

Skin disorders in ship's engineers exposed to oils and solvents

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Ship's engineers are exposed to mineral oil and solvents in their work. This study was intended to investigate if ship's engineers had an increased prevalence of skin disorders and whether any such increased risk could be linked to exposure to mineral oils and solvents. A self-administered questionnaire was sent to 700 male seamen from 3 Norwegian ferry companies. Of the 492 respondents, 169 were currently working as ship's engineers and 295 had never worked as ship's engineers. The outcomes eczema, acne, dry skin, any dermatitis and hand dermatitis were defined from the questionnaire. Prevalences of these skin disorders were compared between the groups. Logistic regression was used to elucidate explanatory variables further. When comparing current ship's engineers with those who had never worked as ship's engineers, the crude prevalence ratios were 1.7 (95% CI 1.1–2.7) for dry skin, 1.7 (95% CI 1.1–2.5) for any dermatitis, 1.3 (95% CI 0.66–2.67) for acne and 1.2 (CI 0.61–2.27) for eczema. The risk of these symptoms increased for the engineers in the regression analysis, after controlling for age, self-reported use of Stoddard solvent, and the use of fuel oil as a hand cleansing agent. The increased prevalence of skin disorders found among ship's engineers in this investigation may be explained by direct contact with mineral oils and solvents.

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Skin contact with petroleum oil, Stoddard solvent (white spirit) and grease can cause contact dermatitis due both to the irritant effect of petroleum solvents and paraffinic oils and to the allergenic properties of the additives to such products (1). The irritant properties of aliphatic hydrocarbons to both skin and mucous membranes increase with increasing chain length up to C14 derivatives (2). Compounds with high boiling points are known to provoke inflammation of the pilosebaceous glands on a more limited basis, giving rise to acneiform eruptions, folliculitis and hyperpigmentation (3).

There is also evidence that the aromatic hydrocarbons and cycloparaffins (4), which cause irritant contact and severe defatting of the skin (3), are more irritating than aliphatic hydrocarbons.

Various types of oil are used as fuel and for lubrication in the engine rooms of ships. In addition, organic solvents are used mainly for degreasing and cleaning purposes. As these agents are a mixture of different hydrocarbons, they may cause dermal effects in exposed workers. A recently published study on Icelandic seamen gave indications

of an increased incidence of skin cancer compared to other Icelandic men (5). We have not found other investigations of skin disorders in seamen. Investigations at other workplaces with skin exposure to petroleum oils have shown that the workers have an increased prevalence of skin disorders (6) and an increased risk of skin tumors, both carcinomas and premalignant lesions (7). The carcinogenic potential of petroleum engine oils is largely, if not entirely, related to the polycyclic aromatic compound content of the oil (8).

The present study was intended to investigate if ship's engineers had an increased prevalence of skin disorders and whether any such increased risk could be linked to exposure to mineral oils and solvents.

Materials and Methods

Study participants

As seafarers are a group with a special life style, we chose to compare the ship's engineers who were exposed to mineral oil with other seamen. The

names and personal data of all employees working at sea were obtained from 3 local ferry shipping companies. A self-administered questionnaire was mailed to all the eligible participants. The questionnaires were mailed between June and September 1993. Non-responders received 1 reminder.

Among the 700 seamen who received the questionnaire, 208 did not respond. Of the 492 respondents, 169 were currently working as a ship's engineer and these constituted the study group. 295 who had their duties at other places on the ship and had never worked as a ship's engineer served as controls. The remaining 28 were former ship's engineers currently working at other sites on the ship. Among the 197 respondents who had ever worked as a ship's engineer, 152 had worked as such for more than 5 years. The ships were small to middle-sized coastal ferries which traversed fjords (narrow sea inlets) on the north-west coast of Norway. The ferry trips usually take from 10 to 20 min and there are between 20 to 70 departures each day. The seamen stay on the ferry for 14 days, followed by 2 weeks leave.

The background variables of the engineers and the controls are presented in Table 1. The group of ship's engineers was somewhat older than the controls and had a greater share of smokers.

Exposure conditions

All the current and former ship's engineers were, or had been exposed to mineral oil and solvents in the engine room. 2 types of oils are mainly used, one a lubricating oil (boiling point(b.p.) 300–700°C) and the other a fuel oil (b.p 175–370°C). The typical fuel oil used on these ships is a complex mixture of paraffins and aromatic hydrocarbons in the range from C₁₁ to C₂₅, with a density of 0.83 at 15°C and a viscosity of 3 cSt at 40°C. The content of aromatic hydrocarbons is between 10 and 30%. The typical lubricating oil is a solvent-refined mineral oil containing paraffins, cycloparaffins, aromatic hydrocarbons and additives. The density is usually about 0.9 at 15°C and the viscosity is 110 cSt at 40°C. Furthermore, the ship's

Table 2. Reported use (%) of different hand cleansing agents among engineers and controls; *p*-values given for the differences between the groups

Type of washing agent	Engineers	Controls
diesel	55.6	18.6 <i>p</i> =0.0000
white spirit	50.9	67.5 <i>p</i> =0.00042
soap and water	94.7	89.2 <i>p</i> =0.044
other solvents	57.4	19.3 <i>p</i> =0.00000

engineers often use diesel and other solvents for washing and degreasing purposes in the engine room, and to clean their hands. Solvents commonly used for such purposes are fuel oil (diesel oil) and white spirit (Stoddard solvent). A typical white spirit contains 57% paraffins and 43% cycloparaffins in the range from C₉ to C₁₃, with a content of aromatic hydrocarbons which today is usually less than 1%. The density is usually about 0.79, the viscosity 1.6 cSt at 25°C, and the boiling range from 190 to 221°C.

