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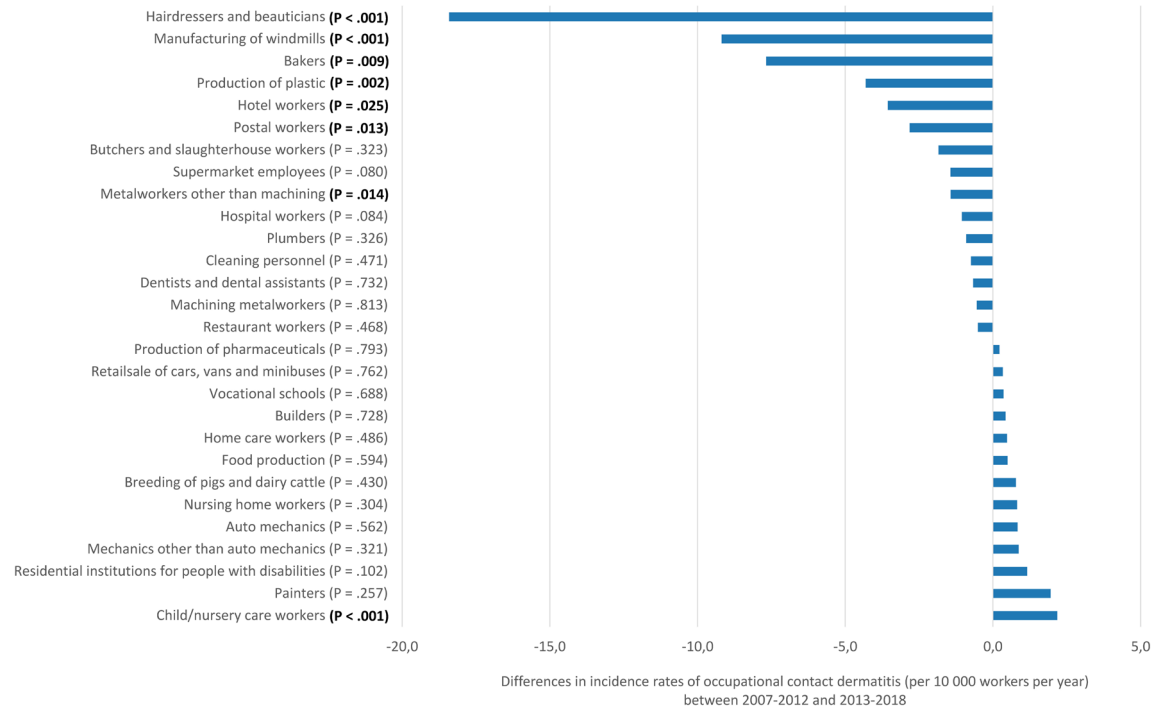

PhD Thesis

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Occupational Contact Dermatitis

Development and testing of a German-inspired intervention

Principal supervisor: Jeanne Duus Johansen

This thesis has been submitted to the Graduate School of Health and Medical Sciences, University of Copenhagen, August 4th 2023

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PhD Thesis

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PREFACE

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Jojo Biel-Nielsen Dietz,
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II. Dietz JB, Menné T, Meyer HW, Viskum S, Flyvholm MA, Ahrensbøll-Friis U, John SM, Johansen JD. *Occupational contact dermatitis among young people in Denmark – A survey of causes and long-term consequences.* Contact Dermatitis. 2022; 86 (5): 404-416

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III. Quaade AS, Alinaghi F, Dietz JB, Erichsen CY, Johansen JD. *Chronic hand eczema: a prevalent disease in the general population related to reduced quality of life and poor overall health measures.* Unpublished Manuscript.

IV. Simonsen AB, Dietz JB, Johansen, JD. *Hand eczema in Danish adolescents – beyond atopic dermatitis.* Unpublished Manuscript.

ABBREVIATIONS

AD	Atopic Dermatitis
CG	Control Group
CI	Confidence Interval
DB07	Danish Industry Code year 2007 (Danske Branchekoder 2007)
DLMI	Danish Labour Market Insurance
DLQI	Dermatology Life Quality Index
DREAM	Danish Register for Evaluation of Marginalization
ESCD	European Society of Contact Dermatitis
HE	Hand Eczema
IG	Intervention Group
IR	Incidence Rate
MCI	Methylchloroisothiazolinone
MI	Methylisothiazolinone
OACD	Occupational Allergic Contact Dermatitis
OCD	Occupational Contact Dermatitis
OHE	Occupational Hand Eczema
OICD	Occupational Irritant Contact Dermatitis
OR	Odds Ratio
SIP	Secondary Individual Prevention
TIP	Tertiary Individual Prevention
VAS	Visual Analog Scale

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Summary

Occupational contact dermatitis (OCD) is the most recognized occupational disease in Denmark and many other Western countries. OCD is contact dermatitis caused or worsened by exposure to irritants or allergens in the workplace. Common irritants that cause OCD are wet work, soaps, food, solvents, and cutting oils, while rubber chemicals, preservatives, hair dyes, plants, and metals are among the most common allergens. Certain professions, such as hairdressing, cleaning, kitchen work, and metalwork, are known to carry a higher risk of developing OCD. However, up-to-date knowledge concerning the current incidence rates (IRs) of OCD in these and other high-risk occupations is needed, as well as information about the development in IRs over the last years to evaluate previously implemented prevention strategies, as well as to identify potential new high-risk occupations.

OCD has been found to often affect young workers in the beginning of their education or career and is more prevalent in women than men (with a ratio of 2:1). Furthermore, workers with atopic dermatitis (AD) are especially vulnerable towards developing OCD. Therefore, in order to direct the prevention effort most efficiently, it is necessary to identify the occupations that involve the youngest workers being diagnosed with OCD. Furthermore, no previous studies have examined the long-term consequences of OCD among young workers.

In Germany, the German statutory accident insurance has introduced a comprehensive multi-step prevention program in 2005 in response to comparably high numbers of OCD cases. In this multi-step prevention program workers receive fast and highly specialized interdisciplinary diagnostics, treatment, and education on skin protective behavior shortly after the first suspicion about an occupational reason for the workers contact dermatitis. No similar intervention concept has been tested in Denmark before.

This thesis consists of four studies.

1. The first study explores the current IRs of OCD, their temporal evolution, and the identification of professions engaging the youngest workers with OCD. We utilized data from the Danish Labour Market Insurance (DLMI) on all recognized cases of OCD in Denmark between 2007 and 2018 and data from Statistics Denmark on the number of employees in the different occupations during the same time period. This data allowed us to

calculate IRs in the 28 most affected occupations and identify any trends between the two time periods, 2007-2012 and 2013-2018. We observed the highest IRs among hairdressers and beauticians, bakers, dentist and dental assistants, windmill manufacturers, and butchers. Moreover, a significant decline in IRs was found in several occupations - most pronounced among hairdressers and beauticians and windmill manufacturers, while the only occupation showing an increasing IR was child/nursery care workers. The lowest median age at OCD notification was observed among bakers, vocational schools, and hairdressers and beauticians.

