence of physician-confirmed rhinitis was highest, exposure to a low level of MWF aerosol, including specific microbe species we couldn't identify, bright light, dry air, and certain work characteristics during inspection are possible risk factors for development of rhinitis. Further studies including identification of fungi species should be conducted so a firm conclusion can be made regarding the development of rhinitis in QC manufacturing plant workers.

Key words: Rhinitis, Metalworking fluids (MWF), MWF aerosol, Grinding operation

Introduction

Rhinitis is inflammation of the mucosa (surface cells) of the nose. It causes such symptoms as sneezing, runny nose (rhinorrhea), postnasal drip, and congestion. It is widely known to be one of three common diseases associated with exposure to mold, dust mites, pets, environ-

mental tobacco smoke, and irritants^{1–3}).

Studies of the effects of occupational exposure on the development of rhinitis are sparse. Some studies have reported an association between occupational environments and frequent rhinitis symptoms. Rhinitis is three times more prevalent than asthma among workers exposed to laboratory animal allergens⁴). A high prevalence of rhinitis symptoms was reported among bakers exposed to flour dust and its additives⁵), among workers exposed to

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chlorine⁶⁾, and among pulp-mill workers exposed to ozone⁷⁾. Hellgren *et al.*⁸⁾ reported that exposure to airborne irritants such as wood dust, paper dust, and cleaners is associated with a higher risk of developing noninfectious rhinitis.

Workers in plants manufacturing automobile parts are exposed to a variety of chemical and biological agents that might be associated with the development of respiratory disease, including rhinitis. Although there is an established association between exposure to metalworking fluids (MWFs) and respiratory diseases such as asthma and hypersensitivity pneumonitis^{9–14)}, little is known about the related risk of rhinitis. Physician-confirmed cases of rhinitis have been rarely reported in studies to date.

In a study by Rosenman *et al.*⁹⁾, the percentage of workers exposed to MWFs reporting 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 Oudyk *et al.*'s study¹⁵⁾ of the effects of exposure to MWFs on respiratory symptoms, 42% of 2,377 workers exposed to water-soluble MWFs reported "runny nose or plugged nose on a weekly or daily basis". Recently, Park *et al.*¹⁶⁾ investigated the association between nose-related respiratory symptoms and exposure to water-soluble MWFs in an automobile engine plant, but found no significant difference in symptoms between workers who did and did not handle MWF. According to Park *et al.*'s study¹⁶⁾, 10.4% to 31.3% of nose-related symptoms or problems have been noted among workers in automobile-part manufacturing plants that use water-soluble MWFs.

We believe that the lack of evidence linking exposure to MWFs or other work conditions to the development of rhinitis is due to the fact that rhinitis is considered a minor disease and common even in the absence of workplace exposure. We conducted an epidemiological study that included quantitative assessment of current exposure to chemical and biological agents, a questionnaire regarding rhinitis-related symptoms, and medical examination for sinus-related disease. In this article, we report our findings regarding Otolaryngologist-confirmed rhinitis. An association between development of rhinitis and use of MWFs as well as other occupational factors is briefly discussed.

Methods

Study plant and operations

The study plant manufactures piston rings for automobiles. The plant began operations in Seoul, Korea in 1959. It moved to another city in 1975 and moved again to its current location in 2001, bringing most of its work-

ers. The plant has two main lines, casting and production, which are separately located and operated. The casting line roughly manufactures the molds for the rings. The molds are refined and made into actual rings in the production line, which consists of grinding, manufacturing, and quality control (QC) operations.

Because the production line uses synthetic MWFs and because workers in the production line have frequently reported nasal symptoms, the production line was chosen for detailed evaluation of operation characteristics and quantitative assessment of worker exposure to agents. The casting line was not included in the investigation.

Quantitative assessment of current exposure to MWFs 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, manufacturing, and QC operations were grouped based on similar exposure in terms of the characteristics of operation, environmental hazards and work practice, which refers to similar exposure group (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. Exposures to MWF aerosols and biological agents (fungi and endotoxins) in the breathing zone of the representative production line workers were assessed.

Airborne MWF mists from the breathing zone were measured using the sampling and analytical methods recommended by the National Institute for Occupational Safety and Health¹⁷⁾. Endotoxin concentrations were quantified using the Kinetic Turbidimetric Limulus Amoebocyte Lysate method (Pyrogen-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⁾.

