

# Occupational dermatitis and allergic respiratory diseases in Finnish metalworking machinists

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| <b>Aim</b>         | To investigate the incidences and trends of occupational skin diseases (OSDs) and allergic respiratory diseases (ARDs) in machinists working in the fabrication of metal products.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Methods</b>     | Data from the Finnish Register of Occupational Diseases during 1992–2001 were analysed. Incidence rates for skin and respiratory diseases of machinists were calculated and compared to the total working population. The patients investigated at the Finnish Institute of Occupational Health in the same period were described in detail.                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Results</b>     | A total of 279 dermatoses and 34 ARDs were reported. Skin diseases accounted for 27% of all occupational diseases. The incidences of the skin and respiratory diseases were 1.6 and 0.2 cases per 1000 person-years, respectively. This represents a 3-fold risk for getting an OSD compared to the total working population. The number of allergic contact dermatitis (ACD) increased 3-fold during the study period. The most common causes of ACD were metalworking fluids (MWFs) and their ingredients such as formaldehyde, ethanalamines and colophony. Eighty-five per cent of ARDs were asthmas. The commonest causes of asthma were metal dusts and fumes, epoxy resins and hardeners and MWFs and their components. |
| <b>Conclusions</b> | Contact dermatitis is a common occupational health problem in metalworking machinists, whereas occupational respiratory disease is rare. Only a few specific chemicals in the metalworking have thus far been identified as respiratory allergens. Specific skin tests and inhalation challenge tests with MWFs and their ingredients are recommended if an OSD or a respiratory disease is suspected.                                                                                                                                                                                                                                                                                                                         |
| <b>Key words</b>   | Contact allergy; machinists; metalworking fluids; occupational asthma; occupational respiratory disease; occupational rhinitis; occupational skin disease.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

## Introduction

Metalworking machinists are exposed to diverse skin and respiratory irritants and sensitizers at work. Metalworking fluids (MWFs), mainly used as 2–10% emulsions in water, are among the commonest chemical exposures. Most MWFs are mixtures of a base oil and auxiliary substances such as emulsifiers, antimicrobial agents, corrosion inhibitors, extreme pressure additives, etc. In addition, machinists can be exposed to lubricating oils, assembling chemicals and to chemicals originating from surrounding processes such as welding and painting.

Contact dermatitis among machinists has often been reported, mostly due to the components in MWFs [1–3]. Machinists' dermatitis has also been observed in epidemiological studies based on the national morbidity statistics and the statistics from dermatology clinics [3–5]. Clinically investigated asthma and rhinitis in machinists have rarely been reported [6–9]. Most of the epidemiological studies have been cross-sectional questionnaire studies or plant surveys, some connected with epidemic outbreaks of respiratory symptoms in a specific plant or process [10,11].

We report here Finnish statistics on occupational skin diseases (OSDs) and allergic respiratory diseases (ARDs) of machinists.

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## Methods

The data in the Finnish Register of Occupational Diseases (FROD) and in the patient register of the Finnish

Institute of Occupational Health (FIOH) during 1992–2001 were analysed.

FROD is a national morbidity record where the cases of occupational disease diagnosed in Finland are recorded. Notification is made by the diagnosing physician who may be a private practitioner or work in any health care unit. In the FROD, each case of OSD and ARD is recorded with a maximum of three diagnoses and three causative agents. In the case of simultaneous allergic and irritant skin disease, the allergic disease is recorded as the main diagnosis, and in case of simultaneous asthma and rhinitis, the one that is more clinically pronounced is recorded as the main diagnosis. OSDs are classified into allergic contact dermatitis (ACD), irritant contact dermatitis (ICD), contact dermatitis of unknown mechanism (ACD/ICD), contact urticaria (CU) or protein contact dermatitis, occupational acne, paronychia, skin infections, other skin diseases and unspecified skin diseases. ARDs are classified into asthma, rhinitis, allergic alveolitis and organic dust toxic syndrome (ODTS). The collection and reporting scheme of the data have been described earlier [5,12].