2. The second study addresses the long-term consequences of OCD among young workers. We developed a questionnaire aimed at young workers with previously recognized OCD between 2010 and 2019. The questionnaire was sent to 6251 workers who were under the age of 35 at the time of notification of OCD (Response rate 47%). Among the respondents, the majority still had severe eczema, and 42% reported job loss due to OCD. Furthermore, we found their quality of life to be negatively affected.
3. The third study addresses the societal costs and the individual occupational consequences of OCD. We combined data from the DLMI on all recognized cases of OCD in Denmark between 2010 and 2015 with data from the Danish Register for Evaluation of Marginalization (DREAM) at Statistics Denmark, which covers received social transfer payments before and after notification. Our findings showed that workers with OCD worked fewer hours per month and received more unemployment benefits and were on paid long-term sick leave more during the two years after notification compared to the two years before notification.
4. The fourth and final study examined the feasibility and effect of an intervention inspired by the German multi-step prevention program within a Danish context. Given the structural differences between Danish and German healthcare and occupational accident insurance systems, we had to adapt the approach to the Danish hospital setting. Our research group created an intervention that includes various components such as immediate consultation with a dermatologist, assessment of chemicals in the participants' products by a chemical engineer, extended allergen testing, education on skin-protective behavior, glove counseling, and standardized treatment. The effect of the intervention was measured by a questionnaire at baseline and at 3-months follow-up. We observed that the severity of the occupational hand eczema (OHE) was statistically significantly lower in the intervention group (IG)

compared to the control group (CG) at 3-months follow-up, and we found several indicators that the IG had received more medical attention at 3-months follow-up than the CG.

In conclusion, the previously acknowledged high-risk occupations continue to dominate the OCD statistics, with some positive development seen among hairdressers and beauticians and windmill manufacturers, among others, while child/nursery care workers have seen an increase in the number of OCD cases over the examined 12-year period. We found OCD among young workers to result in severe long-term consequences in the form of severe eczema symptoms, occupational consequences such as job loss and unemployment, and a decrease in quality of life. Furthermore, we found a statistically significant decrease in work hours per month, and an increase in social transfer payments in the years after notification of OCD. These results indicate the need to implement further preventive efforts in high-risk occupations in Denmark to reduce the occurrence of OCD, as well as tertiary prevention strategies to mitigate the consequences of OCD, especially among young workers. The preliminary results of testing the intervention inspired by the German multi-step prevention program have been positive, showing a reduced severity of OHE at 3-months follow-up compared to the CG. This outcome suggests that a similar preventive strategy could potentially be beneficial and is worth considering for implementation in Denmark.

Dansk Resumé

Arbejdsbetinget eksem er den hyppigst anerkendte erhvervssygdom i Danmark og mange andre vestlige lande. Arbejdsbetinget eksem er kontakteksem forårsaget eller forværret af eksponering over for irritanter eller allergener på arbejdspladsen. Almindelige irritanter, der forårsager arbejdsbetinget eksem, omfatter vådt arbejde, sæber, fødevarer, opløsningsmidler og skæreolier, mens gummikemikalier, konserveringsmidler, hårfarver, planter og metaller er blandt de mest almindelige allergener på arbejdspladser. Visse erhverv, såsom frisører, rengøringspersonale, køkkenarbejdere og metalarbejdere, har en højere risiko for at udvikle arbejdsbetinget eksem end andre. Der er behov for aktuel viden om de nuværende incidens rater (IR) for arbejdsbetinget eksem i disse og andre højrisikoerhverv, samt information om udviklingen i IR over de seneste år, for at kunne vurdere effekten af tidligere forebyggelsesstrategier og identificere potentielle nye risikoerhverv.

Arbejdsbetinget eksem debuterer ofte tidligt i arbejdslivet (ofte under uddannelsen), og er mere udbredt hos kvinder end mænd (ratio 2:1), desuden er arbejdstagere med atopisk eksem særligt sårbare over for at udvikle arbejdsbetinget eksem. For at kunne målrette forebyggelsesindsatsen mest effektivt, er det derfor nødvendigt at identificere de erhverv, der involverer de yngste arbejdstagere, der får diagnosticeret arbejdsbetinget eksem. Derudover mangler der viden om de langsigtede konsekvenser af arbejdsbetinget eksem blandt unge.

Det tyske arbejdsskadeforsikringsinstitut implementerede i 2005 et omfattende flertrins forebyggelsesprogram som svar på det stigende antal sager om arbejdsbetinget eksem i Tyskland. I dette program modtagere arbejderne hurtig og højt specialiseret tværfaglig udredning, behandling, samt undervisning i hudbeskyttende adfærd kort efter første mistanke om arbejdsbetinget årsag til arbejderens eksem. Ingen lignende intervention er tidligere blevet afprøvet i Danmark.

Denne afhandling består af fire studier:

1. Det første studie havde til formål at undersøge de aktuelle IR for arbejdsbetinget eksem i høj-risiko erhverv, udviklingen i IR i de samme brancher, samt at identificere erhverv, der involverer de yngste arbejdstagere med arbejdsbetinget eksem. Vi modtog data fra Arbejdsmarkedets Erhvervssikring over alle anerkendte tilfælde af arbejdsbetinget eksem i Danmark i perioden 2007-2018, samt data fra Danmarks Statistik over antallet af ansatte i de

forskellige erhverv i samme tidsperiode. Ud fra denne data, beregnede vi IR'erne i de 28 mest berørte erhverv og sammenlignede IR'erne mellem de to tidsperioder 2007-2012 of 2013-2018. Vi observerede de højeste IR blandt frisører og kosmetologer, bagere, tandlæger og tandplejere, vindmøllefremstillere og slagtere. Desuden fandt vi et markant fald i IR i flere erhverv – mest udtalt blandt frisører og kosmetologer og vindmøllefremstillere, mens daginstitutionsarbejdere havde en stigning i IR som de eneste. Den laveste medianalder ved anmeldelsen af det arbejdsbetingede eksem blev observeret blandt bagere, erhvervsskoler og frisører og kosmetologer.

2. Det andet studie undersøgte de langsigtede konsekvenser af arbejdsbetinget eksem blandt unge arbejdstagere. Forskningsgruppen udviklede i forbindelse med studiet et spørgeskema rettet mod unge arbejdstagere med tidligere anerkendt arbejdsbetinget eksem i perioden 2010-2019. Spørgeskemaet blev sendt til 6251 arbejdstagere, der var under 35 år på tidspunktet for anmeldelsen (svarprocent 47%). Blandt respondenterne havde flertallet stadig alvorlig eksem, og 42% rapporterede jobtab pga. af deres arbejdsbetingede eksem. Derudover var deres livskvalitet negativt påvirket.
3. Det tredje studie omhandlede samfundets omkostninger og de individuelle erhvervsmæssige konsekvenser af arbejdsbetinget eksem. Vi kombinerede data fra Arbejdsmarkedets Erhvervssikring over alle anerkendte tilfælde af arbejdsbetinget eksem i Danmark mellem 2010 og 2015 med data fra det Danske Register for Evaluering af Marginalisering (DREAM) hos Danmarks Statistisk, omkring modtagne overførselsindkomster i årene optil og efter anmeldelsen. Vores analyser viste, at arbejdstagere med arbejdsbetinget eksem arbejdede færre timer per måned og modtog overførselsindkomst i flere uger i perioden efter anmeldelse sammenlignet med perioden optil anmeldelsen.
4. Det fjerde og sidste studie undersøgte gennemførligheden og effekten af en intervention inspireret af det tyske forebyggelsesprogram i en dansk kontekst. På grund af de strukturelle forskelle mellem det danske og tyske sundhedsvæsen og arbejdsskadeforsikringssystemer, måtte interventionen tilpasses det danske hospitalsvæsen. Interventionen inkluderede hurtig konsultation med en hudlæge, gennemgang ved kemiingeniør af de kemikalier arbejdstageren var udsat for i sin dagligdag, udvidet allergitest, undervisning i hudbeskyttende adfærd og standardiseret behandling. Effekten af interventionen blev vurderet vha. et spørgeskema ved baseline og opfølgning efter 3 måneder. Vi observerede, at sværhedsgraden af arbejdsbetinget håndeksem eksem var statistisk signifikant lavere i

interventionsgruppen sammenlignet med kontrolgruppen ved opfølgningen efter tre måneder.