Questionnaire and medical examination

One hundred eighty-seven workers working on the production line at the time of the study who did not have a history of respiratory disease were invited to participate in a questionnaire with the assistance of trained interviewers. The questionnaire addressed the presence, frequency and severity of rhinitis-related symptoms such as nasal congestion, nasal secretion, itching, and sneezing. Demographic information, including lifestyle, and occupational history were collected. Production workers who complained of rhinitis-related symptoms were medically examined by an otolaryngologist to determine the pres-

Table 1. Characteristics of the study population according to rhinitis status

	Male/female	Age (years, mean $\pm$ SD)	Duration of employment (years, mean $\pm$ SD)	Smoking status ^a	
				Smoker	Non-smoker
Rhinitis (n=99)	86/13	38.1 $\pm$ 9.3	14.0 $\pm$ 9.2	37	46
No rhinitis (n=88)	88/0	39.6 $\pm$ 9.7	14.2 $\pm$ 8.9	38	47

^a19 missing values.

ence of sinus-related diseases such as rhinitis, allergic rhinitis, nonallergic rhinitis, chronic sinusitis, perennial allergic rhinitis, nasal septum deviation, hypertrophic rhinitis, hyposmia, seasonal allergic rhinitis, and nasal polyps. Allergic rhinitis was diagnosed using skin prick test with 10 common inhalable allergens, such as *Alternaria*, *Aspergillus*, Grass pollen, Tree pollen, Cat fur, Cockroach, *D. farinae*, *D. pteronyssinae*, Mugwort, Ragweed. In addition, all workers from the grinding (19) and QC operations (26) underwent physical examination because they reported respiratory symptoms more frequently than did the other manufacturing workers. Both X-ray and computed tomography (CT) were examined to diagnose rhinitis. SPSS 15.0 for Windows was used to conduct χ^2 test to compare general characteristics among three operations.

Results

Worker characteristics

General variables that might affect the development of rhinitis such as age, duration of employment, and smoking status did not differ between workers with and without rhinitis (Table 1). The general characteristics of the 99 workers diagnosed with rhinitis were compared across the three operations (Table 2). The three worker groups differed with respect to sex ($p=0.000$) and smoking status ($p=0.005$). In particular, 53.8% of QC workers were female while all workers from the other two operations were male. There were significantly fewer smokers in the QC operation compared to the other two operations. The average age of QC workers was 33.1 yr (range 22–58 yr), lower than that for the other two operations. Approximately half of the QC workers (54.5%) were less than 30 yr old. The age of female QC workers ranged from 22–35 yr. However, age and duration of employment did not significantly differ across the three operations. No general characteristic significantly confounding the difference in prevalence of rhinitis across operations was found.

Operation characteristics

The incomplete rings are initially sent from the casting line to the grinding operation, where the ring surfaces are

Table 2. General characteristics of 99 workers diagnosed with rhinitis, according to plant operation

		Grinding (n=10)	Manufacturing (n=67)	QC (n=22)	p-value
Sex	Male	10	67	9	0.000
	Female	0	0	13	
Age (yr)	<30	3	12	10	0.091
	30–39	3	24	4	
	40–50	2	24	5	
	>50	2	7	3	
Smoking status ^a	Yes	4	24	3	0.005
	No	4	30	18	
Duration of employment (yr)					0.080
	<5	3	13	4	
	5–10	1	9	8	
	>10	6	45	10	

^a16 missing values.

roughly ground using synthetic MWF. Next, the three manufacturing operations finely grind the inner and outer parts of the rings as well as the surface using the same synthetic MWF. Finally, the rings are inspected and assembled in the QC operation. QC workers are responsible for selecting rings that do not meet the specified quality criteria. This is accomplished via visual inspection under a fluorescent lamp. Rings that do not meet the criteria are dropped into a plastic box under the table; workers assemble the rings that pass inspection (Fig. 1). QC workers continuously sit at a table during working hours. Due to lack of local exhaust ventilation, they are continually exposed to a small amount of MWF, microbes, and metal left on the surface of the rings. In addition, they are continuously exposed to bright glare from a lamp (36 W) within their breathing zone.

Current exposure to MWF mist, endotoxins, and microbes

Nearly all workers were exposed to concentrations of MWF mist higher than 0.2 mg/m³ of the threshold limit value listed as a notice of intended change by the American Conference for Governmental Industrial

Fig. 1. Working posture of QC workers who inspect and assemble piston rings for automobiles.

A female worker is inspecting the quality of rings under a fluorescent lamp.

a: fluorescent lamp, b: piston ring for inspection, c: box collecting poor quality rings

Table 3. 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			
Sample number	12	12	12
Mean (range)	0.85 (0.05–7.65)	11.4 (6.1–44.3)	1.1×10^5 ($19\text{--}5.4 \times 10^5$)
Manufacturing			
Sample number	22	22	22
Mean (range)	0.48 (0.18–1.38)	8.3 (3.8–19.4)	1.1×10^5 ($7\text{--}2.7 \times 10^6$)
QC			
Sample number	11	11	10
Mean (range)	0.26 (0.08–0.70)	3.2 (2.7–4.7)	1.6×10^3 ($6.9 \times 10^2\text{--}4.3 \times 10^3$)

Hygienists²⁰). Exposure of workers in the grinding operation to MWF mist averaged 0.85 mg/m³, which is above the recommended exposure level (REL) of 0.5 mg/m³²¹).