Up to 1999, data were collected from the occupational category of turners, machinists and toolmakers (class no. 751) according to the Finnish classification of occupations [13]. Thereafter, machinists were classified in the FROD as machine-tool setters and setter operators (class no. 7223), metal-wheel grinders, polishers and tool sharpeners (class no. 7224) and machine-tool operators (class no. 8211) [ISCO-88 (COM)]. The number of machinists was ~14 000–20 000 in 1992–2001, and ~4% of them were women (Statistics Finland). In order to get more specific information on clinical and causative factors of occupational allergic diseases of machinists, the cases investigated at FIOH were extracted from the FROD, and coupled with data from the patient register of FIOH. One case was removed because he had not been investigated at FIOH (wrong coding) and two cases because of wrongly coded occupation.

During 1992–2001, 17% of OSDs and 50% of ARDs were investigated at FIOH. All patients with a suspicion of occupational contact dermatitis were patch tested with the Finn Chamber method according to the recommendations of the International contact dermatitis research group, with modified European standard series and series according to exposure. The additional series included oils and cooling fluids, antimicrobials, ethanalamines and coconut fatty acid derivatives. Most of the patients were also patch tested with products from their workplace. Standard skin prick tests including common environmental allergens were also used in all patients suspected of having occupational dermatitis. Additional skin prick tests, e.g. carboxylic anhydrides, were performed according to exposure when it was clinically relevant [14]. The patients were followed up for 6 months after the diagnosis either with a mailed questionnaire or with a visit to FIOH.

The investigations for occupational asthma or rhinitis at FIOH were performed according to the international guidelines [15,16]. Before the challenge tests, the stability of the lower airways was assessed with spirometry and by following FEV1 and peak expiratory flow (PEF) for 24 h. Skin prick tests were performed using the standard series. Additional skin prick tests with metal compounds and carboxylic anhydrides, and specific serum IgE antibody tests (radio allergy sorbent test) with isocyanates, were performed according to the exposure.

When occupational asthma was suspected, the inhalation challenge tests were performed using the substance to which the patient connected his symptoms, was sensitized to or was associated with falls in PEF in the workplace. Among the chemicals used in the challenge tests were MWFs (diluted, unused), diethanolamine (DEA), diisocyanates and epoxy resin compounds. The inhalation challenge tests were carried out in an exposure chamber for 15–30 min. For diisocyanates and metal salts, a standard protocol was applied, whereas with the other agents, the patients handled the chemical as at work [17,18]. MWFs were either warmed to 40°C in an open dish or aerosolized to the chamber by compressed air. Epoxy resins and hardeners containing carboxylic anhydrides were heated to ~60°C. The air concentrations of the substances were kept below the occupational exposure limit values to avoid irritant reactions. A control challenge without the active chemical was performed in each patient. A PEF drop of  $\geq 15\%$  during the first hour, or a drop of  $\geq 20\%$  thereafter for 24 h, was regarded as significant. Lung function was followed up with a microspirometer (One Flow; STI Medical, St Romans, France or Micro Plus Spirometer, Micro Medical, UK).

If occupational rhinitis was suspected, the upper airways were examined and followed by an otorhinolaryngologist before and, for 1 h, after the challenge. The diagnosis was based on the amount of nasal secretion, nasal blockage and acoustic rhinometry measurements [19].

This study design was approved by the Ethics Committee on occupational health issues of the hospital district of Helsinki and Uusimaa.

## Results

During 1992–2001, a total of 1027 occupational diseases were diagnosed in machinists. The incidence was 5.9 cases per 1000 person-years among machinists and 2.7 cases per 1000 person-years in the total workforce. The most important occupational diseases were hearing loss (31%), skin diseases (27%) and strain injuries (26%). Asbestos-related diseases constituted 9%, other diseases 4% and ARDs 3% of the occupational diseases.

During the study period, a total of 279 cases of OSDs in 262 patients (91% men) were reported. Ninety-seven

per cent of the dermatoses were contact dermatitis of which 144 (53%) were ICD and 107 (39%) ACD. The rest were unspecified ACD/ICD (21 cases), CU (one case), occupational oil acne (one case) and other or unspecified skin diseases (five cases). Fifteen people had two and one had three notified skin diseases (combinations of ACD and/or ICD). The number of ACD cases per year increased during the study period from four to 13, while the number of ICD increased from 10 to 19 cases. A total of 34 cases (32 in men) of ARDs in machinists were reported, one to seven cases yearly. The commonest diagnosis was asthma, numbering 29 cases. There were four cases of allergic rhinitis and one case of allergic alveolitis.