De kendte højrisikoerhverv fortsætter med at dominere statistikerne over arbejdsbetinget eksem, med nogen positiv udvikling blandt, blandt andre frisører og kosmetologer og vindmøllearbejdere, mens daginstitutionsarbejdere har oplevet en stigning i antallet af arbejdsbetingede eksemer over den undersøgte 12-års periode. Vi fandt, at arbejdsbetinget eksem blandt unge arbejdstagere havde alvorlige langsigtede konsekvenser i form af vedvarende svære eksemsymptomer, erhvervsmæssige konsekvenser såsom jobtab, arbejdsløshed samt en forringelse af livskvaliteten. Derudover fandt vi en statistisk signifikant nedgang i antal månedlige arbejdstimer og en stigning i modtagne overførselsindkomster i årene efter anmeldelse af OCD. Disse resultater indikerer et behov for at implementere yderligere forebyggende tiltag i højrisikoerhverv i Danmark for at reducere forekomsten af arbejdsbetinget eksem, samt tertiære forebyggelsesstrategier for at mindske konsekvenserne af arbejdsbetinget eksem, især blandt de yngre arbejdstagere. De første resultater fra undersøgelsen af effekten af et interventionskoncept inspireret af den tyske forebyggelsesindsats har været positive, og viser en reduceret sværhedsgrad af arbejdsbetinget håndeksem efter tre måneder sammenlignet med kontrolgruppen. Dette resultat antyder, at en lignende forebyggende strategi potentielt kunne være gavnlig og er værd at overveje for fremtidig implementering i Danmark.

1. Introduction

Occupational contact dermatitis (OCD) is a commonly recognized occupational disease in Denmark,[1] carrying far-reaching implications for future working life and quality of life.[2–5] Although high-risk occupations have been previously identified, there is a need for current data on the incidence rates (IR) of OCD in these, and potentially other, high-risk occupations. Furthermore, understanding the recent trend in IRs is crucial for evaluating the effectiveness of implemented preventive strategies, and identifying new high-risk occupations.

OCD often affects young workers early in their training in high-risk occupations,[6–9] making the identification of professions that involve the youngest workers with OCD crucial for directing future preventive strategies efficiently. Although several studies have examined the long-term consequences of OCD among predefined high-risk occupations such as hairdressers,[10–12] the effects in other occupations and, notably, among young workers are less known.

The primary objectives of this PhD project were to identify current high-risk occupations for the development of OCD, as well as the development within these occupations, to identify the occupations with the youngest workers with OCD, and to examine the long-term consequences of OCD among the young workforce, and lastly assessing the societal costs of OCD. Moreover, we developed and evaluated a Danish-adapted intervention inspired by the German prevention effort, in order to present a possible future intervention strategy.

2. Background

2.1 Contact Dermatitis

Contact dermatitis is an inflammatory, itchy skin condition characterized by erythema, infiltration, and possibly vesicles in the acute phase, later possibly evolving into a chronic condition with scaling, lichenification and fissures. Contact dermatitis can be caused by prolonged or repeated contact with either irritants or allergens, causing irritant or allergic contact dermatitis, respectively, and often affects the hands leading to hand eczema (HE). While irritant and allergic contact dermatitis have different underlying causes, they manifest clinically in similar ways. However, differences have been observed, with irritant contact dermatitis more frequently observed in dry fissured HE, pulpitis, and nummular HE, while allergic contact dermatitis was most often found in vesicular types of HE, characterized by recurrent eruptions.[13]

2.1.1 Allergic Contact Dermatitis

2.1.1.1 Type IV (delayed) Hypersensitivity Reaction / Allergic Contact Dermatitis

Allergic contact dermatitis, also known as Type IV (or delayed) hypersensitivity reaction, is caused by a specific immune reaction to relatively small reactive chemicals that become antigenic after protein binding (haptens). This reaction involves a sensitization phase, during which the individual is sensitized towards the allergen, without displaying any clinical symptoms. Upon re-exposure to the allergen, the elicitation phase begins. Here, the activation of allergen-specific T cells leads to clinical symptoms.[14]

2.1.1.2 Type I (immediate) Hypersensitivity Reaction / Protein Contact Dermatitis

Type I (or immediate) hypersensitivity reaction is caused by high molecular weight allergens, such as peptides or proteins. These allergens induce a specific IgE response, which can result both in an immediate reaction of urticarial character and, upon continuous or repeated exposure, lead to eczematous lesions resulting in protein contact dermatitis.[15]

2.1.2 Irritant Contact Dermatitis

Irritant contact dermatitis is a result of direct damage to the corneocytes leading to an inflammatory reaction via the innate immune system. It involves compromise of the skin barrier, infiltration by immunocompetent cells, and the production of inflammatory signal molecules. The severity of the reaction is correlated to the concentration, contact duration, and properties of the irritant.[16]

2.2 Atopic Dermatitis

Atopic dermatitis (AD) is a prevalent inflammatory skin disease, with a complex and partly unknown etiology. AD is characterized by dry skin and itchy rashes, often presenting in age-specific locations. In infants, AD primarily affects the cheeks, scalp, and extensor sides of the extremities. While the disease manifests on the flexural aspects of joints in children and shows a more diverse expression in adults, commonly involving the hands and neck.[17]

Historically, AD has been predominantly considered a condition that is resolved before adulthood. However, recent studies suggest a significant persistence of AD into adulthood, with a large Danish prospective cohort study finding 50% of individuals diagnosed in school-age have persistent AD in adulthood.[18] The lifetime prevalence of doctor-diagnosed AD among adults in studies performed on data from the 21st century has been reported to range between 17.6 to 20.2%.[19] Furthermore, the prevalence of AD appears to have increased over the last century.[19]

The pathophysiology, although not fully understood, involves a combination of genetic, immunological, and environmental factors. Mutations in the filaggrin gene represent the most substantial genetic risk.[20] Dysfunctional skin barrier,[21] abnormalities in the skin microbiome,[22] and a dysregulated immune system are also thought to contribute.[23]

AD is a significant risk factor for the development of HE in adulthood,[24,25] and it's similarly known to be an important risk factor for the development of OCD.[26]