Exposures to MWF mist, fungi, and endotoxins were highest for the grinding workers, lower for production workers, and lowest for QC workers (Table 3).

Most workers were exposed to fungi levels above 10³ CFU/m³. All exposures to endotoxins were lower than the 50 EU/m³ limit of occupational exposure proposed by the National Health Council of the Netherlands²²). Exposures to other chemical agents including chromium and ethanolamine (data not shown) were far too low to adversely affect workers' respiratory health. The humidity in the QC operation ranged from 27.5–32.7% during

Table 4. Prevalence of rhinitis according to plant operation

Type of rhinitis	Grinding	Manufacturing	QC	Total
Nonallergic rhinitis	6	25	10	41
Allergic rhinitis	2	24	10	36
Sinusitis	1	3	0	4
Other ^a	1	15	2	18
Number of patients	10	67	22	99
Number of workers	19	142	26	187
Prevalence (%)	52.6	47.2	84.6	52.9

^aIncludes sinusitis, nasal septum deviation, hypertrophic rhinitis, hyposmia, seasonal allergic rhinitis, and nasal polyps.

working hours (mean 29%); this was lower than for the two other operations (31.2–43.8%). Irritants such as ozone, NO₂, and SO₂ that are known to be related to an increase in healthcare visits for allergic rhinitis^{7, 23}) were not detected in the production line.

Physician-confirmed rhinitis

Of 187 workers interviewed, 115 exhibited rhinitis-related symptoms and underwent physical examination. Ninety-nine of 115 workers were diagnosed with rhinitis. Table 4 summarizes the prevalence rate by rhinitis type. Nonallergic and allergic rhinitis accounted for 78.8% of cases; this prevalence was much higher than that of other rhinal-related diseases. Paranasal sinusitis, sinusitis, and nasal polyps were also found, but the prevalence was low. Rhinitis was confirmed in 22 of 26 QC workers (84.6%). This was the highest prevalence among the three operations, despite the fact that QC workers had lower exposures to MWF mist and microbes. All 12 male QC workers and 10 of 14 female QC workers developed rhinitis. Of workers who underwent the allergic skin prick test using ten allergens including *Aspergillus* and *Alternaria*, only one workers who are working at grinding operation showed positive response to *Alternaria*.

Discussion

Many studies conducted in indoor environmental settings have shown that most cases of allergic and nonallergic rhinitis are caused by bacterial and fungal infections^{2, 24–29}). In automobile plants using water-soluble MWFs like synthetic MWFs, exposure to MWF aerosol, including microbes, their toxins, and other metallic elements could contribute to the etiology and exacerbation of respiratory diseases.

Several studies conducted in automobile plants that use MWFs reported respiratory complaints, asthma, upper respiratory symptoms, or HP in workers exposed to MWFs^{9, 10, 14, 30}). Many studies have shown that there is

a significant association between exposure to MWFs and the development of asthma in automobile workers^{9, 10, 14, 21, 30, 31}). Based on epidemiological studies presenting strong evidence for an association between asthma and rhinitis^{26, 32–34}), it seems likely that workers at automobile plants that use MWFs are at risk for rhinitis.

There have been few studies of rhinitis in plants using MWFs. In this study, we found a high prevalence of physician-confirmed rhinitis in workers involved in the manufacturing of automobile rings. Because physician-confirmed rhinitis avoids reliance on the subjective self-report of respiratory symptoms by study workers, our results could help to inform the causes and risk of rhinitis in automobile part manufacturing plants that use MWFs.

The automobile plant that we studied houses grinding, manufacturing, and QC operations. We found that 99 of 187 workers (52.9%) were medically diagnosed with rhinitis (Table 4). The prevalences of rhinitis-related symptoms (61.5%) and clinically diagnosed rhinitis (52.9%) are higher than those previously reported for automobile plants using MWFs^{9, 15, 16, 35}). Ameille *et al.*³⁵), reported that the prevalence of rhinitis was 15.8–17.6% in workers handling soluble and straight MWF. Rosenman *et al.*⁹) reported that 37.3% (emulsified MWFs), 42.9% (semi-synthetic MWFs), and 48.1% (synthetic MWFs) of workers exposed to MWFs visited a doctor for sinus problems. The number of workers experiencing nasal stuffiness symptoms daily or weekly ranged from 25.1–42.9%. Oudyk *et al.*¹⁵) reported that 42% of 2,935 employees working at a large automotive machining location complained a runny or plugged nose symptoms daily or weekly.