The 10-year incidences of OSD and respiratory disease are shown in Figure 1. Incidences of ACD, ICD and asthma according to age are shown in Figure 2. The annual incidence of skin disease in machinists increased from 1.0 to 1.5 cases per 1000 employees while in the total working population it decreased from 0.5 to 0.4. Twenty-four cases (9%) of the skin diseases were in women. The incidence of all skin diseases among women was 3.3 cases per 1000 person-years compared to 1.6 among men. Only two cases of asthma were reported in women.

Cases of ACD and asthma and the main causes are listed in Table 1. A total of 121 (89%) of the patients were men. Their mean age was 43 years. The average exposure time was 15 years (2 months to 44 years). The most common causes of ACD were MWFs, their ingredients, such as formaldehyde, ethanolamines and colophony, and metals. Twenty-five per cent of the cases were investigated at the FIOH, most of them due to specific MWF ingredients. The commonest inducers of ICD were MWFs, oils and lubricants, organic solvents, wet and dirty work and washing agents. The most important

causes of asthma were metals and synthetic resins. In two persons, both an OSD and ARD were notified. Both of the cases were investigated at the FIOH. One had ACD caused by formaldehyde and asthma caused by DEA (patient no. 12 in Table 2 and patient no. 3 in Table 3; note that Tables 2 and 3 are available as Supplementary data at *Occupational Medicine* Online). The other had ACD, CU and rhinitis caused by methylhexahydrophthalic anhydride (MHHPA) (patient no. 22 in Table 2). This case has been reported in detail [20].

Forty-five (17%) of the cases of dermatitis in the FROD were reported from the FIOH. Twenty-seven (60%) of them were of a main diagnosis of ACD and 18 (40%) that of ICD. In skin prick tests, 12 (27%) of the patients had positive reactions to environmental allergens in the standard series. In skin prick tests, only one patient had a positive reaction to occupationally relevant allergens, namely to MHHPA. Details of the patients with occupational ACD are shown in Table 2. All diagnoses of ACD required occupationally relevant contact allergies discovered on patch testing. Fifteen patients had eczema only on the hands. The rest had eczema also on the wrists, forearms, face or legs. Seventeen of the 18 patients with ICD as the main diagnosis had hand eczema. One patient had ICD on his arms, face, neck and legs due to heat and sweating. MWF was the main cause in 15 cases of ICD. Other main causes of ICD were soldering fluid and dirty work. After a 6-month follow-up, 24 (53%) of the patients with ACD still had skin symptoms. Eventually, 21 (47%) patients had to change their work tasks or job, or retire mainly because of skin problems.

Fifteen (50%) of the cases of ARDs recorded in the FROD were reported from the FIOH: 13 cases of asthma and two cases of rhinitis. The details of the asthma patients at FIOH are in Table 3. Seven of the patients

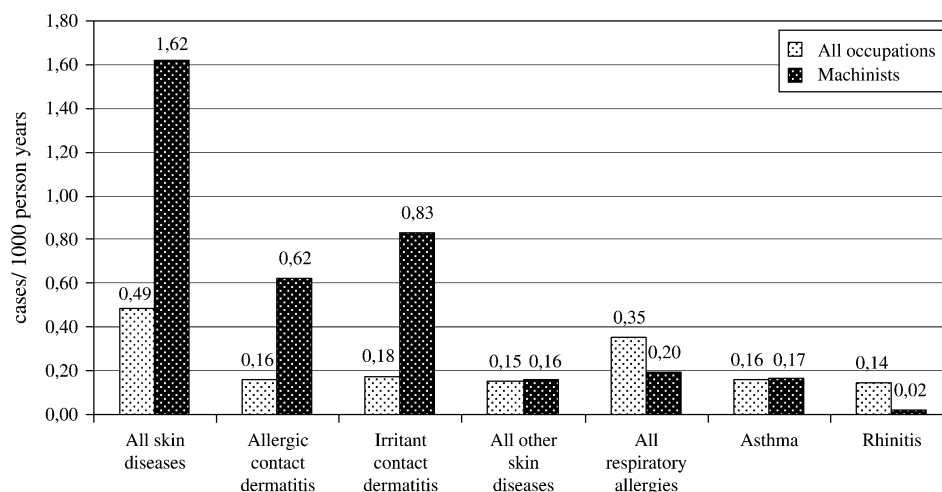


**Figure 1.** Incidences of OSD and respiratory disease of machinists versus total working population (all occupations) in Finland during 1992–2001.