2.3 Occupational Contact Dermatitis

Occupational Contact Dermatitis (OCD) is a form of contact dermatitis that is either caused or worsened by exposure to irritants and/or allergens in the workplace. More than 90% of all OCD cases involve the hands leading to occupational HE (OHE).[6,27] Common irritants leading to OCD include wet work (including prolonged glove use), foods, oils, and metalworking fluids.[28] Conversely, the allergens most often implicated in OCD are rubber additives (typically found in gloves), preservatives, epoxy resins, and metals.[6,29–31]

2.4 Wet Work

Wet work is defined as having wet hands for more than 2 hours per working day, washing hands more than 20 times per working day, or wearing occlusive gloves for more than 2 hours per working day,[32] and has been identified as an important risk factor for OHE.[33] Approximately 60% of recognized cases of OCD in Denmark can be attributed to wet work.[29]

2.5 High-Risk Occupations

Previous studies have identified certain occupations to be high-risk for the development of OCD. These include, but are not limited to, hairdressers and beauticians, food industry workers, cleaning personnel, healthcare workers, metal workers, and mechanics.[7,29,34] The one-year prevalence of HE in high-risk occupations such as healthcare and hairdressing has been found to be twice as high as in the general population.[8,10,35,36]

2.5.1 Hairdressers

Hairdressers have been found to be particularly at risk for developing OCD. This risk is largely attributable to the high amount of wet work (86.6% have ≥ 2 hours of wet work each day, 54% ≥ 4 hours)[37], and frequent and direct skin contact with a wide range of potentially harmful chemicals found in hair care products. These products, including hair dyes, bleaches, perms, and shampoos, contain allergens such as p-phenylenediamine, toluene-2,5-diamine, ammonium persulfate, fragrances, and preservatives.[38–40] In recent years, occupational allergic contact dermatitis (OACD) caused by acrylates has become more common among hairdressers, due to the growing demand for acrylic nails.[41–43] Furthermore, the use of protective gloves, poses the risk of contact with rubber accelerators such as thiurams and carbamates.[44]

2.5.2 Food Industry Workers

Working conditions in the food industry often entail significant wet work and contact with an array of skin irritants and allergens, such as food substances, soaps, and disinfectants. The high hygienic standards demanded by the industry further exacerbate this exposure. In a 2010 study by Meding et al.[45], it was found that approximately 60% of all kitchen assistants and restaurant workers reported at least two hours of wet work each day. Furthermore, work in the food industry often also involves high levels of manual labour, such as that experienced by swine slaughterhouse workers, whose hands and forearms are exposed to water, gut contents, gastric juice, salt, and relatively frequent hand washing.[46]

Occupational irritant contact dermatitis (OICD) is the most common condition resulting from the exposures in the food industry, but protein contact dermatitis is not uncommon due to exposure to proteins in food.[15,47]

2.5.3 Cleaning Personnel

The nature of work in the cleaning industry often results in large amounts of wet work, along with contact with hazardous cleaning and disinfecting agents, as well as the necessity to wear occlusive

gloves for an extended duration throughout the workday.[48,49] The majority of OCD cases are OICD cases (60-75%), with OACD being reported in 21-32%. An Italian study from 2009 examined the contact allergens and irritants in household washing and cleaning products and found preservatives and fragrances to be the main allergens found in washing and cleaning products, with methylchloroisothiazolinone/methylisothiazolinone (MCI/MI) listed in 35.7% and limonene in 43.6% of the products.[50]

2.5.4 Healthcare Workers

In the healthcare sector, hygienic demands are high due to the nature of the work. Frequent handwashing, prolonged and frequent glove use, and hand disinfection are unavoidable parts of the workdays for healthcare workers.[51] Furthermore, exposure to thiurams used as rubber accelerators in single-use protective gloves poses a risk for the development of OACD.[52]

2.5.5 Metal Workers and Mechanics

OCD is prevalent among metal workers and mechanics, primarily due to the mechanical strain of the work, high amounts of wet work, and exposure to metalworking fluids with considerable irritant and allergenic potential.

In a North American study examining all OCD cases referred for patch testing between 1998 and 2014, the most common occupational allergies found among mechanics and repairers were rubber accelerators such as thiurams and carbamates, and MCI/MI. These substances were found in gloves, automotive vehicles, solvents, oils, lubricants, and fuels.[53]

Furthermore, Meding et al.[45] found wet work to be fairly common among Swedish machine mechanics, with approximately 8.9% reporting wet work for more than two hours daily in 2010.

In addition, metalworkers have demonstrated low compliance with the application of moisturizers,[54] which poses a challenge to their care and treatment.

2.6 Young Workers and Occupational Contact Dermatitis

Young workers are particularly vulnerable to the development of OCD. Previous studies have found the age of onset to be around 25-36 years.[6,7] Moreover, OCD often manifests during training or within the initial few months of employment in high-risk occupations.[6] A recent Danish study focusing on hairdressers has found the time to onset of HE, including apprenticeship, to be a median of 1.2 years.[55] Furthermore, the IR of occupational skin disorders among hairdressing apprentices is

highest within the first three years of training,[8] and 29% of apprentice bakers have been found to develop hand dermatitis within six months of starting their training.[9]

2.7 Consequences of Occupational Contact Dermatitis

OCD carries significant implications, impacting both the quality of life and the professional lives of those afflicted.

Research shows that OCD often leads to reduced career length, particularly in professions such as hairdressing.[10,11] A 3-year follow-up study of 248 hairdressing apprentices found that 21.8% had left the trade, 70.3% because of health complaints, and 47.4% of these because of skin disease.[12] Moreover, several studies have documented additional adverse occupational consequences of OCD, such as job loss, unemployment and increased sick leave.[2,3]

OCD has also been shown to significantly diminish an individual's quality of life.[4,5] In a European multicenter study, patients with HE reported significantly higher levels of distress, suicidal ideation, depression, and anxiety as compared to controls.[56]

Complicating its impact, OCD frequently presents as a chronic, relapsing condition with a generally poor prognosis.[2] This chronicity, together with its intrusive impact on personal well-being and professional performance, highlights the particularly disruptive nature of the disease.

2.8 Diagnostics and Treatment of Hand Eczema in Denmark

The following outlined diagnostics and treatment course represents the gold standard as recommended by the European Society of Contact Dermatitis (ESCD) for diagnosing and treating HE.[57,58]

2.8.1 Medical History and Clinical Examination

A comprehensive medical history, obtained through a structural interview, is crucial in assessing the etiology and exposures related to HE. The medical history should include information on the patients' current symptoms, duration and progression of the disease, instances of exacerbations and remissions tied to work-related activities and exposures, and personal as well as family history of AD. Furthermore, concurrent skin or systemic diseases, previous allergy tests and results thereof, medication usage, and smoking habits should also be collected.

The clinical examination should include a thorough inspection of the hands and any other relevant areas. As HE can bear clinical similarities to a wide range of other skin diseases, differential diagnoses such as psoriasis and scabies, among others, should be ruled out.[57]

2.8.2 Exposure Assessment

As part of the gathering of the medical history, the patients' occupational and private exposures should be thoroughly evaluated. This evaluation should include an assessment of the extent of wet work, along with a detailed review of product labels for potential allergens, as well as material safety data sheets of the products the patient interacts with both in the workplace and at home.