This high prevalence of rhinitis was found despite the fact that current worker exposure to MWF aerosol was below 0.5 mg/m³. Exposure to MWF mist was below the range (0.59–2.12 mg/m³) reported by Park *et al.*³⁶) for a Korean plant manufacturing automobile engines. That plant involved operations similar to this study, and several sinusitis cases were reported. However, exposure to MWF mist was generally higher than the exposures reported in several other studies finding cases of HP^{10, 14}), cross-shift decrement³⁰), or a high prevalence of respiratory symptoms in automobile plants^{9, 14}). Our findings confirm the NIOSH contention that nonmalignant respiratory diseases like rhinitis can develop even with exposure below its REL (0.5 mg/m³)²¹). To date, there is no suggested limit for occupational exposure to MWF aerosol to protect against nonmalignant respiratory diseases such as asthma, rhinitis, and HP.

We initially hypothesized that exposure to microbes would cause workers handling synthetic MWFs to exhibit more rhinitis or rhinitis-related symptoms than QC

workers who do not handle MWF directly. However, the prevalence of confirmed rhinitis was highest for QC workers. This prevalence (84.6%) is quite high, even allowing for the fact that rhinitis is relatively common in the absence of workplace exposure. To our knowledge no other study has reported a higher prevalence of rhinitis than the results presented here. Ameille *et al.*³⁵), reported that the prevalence of rhinitis was present in 14.1% of the assemblers who performed no machining operations with MWF.

Identification of causative occupational factors can be especially difficult when the health outcome of concern is relatively common—even in the absence of workplace exposure. Such is the case with rhinitis.

Our study assumed that exposure to MWF aerosol, including microbes, endotoxins, and metals, is related to the development of rhinitis in workers involved in grinding and manufacturing operations at plants manufacturing automobile parts. This assumption may be supported by our finding that 49 (63.6%) of 77 rhinitis patients in grinding and manufacturing operations were determined to handle synthetic MWF directly. However, considering that QC workers were exposed to less fungi, endotoxins, and MWF aerosol than were workers in the other two operations (Table 3), we conclude that the high prevalence of rhinitis in the QC operation is related to occupational or workplace factors other than MWF aerosols.

Our industrial hygiene investigation into QC operation considered three factors (exposure to low humidity, exposure to bright light, and working posture with head tilted forward) not discovered in the two other operations as possible contributors to the high prevalence of rhinitis for QC workers, although we could not identify risk factors for rhinitis using only physician-confirmed cases of rhinitis. In addition, QC workers are consistently exposed to direct glare from a fluorescent lamp (32 W) within their breathing zone. These factors are in agreement with Middleton's study³⁷) showing that non-allergic rhinitis patients frequently report congestion or rhinorrhea in response to changes in air temperature, humidity, exposure to bright light, etc. QC workers also sit in one posture during working hours, with head tilted forward to inspect handfuls of rings (Fig. 1). Although forward tilt of the head has not yet been associated with the development of rhinitis, it may be related to high prevalence of the condition.

This field study failed to demonstrate any meaningful association between a prevalence rhinitis rate and either level of MWF mist or bioaerosol levels (fungi and endotoxin) although prevalence rate of rhinitis from workers handling synthetic MWF is found to be higher than those reported (Table 4). In addition, we can't identify a significant factor to cause higher rhinitis rate from QC work-

ers than other operation workers. There could be limitations of this study that may relate to lack of relationship. First, investigation for identification of specific fungi species was not conducted. Unfortunately, further medical examination such as nasal provocation and serum specific antibody tests couldn't be conducted to identify the fungi species that may cause rhinitis. Second, we did not assess exposure to either MWF-related contaminants or components or specific microbe species that may be associated with rhinitis risk, although other occupational factors such as bright light and working practices were suggested. In spite of those limitations, this field study could be guide to recognize the occupational factors that may cause the development of rhinitis in synthetic MWF using plants.

Conclusions

The prevalence of physician-confirmed rhinitis in a plant manufacturing piston rings for automobiles was higher than all rates previously reported for automobile plants and other occupational settings. We conclude that exposure to MWF aerosol, including microbes, endotoxins, and metals, is related to the development of rhinitis in workers involved in grinding and manufacturing operations at plants manufacturing automobile parts. In addition, we propose that the high prevalence of physician-confirmed rhinitis (84.6%) in workers inspecting and assembling automobile rings may be linked to exposure to glaring light and dry air in the workplace, working posture, and low levels of exposure to MWF aerosol containing microbes. Further studies should be conducted so a firm conclusion can be made regarding the development of rhinitis in QC manufacturing plant workers.

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