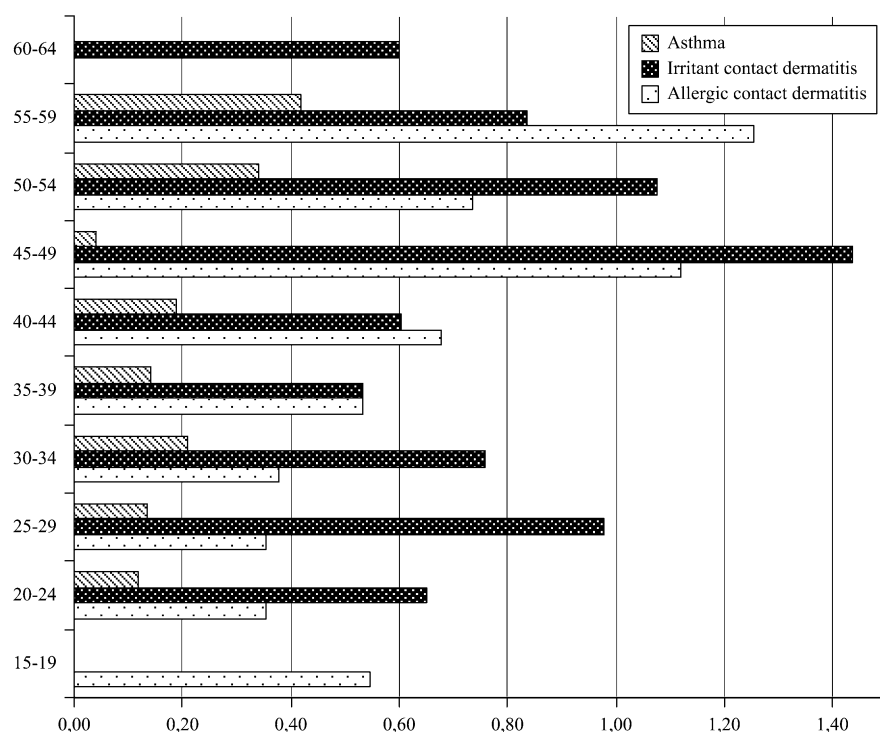


**Figure 2.** Incidence of machinists' occupational ACD, ICD and asthma (cases per 1000 person-years) according to age.

were ex-smokers and two were current smokers. Six of the patients had positive reactions on the standard skin prick test series. Exposure times ranged from 1 day to 34 years. Dyspnoea, cough and wheezing were the commonest symptoms. Eight of the patients had started regular asthma medication, but in the challenge tests, only one patient was on regular medication (patient no. 12, Table 3). Workplace PEF monitoring was carried out in eight cases. IgE-mediated sensitization to workplace compounds was shown in one asthma and two rhinitis patients, all of whom were sensitized to carboxylic anhydrides.

Occupational asthma was confirmed by specific challenge tests in 12 cases and by a workplace challenge in one case. The FEV1 drops varied between 16 and 37% and the PEF drops between 17 and 30%. Seven asthmatic reactions were late, four were immediate and two were dual. Asthma medication was started or continued in 12 cases. Occupational rehabilitation was recommended in four, and avoidance of exposure in the other cases.

The rhinitis cases were caused by carboxylic anhydrides. One diagnosis was based on work-related symptoms, exposure, IgE-mediated sensitization to MHHPA and other cases from the same workplace. The other patient did not get a positive nasal or lower airway reaction in MHHPA challenge, but developed a skin reaction. The final diagnosis was based on symptoms, IgE-mediated sensitization to carboxylic anhydrides and occupational CU from MHHPA (patient no. 22, Table 2).

## Discussion

The present study confirms that among machinists chemically induced OSD is common, whereas occupational respiratory disease is very rare. During the study period, OSD increased and risk was higher in women and young age groups. The causative factors of OSD were mainly the ingredients of MWF whereas respiratory diseases were mainly caused by other exposures.