In combination with the medical history and the clinical examination of the patient, this can inform the selection of patch tests. Nevertheless, while experienced dermatologists can often predict clinically relevant contact allergens based on the history and clinical appearance of the dermatitis, they are not always accurate.[59,60] Therefore, the use of baseline series for allergen testing is always recommended to ensure a comprehensive and accurate diagnosis. In support of this approach, the ESCD has recommended a European baseline series of allergens. This selection comprises allergens that have led to contact allergy in more than 0.5-1.0% of patients with suspected contact dermatitis.[61] Allergens with contact allergy rates below 0.5% are also included if the allergen is ubiquitous or of high clinical relevance.[62]

2.8.3 Patch Testing

Patch testing is the standard procedure to diagnose contact allergy resulting from type IV hypersensitivity. Patch testing should be performed on all patients experiencing HE. The choice of substances to be tested should be thoughtfully determined in light of the exposure assessment and the patient's history. During patch testing, allergens relevant to the patient are applied directly onto the skin in a diluted solution within occlusive chambers. The ESCD recommends an occlusion duration of 2 days, with subsequent readings of the patch results on days 2, 3 or 4 and again on day 7.[58]

The significance of a positive patch test result is determined by the patients' history, clinical manifestations, and comprehensive assessments of the exposure, encompassing both the nature and extent of the allergen contact.

2.8.4 Skin-Prick Testing and Specific IgE Measurements

When protein contact dermatitis, resulting from a type I hypersensitivity reaction, is suspected, skin-prick testing or prick-prick testing can be utilized in addition to patch testing. The selection and number of allergens for skin testing should be determined based on the patients' clinical history and allergen exposure patterns.

In skin-prick testing, allergen extracts are applied to the skin. A puncture device is then used to pass through the drop and penetrate the skin, introducing small amounts of allergen extract just below the epidermis. If the patient is sensitized, the allergen penetration triggers the release of histamine, resulting in a wheal and flare response.[63]

Prick-to-prick testing is the preferred method when considering a test with fresh foods of plant or animal origin, due to its more specific and accurate results.

Supplementing these tests, measuring specific IgE in the blood may provide additional information on the patients' sensitization profile.

2.8.5 Treatment

Treatment of HE involves various approaches to alleviate symptoms, reduce inflammation, and prevent recurrences. The following treatment options have been recommended by the ESCD[57] based on the Cochrane review by Christoffers et al.[64] on interventions for HE.

The first step in the treatment of HE is the identification and avoidance of causative factors. It involves identifying and eliminating irritants or relevant allergens in the workplace and at home. Education on the pathogenesis of HE and the proper use of personal protection equipment, such as protective gloves, are important strategies to improve motivation and ability to manage the condition. Furthermore, the use of emollients/moisturizers plays a vital role in restoring and maintaining the skin barrier.

Short-term treatment with topical corticosteroids is the first-line treatment for managing acute HE, effectively reducing inflammation and alleviating symptoms. In some cases, long-term intermittent use of topical corticosteroids may be considered for maintenance therapy to prevent relapses. If the HE is refractory to topical corticosteroids, topical calcineurin inhibitors (such as tacrolimus ointment) or phototherapy of the hands can be considered.

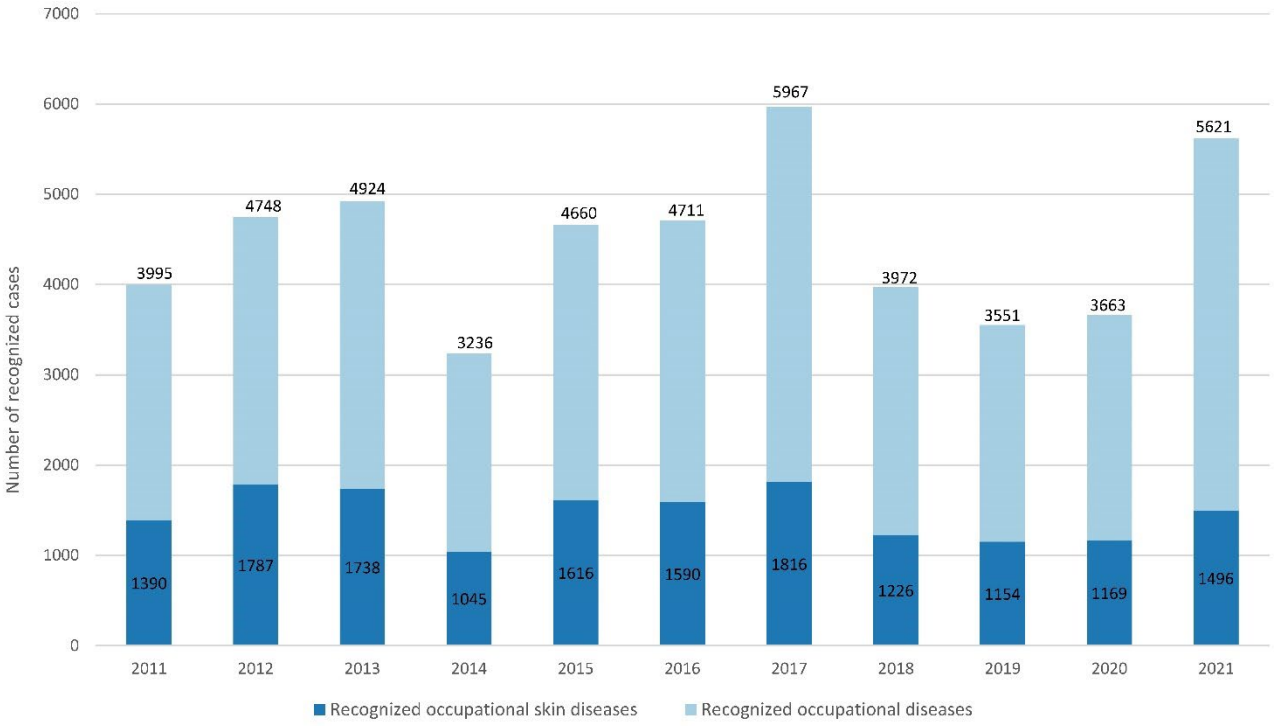
If topical treatments fail, the recommended second-line treatment is systemic treatment, for example with alitretinoin. Several off-label treatment options exist if the first- and second-line treatment fails

or is contraindicated: cyclosporin, azathioprine, methotrexate, and acitretin (for hyperkeratotic chronic HE). Additional potential treatments that require further research include dupilumab,[65,66] a human monoclonal antibody inhibiting interleukin-4 and -13 signaling, and delgocitinib,[67,68] a topical Janus kinase inhibitor.[57]

2.9 Previous Prevention Initiatives Tested and/or Implemented in Denmark

Over the last decade, skin diseases have been the most frequently recognized occupational diseases in Denmark, accounting for approximately one-third of all acknowledged cases of occupational diseases (Figure 1).[1,69] This has prompted an enhanced focus on prevention in Denmark.

Figure 1. *Number of recognized cases of skin diseases and total number of recognized cases of occupational diseases between 2011 and 2021.*



Prevention comprises primary, secondary, and tertiary prevention strategies. Primary prevention focuses on avoiding the occurrence of a disease in healthy individuals, secondary prevention targets

early signs and symptoms to prevent disease progression, and tertiary prevention seeks to reduce the disease severity and prevent complications in those already manifesting disease symptoms.