A previous assessment of airborne exposure to mineral oil mist in the engine rooms of the ferries under study revealed levels between 0.12 and 0.77 mg/m³, with a mean of 0.49 mg/m³ (9). Exposure at this level was found to be a probable cause of a slightly increased risk of respiratory disorders among the ship's engineers. Thus, the ship's engineers have probably had exposure to mineral oil aerosols on uncovered parts of the skin other than the hands to some degree. The other members of the crew on the ferries, who served as controls, mainly worked on deck. As part of their work may be dirty, such as handling the vehicles and painting, they also occasionally use organic solvents to clean their hands. The proportions of the ship's engineers and the controls who reported the use of different hand cleansing agents are shown in Table 2. "Current ship's engineers" reported more use of diesel as a hand washing agent, while the controls reported use of white spirit more often than the engineers.

Questionnaire

The questionnaire included some general questions on health and work history, and more specific questions about skin diseases, and the localization of skin problems. It also asked which skin cleansing agents were commonly used.

The outcome of the study was the occurrence of skin complaints, as stated in the questionnaire. A participant was regarded as having "eczema", "acne" and "dry skin" if he reported having had symptoms of these conditions every week during the last year.

"Any dermatitis" was defined as having re-

Table 1. Background variables for the study subgroups of current ship's engineers and controls

	Current engineers (<i>n</i> =169)	Controls (<i>n</i> =295)
mean age (SD)	46.6 (9.6)	42.5 (9.8)
current smokers (%)	59.2	54.6
years as an engineer (SD)	20.9 (10.3)	0
years as a seaman (SD)	24.0 (9.8)	22.1 (10.1)

ported symptoms of eczema and/or dry skin at least 1× a week during the last year. "Hand dermatitis" was defined as "any dermatitis" with additional reporting of the localization of the dermatitis on the hands.

Statistical methods

Analysis of the data was performed by means of the Statistical Package for Social Sciences (SPSS/PC+) and the EPI Info programme. Confidence intervals for the given prevalence ratios were determined by the use of the Mantel Haenszel approach. Explanatory variables for the outcomes "dry skin", "any dermatitis", "hand dermatitis" and "acne" were further analyzed by means of multiple logistic regression. The independent variables considered for inclusion in the model were supposed determinants for skin disorders; self-reported use of white spirit (Stoddard solvent) or diesel oil (fuel oil) as skin cleansing agents, and "being an engineer". The interactions between use of white spirit and diesel oil as hand cleansing agents, use of white spirit as hand cleansing agent and "being an engineer", and use of diesel oil as hand cleansing agent and "being an engineer" were also tested in the model. As they did not contribute important information, the interactions were excluded from the final analyses. In the final analyses, independent variables like "self-reported use of white spirit as hand cleansing agent", "self-reported use of diesel oil as hand cleansing agent", and "being an engineer" were included in the model and analysed by forced entry, also controlling for age.

Results

Table 3 presents the crude prevalences of skin complaints at least every week during the last year, and the relative risks of the defined skin disorders. The engineers had an increased risk of all outcomes, but this was only statistically significant for "dry skin" and "any dermatitis". The crude prevalences and relative risks for self-reported dermatitis (any kind of dermatitis) on the different parts of the body are given in Table 4. Hand dermatitis was the

Table 3. Crude prevalence of skin disorders (%) at least every week during the last year, for engineers and controls

Type of disorder	Engineers (n=169)	Controls (n=295)	RR(95% CI)
eczema	10.5	8.9	1.18 (0.61–2.27)
acne	10.5	7.9	1.33 (0.66–2.67)
dry skin	22.1	12.7	1.74 (1.12–2.72)
any dermatitis	23.1	13.6	1.70 (1.14–2.54)

Table 4. Prevalences and relative risk for skin disorders at any time (%) for ships engineers and controls

Localization of dermatitis	Engineers	Controls	RR (95%CI)
hands	42.0	24.7	1.70 (1.30–2.22)
arms	10.7	13.9	0.77 (0.46–1.29)
legs	11.8	11.9	1.00 (0.60–1.67)
chest	11.2	12.9	0.87 (0.52–1.46)
feet	3.6	5.4	0.65 (0.26–1.64)
head	21.3	20.0	1.07 (0.74–1.54)
abdomen/back	11.8	7.8	1.52 (0.86–2.68)

only outcome that showed a statistically significant increased relative risk.