Skin diseases are common occupational diseases in modern industrialized countries, and machinists have been found to be among high-risk occupations for occupational contact dermatitis [3,4,5,21]. The incidence of OSD in machinists (1.62 per 1000 person-years) in the present study was quite high compared to previous register-based studies with incidences ranging from ~0.46 to 1.62 per 1000 persons per year [4,22,23]. However, international comparisons are difficult to make due to differences in notification procedures and reporting and definition of occupational group. Nevertheless, the prevalence of clinically assessed minor or major skin disorders in populations of machinists has been >25% in cross-sectional studies, suggesting that the morbidity records highly underestimate the incidence of OSD [4,24-26]. The finding that ICD was more common than ACD is in accordance with results of earlier studies [27]. The increase in incidences of OSD during the study period is probably due to the poor employment situation at the beginning of 1990s and to improvements in diagnostics such as increase in knowledge about the

**Table 1.** Causative agents of ACD and asthma according to the main diagnosis in the FROD during 1992–2001

| Causative agent                                    | No. of ACDs (FIOH cases) | No. of asthmas (FIOH cases) |
|----------------------------------------------------|--------------------------|-----------------------------|
| Antimicrobial agents                               | 107 (27)                 | 29 (13)                     |
| Formaldehyde and formaldehyde releasers            | 34 (10)                  | 0 (0)                       |
| Isothiazolinones                                   | 23 (8)                   | 0 (0)                       |
| Methyldibromoglutaronitrile                        | 4 (1)                    | 0 (0)                       |
| Other or non-specified antimicrobials              | 2 (1)                    | 0 (0)                       |
| 5 (0)                                              | 5 (0)                    | 0 (0)                       |
| MWFs (ingredient not specified)                    | 18 (0)                   | 1 (1)                       |
| Metals and metal compounds                         | 12 (1)                   | 10 (5)                      |
| Cobalt and its compounds                           | 6 (0)                    | 1 (1)                       |
| Nickel and its compounds                           | 4 (1)                    | 0 (0)                       |
| Chromium and its compounds                         | 2 (0)                    | 3 (1)                       |
| Welding fumes                                      | 0 (0)                    | 4 (2)                       |
| Hard metal dust                                    | 0 (0)                    | 2 (1)                       |
| Plastic chemicals                                  | 9 (3)                    | 7 (5)                       |
| Epoxy resins                                       | 2 (0)                    | 1 (1)                       |
| 2,4,6-Tris-(dimethylaminomethyl) phenol            | 1 (1)                    | 0 (0)                       |
| Polyamines (epoxy hardeners)                       | 0 (0)                    | 1 (1)                       |
| Carboxylic anhydride derivatives (epoxy hardeners) | 1 (1)                    | 2 (2)                       |
| Methacrylates                                      | 2 (1)                    | 0 (0)                       |
| Diphenylmethane diisocyanate                       | 0 (0)                    | 1 (1)                       |
| Polyurethane resins                                | 1 (0)                    | 0 (0)                       |
| Resins and plastics not specified                  | 2 (0)                    | 2 (0)                       |
| Alkanolamines                                      | 7 (5)                    | 2 (2)                       |
| Monoethanolamine                                   | 2 (2)                    | 0 (0)                       |
| DEA                                                | 4 (3)                    | 1 (1)                       |
| TEA                                                | 1 (0)                    | 1 (1)                       |
| Alkanolamineborates                                | 1 (1)                    | 0 (0)                       |
| Rubber chemicals                                   | 6 (1)                    | 0 (0)                       |
| Colophony                                          | 4 (2)                    | 0 (0)                       |
| Coconut fatty acid derivatives                     | 3 (3)                    | 0 (0)                       |
| Oils and lubricants                                | 2 (0)                    | 0 (0)                       |
| Other chemical factors                             | 9 (1)                    | 5 (0)                       |
| Biological factors                                 | 0 (0)                    | 2 (0)                       |
| Endotoxins                                         | 0 (0)                    | 2 (0)                       |
| Causative agent not reported                       | 2 (0)                    | 2 (0)                       |

Cases investigated at FIOH are in parenthesis.

skin-sensitizing chemicals of metalworkers during the 1990s [1,2,14,28–30].