In Denmark, primary prevention measures of OCD have been implemented through legal regulations that control exposure to some specific allergens. For example, in response to the high prevalence of chromate sensitizations among cement workers,[70] Danish legislation in 1983 mandated the inclusion of ferrous sulphate to lower the content of water-soluble chromate to no more than 2 ppm in dry cement. This action was further reinforced by an EU legislation in 2005 that prohibited the usage or selling of cement and cement-containing preparations with a chromate content exceeding 2 ppm.[71] These laws led to a substantial decrease in OCD cases stemming from chromate allergies due to cement usage, not only in Denmark,[72] but also across other European countries.[73]

Since 1985, Denmark has made it a legal requirement for individuals to undergo an educational program on necessary safety measures before working with epoxy resins.[74] However, a study from 2012 found that only 50.5% of workers with occupational exposure to epoxy resins and a positive patch test reaction to epoxy resins, had participated in an educational program, indicating that reinforcement of the law is required.[75]

Various studies have tested the effect of educational programs in high-risk occupations, both to prevent the occurrence of OCD, and to foster early detection and treatment of OCD cases. For instance, an intervention study in 1999 implemented a skincare program employing both education and written instructions for 375 wet work employees across seven elderly care homes in Denmark. The post-intervention evaluation after five months exhibited a significant improvement in skincare knowledge, behavioral change, and reduction of skin symptoms in the intervention group compared to the control group.[76]

In 2000, an intervention study tested an educational program's effectiveness in preventing OCD among 107 student auxiliary nurses.[77] The results indicated that 48% of the intervention group, versus 58% of the control group, experienced an exacerbation of skin problems during practical traning.[77]

A year-long workplace intervention in 2002 aimed to reduce OCD in gut cleaning departments of Danish swine slaughterhouses. The intervention combined educational activities, recommendations,

and comprehensive organizational involvement, leading to a significant 27% relative reduction of OCD in the intervention group compared to the control group.[46]

A similar prevention program was tested on wet work employees across five Danish cheese dairies in 2002/2003. At follow-up, the intervention dairies had a marked increase in glove and moisturizer use.[78]

The Hand Eczema Trial (HET) initiated in 2009 was a randomized trial that measured the impact of a secondary preventive hand eczema program among 255 healthcare workers with HE. A positive effect of the intervention was found at follow-up after five months, with reduced severity, increased health-related quality of life and improved skin protective behavior.[79]

From 2008 to 2010, an intervention study tested the effect of an educational program implemented in hairdressing schools educating hairdressing apprentices on skin biology, contact allergy/urticaria and how to prevent OCD. The intervention resulted in increased glove usage and reduced incidence of HE 18 months post-intervention.[80] This initiative evolved into a nationwide skin protection program implemented across all Danish hairdressing vocational schools in 2011. By 2015, the executive order on hairdressing vocational training was updated, requiring apprentices to pass a theoretical and practical exam based on the educational program's content.[81] Subsequently, a decrease in the prevalence of HE was observed among hairdressers trained post-implementation compared to those trained prior.[82]

2.10 The Danish Accident Insurance and Healthcare System

The Danish Labour Market Insurance (DLMI) is the official entity in Denmark responsible for the examining, recognition, and economic compensation of occupational diseases.

The recognition criteria for OCD within the DLMI system include the presence of typical symptoms, relevant exposure at the workplace, and a temporal relationship between the exposure and the onset or worsening of contact dermatitis symptoms.

Typically, a worker with suspected OCD will initially consult a general practitioner, who will likely refer the patient to a local dermatologist (Figure 2). This dermatologist will undertake further examinations and patch testing for allergies. In some rare instances, the general practitioner might directly refer the worker to a department of occupational medicine or a dermatological department at a hospital. In most cases, diagnostics and treatment will be provided by the local dermatologist,

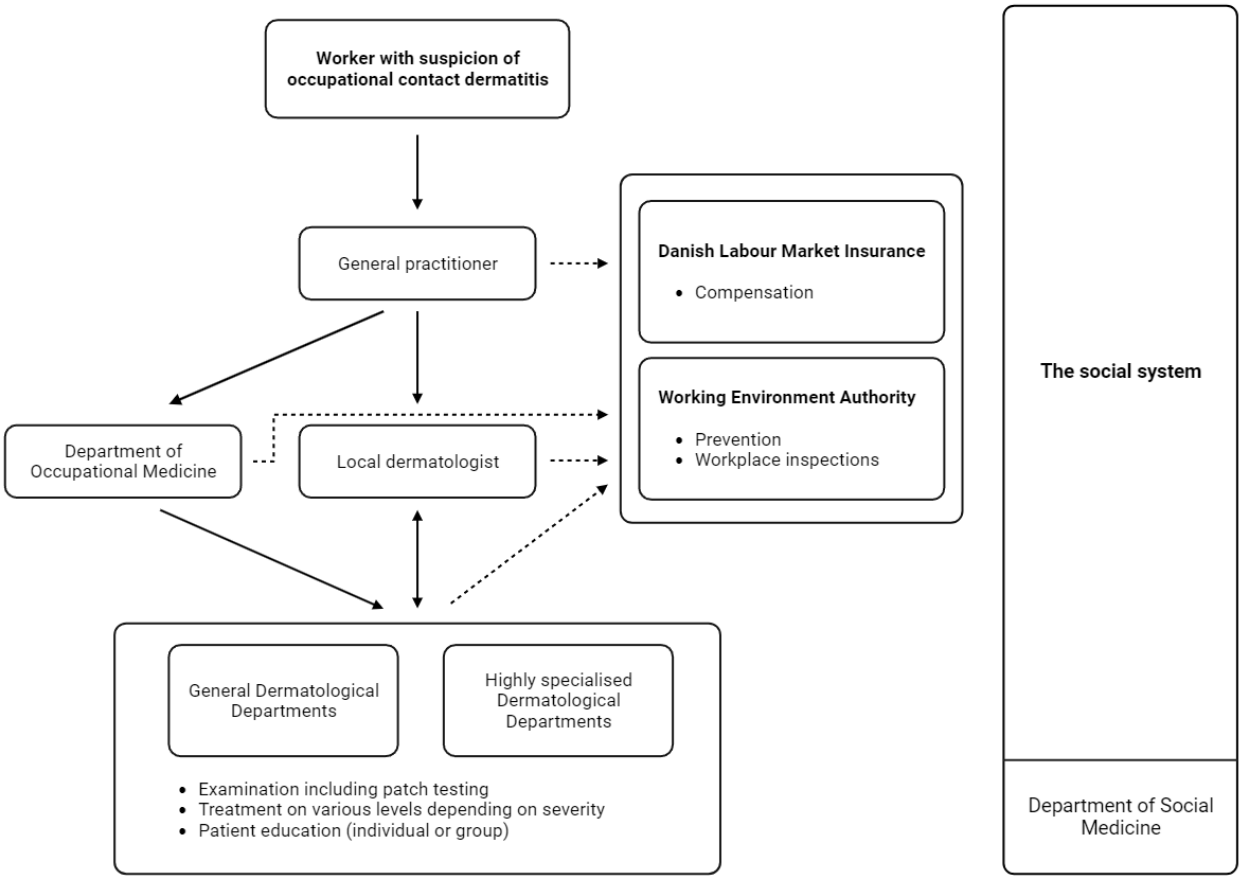
but there can be instances where the worker is referred to a dermatological department by the local dermatologist.