The results from the regression analysis of different explanatory variables in relation to the outcomes are presented in Table 5. When controlled for the other independent variables, "being an engineer" was the only variable that revealed a statistically significant increased odds ratio for the outcomes.

Discussion

The present study was aimed at elucidating whether ship's engineers have an increased risk of skin disorders and whether any such increased risk could be linked to occupational exposure. The cross-sectional design of the study probably brought about some selection problems. On the other hand, a selection bias, with diseased subjects having left the study group, would probably underestimate the risk. Furthermore, skin complaints among seamen are probably seldom so severe that this causes them to leave their occupation.

Non-differential misclassification may arise when both the determinants of disease and the outcome are characterized by means of a self-administered questionnaire. However, in most cases, this will lead to an underestimation of a true increased relative risk. Thus, we find it right to view the observed differences between ship's engineers and controls as real, and that the relative risks found should be regarded as conservative estimates. As the study comprises seamen from different ferries in coastal traffic, we also assume that the results will have some external validity, reflecting the situation for other seamen.

The most significant determinant for the outcomes "dry skin" "any dermatitis" and "hand dermatitis" was the independent variable "being an engineer". All ship's engineers have rather extensive skin contact with mineral oils and grease in their work. They also use organic solvents, including diesel, for hand cleansing purposes. A greater proportion of the controls reported the use of

Table 5. Odds ratios, with 95% confidence intervals in parenthesis, as determined by multiple logistic regression for the explanatory variables; self-reported use of Stoddard solvent as a hand cleansing agent, self-reported use of fuel oil as a hand-cleansing agent, and being an engineer, in relation to selected outcome variables; all results are also corrected for age

Explanatory variables	Outcome variables			
	acne	dry skin	any dermatitis	hand dermatitis
being an engineer	2.8 (1.11–7.2)	2.4 (1.27–4.46)	2.3 (1.27–3.97)	2.4 (1.23–4.87)
using Stoddard solvent	2.2 (0.86–5.46)	1.2 (0.63–2.10)	0.9 (0.54–1.61)	1.1 (0.60–2.11)
using fuel oil	0.5 (0.18–1.46)	0.9 (0.44–1.68)	0.8 (0.44–2.27)	1.2 (0.59–2.49)

white spirit as a hand cleansing agent. Even so, we find reasons to believe that the engineers use solvents for this purpose more intensely and frequently. Together with the skin contact with grease and mineral oils, we assume contact with organic solvents, including diesel, to be the main reason for the observed increased risk for hand dermatitis. When comparing different types of solvents, it is important to note that white spirit has a lower viscosity and a lower content of aromatic hydrocarbons, and thus a smaller potential for irritation of the skin. On the other hand, white spirit has a high content of cycloparaffins which are more irritating than paraffins (saturated hydrocarbons with straight or branched carbon chain; alkanes). When skin contact with solvents is unavoidable, it is desirable to use a solvent with a boiling point as high as possible. Furthermore, paraffins should be preferred to cycloparaffins (naphthenes) or aromatics.

The prevalence of dermatitis on parts of the body other than the hands did not differ between the engineers and the controls. We therefore conclude that the observed exposure levels to airborne oil mist, which causes lung problems among the engineers (9), did not as such result in dermatitis on other parts of the skin.

The outcome "acne" had a negative association with age. Due to the phrasing of the questionnaire, the participants had probably thought about pubertal acne. However, when adjusted for age and the use of Stoddard solvent and diesel as a hand cleansing agent, the engineers reported more acne compared to the other seamen. It can, therefore, not be ruled out that some of the acne reported may also represent "oil acne".

In the present study, it was not possible to investigate the occurrence of skin cancer. From other studies, there is evidence that mineral oil can cause dermal cancer, probably with preceding hyperkeratosis (6). There is also some evidence that epidermal hyperplasia induced by cutaneous irritation may have promoting effects in experimental skin carcinogenesis (10). In the light of previous findings of an increased skin cancer risk among workers exposed to petroleum oils (7) and among

seamen (5), it is possible that the observed skin irritation due to organic solvents among the engineers could enhance the carcinogenicity of lubricating oils and grease.

For the more specific skin disorders, it is difficult to detect differences by use of a self-administered questionnaire. The participants obviously have problems in diagnosing their own skin diseases. Consequently, we can say very little about the types of skin disorders among the study participants. We included therefore, in the analyses, an outcome variable for a non-specific skin disorder, "any dermatitis", which included "dry skin" and "eczema".

This outcome did not show any higher prevalence among the seamen than "dry skin" alone. We conclude, therefore, that dry skin on the hands and arms is the most common skin problem among ship engineers, and that this is probably a result of a combination of contact with lubricating oils and grease and the frequent use of organic solvents and fuel oil as a hand cleansing agent. Based on the present study, airborne oil mist in the engine room does not seem to cause skin problems.

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