The results indicate that female machinists are at higher risk of getting OSD than men. Our results are in line with previous studies in which the higher risk for hand eczema in women has been associated with wet work such as household work [31]. The higher rates of ICD in the young age groups may be due to skin atopy and irritative factors in machining. It has been shown that childhood atopic dermatitis is a risk factor for ICD and that atopic dermatitis manifests itself especially in the early years of working life [32].

The commonest inducers of ACD among machinists were antimicrobials, especially formaldehyde released from formaldehyde liberators in MWFs [3]. The MWF formulations constantly change, and it is important for clinicians to keep up with new ingredients used in MWF. An example of a new preservative in MWF is iodopro-

pynyl butyl carbamate (IPBC) [33]. Recently, we had a case of occupational ACD to IPBC at FIOH. Contact allergy to ethanolamines may be under-diagnosed in Finland, as usually only triethanolamine (TEA) is included in test series. At FIOH, TEA has been tested since 1991 and DEA and MEA since 1997. Plastic or rubber chemicals are not typical contact allergens in machinists. The cases caused by rubber chemicals are mostly due to wearing of protective rubber gloves, although MWFs and other lubricating oils may contain the same chemicals [2,34,35].

Our results showing a low risk of occupational asthma in machinists differ from observations in the UK where the incidence of asthma within some machining-related occupations was >2-fold higher compared to our results, and where MWF ranked 13th of the asthma-causing agents reported by chest physicians [36]. The difference is largely due to the different notification systems and criteria of occupational asthma. It was recently reported

that occupational asthmas account for only 5% of all adult-onset asthmas in Finland suggesting that, in general, occupational asthmas are difficult to diagnose [37]. In Finland, chemically induced occupational asthmas are usually diagnosed at FIOH with specific inhalation challenge tests. It is unusual for all suspected causative agents to be tested, as the test protocol is burdensome for the patients. Another drawback in specific challenge tests is that the cumulative effect of several irritants is missed. Thus, it is possible that the present results underestimate machinists' asthma and rhinitis.

Causative agents of ARD in machinists differ from the ones of ACD due to different immunological mechanisms in the skin and lungs, and differences in exposure factors, such as accessibility of the agent to the upper airways or the lungs. As shown in the present study, the typical respiratory exposures in machining rarely cause IgE-mediated diseases. ARD induced by diisocyanate and carboxylic anhydride may be IgE mediated, whereas to our knowledge, IgE sensitization to epoxy amine hardeners has not been reported [17,38]. In the FIOH patients, exposure to plastic chemicals originated mostly from processes other than machining. Some asthmas induced by metal compounds have been connected with IgE sensitization, but none of the present FIOH patients were sensitized to metals [39]. Although irritating to the airways, MWF ingredients are not common causes of occupational asthma. Endotoxins in MWFs may cause various respiratory symptoms, but the mechanism behind symptoms other than those in ODTs is unclear [40]. In Finland, allergic alveolitis in machinists is quite unknown possibly because their occupational exposure is not considered as a typical inducer of alveolitis or because of generally high microbiological quality of workplace air.

According to Finnish legislation, physicians are required to report every case of occupational disease to the FROD. A case is recorded in the FROD regardless of whether the disease is finally accepted and compensated by the insurance company. Also some non-occupational diseases or symptoms may be notified. Nonetheless, in our opinion, a more serious drawback is incompleteness of the data due to under-reporting and under-diagnosis [5]. Only the main diagnoses in the FROD data were analysed in this study because information obtainable from the additional diagnoses of non-FIOH patients is limited. In part of the cases investigated elsewhere, the specific causative agents are not investigated, but the occupational origin of the diseases is recognized according to common national principles. All new notifications are checked by the researchers at FIOH prior to data recording in order to correct the most obvious mistakes in coding of the diagnosis or causing factors. The general shortcomings of morbidity statistics have been discussed previously by other researchers [4,5,21,36,37].

In conclusion, the chemicals used in metalworking may cause both skin and respiratory allergies. The causative agents, immunologic mechanisms and cumulative effect of several irritants and sensitizing chemicals regarding the onset of occupational asthma and rhinitis need further investigation. In order to validate the present results, epidemiological studies coupled together with clinical investigations are needed.

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## Conflicts of interest

None declared.

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