Notification of the suspicion of OCD to the DLMI is legally required by any doctor who suspects an occupational disease, but dermatologists (either local or hospital-based) typically handle these notifications. The DLMI then requests a dermatologists' statement to serve as the basis for case handling. A legal professional, with support from medical specialists, is responsible for the final decision regarding recognition.

A case can be recognized with or without the awarding of economic compensation, which is granted only if the degree of injury is evaluated to be ≥ 5%. This degree of injury is determined by an individual evaluation of the worker's degree of eczema. It encompasses a global assessment of chronic changes, including severity (none, mild, moderate, severe) and frequency of eruptions (seldom, regularly, frequent). This assessment is based on the dermatologists' statement. The identification of certain occupational allergies, which are perceived as challenging to avoid, will result in the awarding of additional percentage points of injury (5%). This includes allergies to substances like nickel, chromium, formaldehyde, and MCI/MI. If the criteria are met, the contact dermatitis will be recognized as an occupational disease, potentially leading to compensation for the affected worker. On the other hand, other factors, such as preexisting AD, will result in the deduction of percentage points in the awarded compensation in the case of OICD.

In Denmark, further prevention and workplace inspections are conducted by the Working Environment Authority. The public healthcare system handles all diagnostics and treatment, while the occupational consequences of OCD, such as job loss or incapacity to utilize their education for work, are managed by the Danish social system.

Figure 2. *The handling of occupational contact dermatitis cases in Denmark. Created with BioRender.com.*



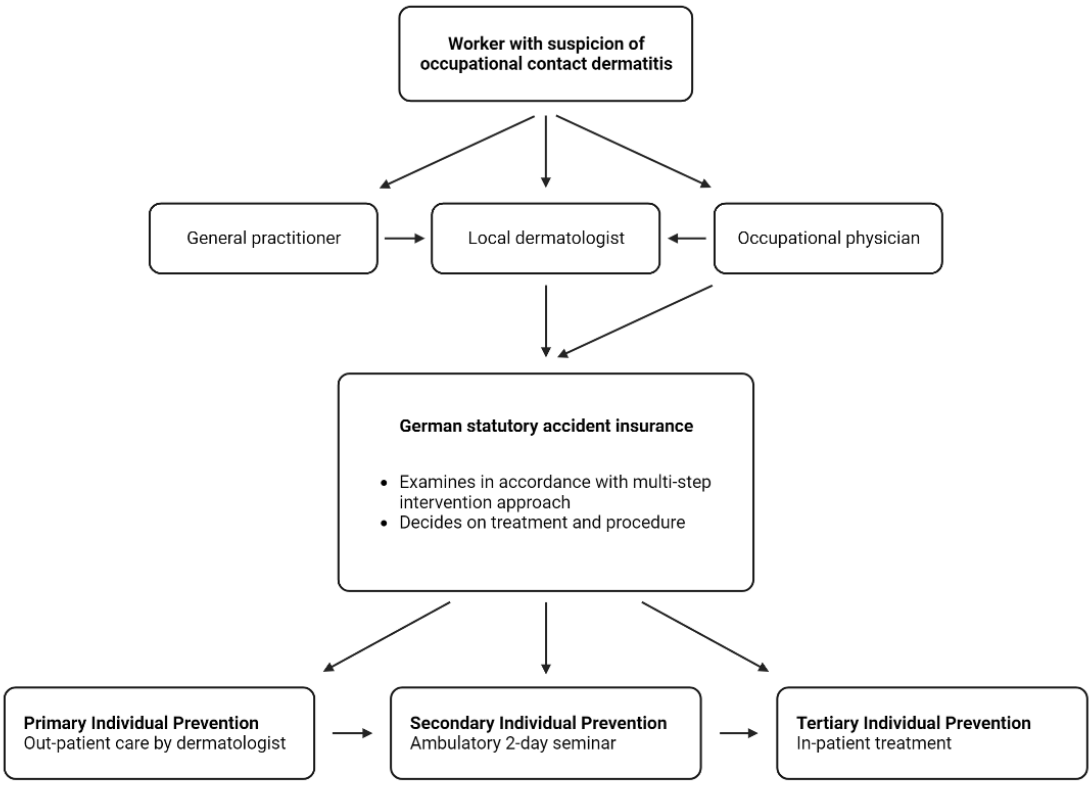
The socioeconomic costs of OCD in Denmark are considerable, with estimates suggesting costs near €100 million per year. However, it is important to note that this estimate is based on assumptions made over 25 years ago.[83] During the last seven years, the DLMI has spent on average €21.5 million annually on compensation for permanent injury and reduction in earning capacity for afflicted workers with OCD,[84] making OCD one of the costliest diseases in the DLMI system.[1]

2.11 The German Accident Insurance and Healthcare System

Similar to Denmark, OCD has historically been one of the most prevalent occupational diseases in Germany, with the associated socioeconomic costs being estimated to be more than €1.5 billion.[85]

In response to this, the German statutory accident insurance implemented a comprehensive multi-step prevention program in 2005.[86] When the German statutory accident insurance is notified about a worker with OCD; the severity of the symptoms, the risk of chronicity, and the associated risk of job loss are initially assessed using a dermatologist assessment. The most appropriate intervention step for the patient is then determined based on these findings. The multi-step prevention program includes three possible interventions (Figure 3).

Figure 3. *The handling of occupational contact dermatitis cases in Germany. Created with BioRender.com.*



Workers with suspected OCD initially receive outpatient diagnostics and treatment by a local dermatologist. Those with early or mild symptoms are offered a Secondary Individual Prevention (SIP), which includes an outpatient skin protective seminar and dermatological care, aiming to enhance disease management and individual skin protective strategies at an early stage to foster remission and prevent disease worsening and development into a chronic condition.

Should SIP prove ineffective, or if the worker faces a high-risk of abandoning their profession due to the severity of their condition, a Tertiary Individual Prevention (TIP) is provided. The TIP is aimed at mitigating the severity of disease, improving the quality of life, and helping affected workers to remain in their profession. This program involves a three-week inpatient rehabilitation with a multidisciplinary approach, a subsequent three-week off-work period, and continuous dermatological follow-up.

All aspects of prevention, treatment, recognition, compensation, and possible job rehabilitation are the responsibility of the German statutory accident insurance.

A recent Danish review of the German multi-step intervention prevention has found that SIP and TIP lead to decreased OCD severity, improved quality of life, and enable most workers to continue in their chosen profession.[87] A similar model has since been adopted and implemented in Austria as well.[88]

3. Objectives

The overall objectives of this PhD project were to identify current high-risk occupations for the development of OCD, and to examine the consequences of OCD on long-term eczema status, quality of life and occupational consequences, and connected societal costs. Furthermore, we wanted to test the effect of a Danish-adapted intervention inspired by the German TIP approach on the severity of OHE, quality of life and related occupational consequences.

Study I: To identify high-risk occupations for the development of OCD and to examine any development in IRs of OCD over a 12-year period within the known at-risk occupations.

Study II: To examine the long-term consequences of OCD on young people's lives with a focus on their eczema status and quality of life and occupational consequences after the notification of OCD.

Study III: To examine the occupational and socioeconomic consequences of OCD and assess the societal costs connected to OCD.

Study IV: To examine the effectiveness of a Danish-adapted intervention utilizing fast medical diagnostics and treatment, education on skin-protective behavior and highly specialized diagnostics and treatment performed by a multidisciplinary team, inspired by the German TIP approach on the severity of OHE, quality of life, and occupational consequences.

4. Materials and Methods

4.1 Data Extraction from the Danish Labour Market Insurance (Studies I, II and III)

We extracted data from the DLMI on all notified and recognized cases of OCD in Denmark in three different time periods: Study I: Jan 2007 – Dec 2018, Study II: Jan 2010 – Dec 2019, and Study III: Jan 2010 – Dec 2015. The data extracted included sex, age at notification, diagnosis, and industry of employment (Danish Industry Code year 2007 – DB07).

4.1.1 Handling of Duplicates

It is possible for the same worker to appear in the registry multiple times if they first had an OICD recognized and then later had an OACD recognized. Alternatively, they could have multiple recognitions of OICD for different occupations. To avoid duplicate entries in our analysis, we categorized workers as having either OICD or OACD. In cases where workers had both diagnoses recognized, they were categorized as having OACD. This solution was chosen as OICD is an exclusion diagnosis made when no relevant allergies have been identified, so if an OACD has also been recognized, it takes precedence in the categorization. We retained the date of the earliest notification as a proxy for the onset of OCD, along with the industry of employment at the time of the first notification.

4.2 Data Extraction from Statistics Denmark (Study I)

We obtained data from Statistics Denmark on the number of part- and full-time employees between 2007 and 2018, following the DB07 classification. To evaluate the most affected industries of employment, we established the following criteria for the occupations to include in further analysis:

- There should be ≥ 90 recognized cases registered in the DLMI between January 1st 2007 and December 31st 2018
- The occupation should have ≥ 5000 employees (part- or full-time) on average in Denmark between 2007 and 2018
- The overall IR from 2007 to 2018 ≥ 4.0 per 10 000 workers per year

4.3 Data Extraction from the Danish Register for Evaluation of Marginalization (Study III)

The social security code of workers with recognized cases of OCD notified between 2010 and 2015 was used to extract data from the Danish Register for Evaluation of Marginalization (DREAM), which is stored at Statistics Denmark. DREAM contains information on all social transfer payments received, the monthly degree of employment (work hours/month), place of residency (municipality), place of work (municipality), and industry of employment for each month (DB07).

4.3.1 Paid Long-Term Sick Leave

Only instances of paid long-term sick leave are registered in DREAM. For an individual to qualify for this, they must first undergo an initial period of sick leave covered by their employer. Changing legal reforms over time have led to variation in the duration of this period from January 2008 to December 2017.[89] Specifically, the necessary period of sick leave covered by the employer was 15 days from April 2007 to June 2008, extended to 21 days from June 2008 to January 2012, and was further increased to 30 days from January 2012 onwards.[89]

It is important to note that DREAM does not document the duration of sick leave covered by the employer or the specific reasons that qualify an individual for paid long-term sick leave.

4.4 Questionnaire Construction (Studies II and IV)

The research group developed a questionnaire consisting of 263 questions. The questionnaire was evaluated and revised through interviews with peers and with HE outpatients from Gentofte Hospital, Department of Dermatology. All items were considered relevant and easy to understand by the participants.

The questionnaire included questions on the current status and severity of eczema, current occupational status, occupation responsible for the development of their OCD and exposures related to this occupation, and occupational consequences of the OCD. The questions used were primarily taken from the Nordic Occupational Skin Questionnaire (NOSQ-2002),[90] and the Health 2006 survey.[91] Severity of current HE was evaluated using a self-administered photographic guide based on photographs of HE,[92] along with a visual analog scale (VAS). A history of AD was estimated by a question about doctor-diagnosed AD.[93] Quality of life was assessed using Dermatology Life Quality Index (DLQI), Skindex-29 and EQ-5D-5L.[94–96] We used the categorization of Skindex-29 scores suggested by Nijsten et al.[97]

The questionnaire was used in studies II and IV. In study IV, the participants were asked to fill out the questionnaire at inclusion, and then again, in a slightly adapted version, at 3-months follow-up.

4.5 Development of a Danish-adapted Intervention Inspired by the German TIP approach (Study IV)

Given the significant structural differences between the Danish and German healthcare and occupational accident insurance systems,[98] directly implementing the German multi-step prevention program was not feasible within the scope of the project. Consequently, a custom approach suitable for the Danish hospital setting had to be developed. Inspired by the rapid medical diagnostics, specialized treatment, and education on skin-protective behavior strategies of the German TIP approach, our research group designed an intervention suitable for a Danish hospital setting.

The aim was to focus on fast medical diagnostics and treatment, skin-protective behavior education and highly specialized diagnostics and treatment performed by dermatologists with specialized knowledge in OCD.

To expedite medical diagnostics and treatment, participants from the intervention group (IG) were invited to a consultation with a dermatologist at the Department of Dermatology at Gentofte Hospital within 2-3 weeks of joining the study. Prior to this consultation, a exposure assessment was conducted over the phone and email, allowing for immediate patch testing in conjunction with the initial doctor's consultation.

The education on skin protective behavior encompassed a video, specifically produced for the research project, which detailed essential aspects of OHE, prevention techniques, treatment strategies, and the importance of skin-protective behavior. Additionally, participants received individualized guidance on skin protective behavior and glove counseling, provided by a nurse with specialized experience in the field.

The diagnostics and treatment provided were highly specialized, with a chemical engineer experienced in exposure assessment reviewing the ingredient information of all the participant's work and personal products. In collaboration with the treating dermatologist, the chemical engineer then compiled a list of allergens for subsequent testing following the recommendation from the ESCD and updates.[58] The initial treatment plan, based on a predefined standardized treatment strategy following ESCD's recommendation for HE treatment,[57] was established during the first doctor's consultation. In relevant cases, when fulfilling predefined criteria, referrals were made to

the Department of Social Medicine and/or the Department of Occupational and Environmental Medicine.

The control group (CG) participants were asked to navigate the Danish healthcare system independently.

4.6 Recruitment of Participants from the Danish National Referral Database (Study IV)

Participants were recruited following their initial referral from a general practitioner to a dermatologist due to suspected OHE. Information on active referrals from a general practitioner to a dermatologist was obtained from the Danish National Referral Database.

As per Danish law, a research project can obtain access to health-related personal data for a specific health science research project without obtaining prior consent from the patient, provided the project is of significant societal interest and has been approved by the Patient Safety Authority. However, the law stipulates that before a researcher can contact the patient using the obtained information, permission must first be secured from the patient's treating physician.[99] To comply with this, we contacted the referring general practitioner for their approval before contacting the participants via secure email (eBoks) and phone with written and oral information about the study.

The enrollment period was from June 2020 to December 2022. Due to technical difficulties in the National Referral Database system, there was a break in recruitment from January 2021 until December 2021. Participants gave informed consent complying with the Helsinki Declaration before entering the study.

4.7 Data Extraction from the Online Shared Medication Record and Electronic Health Journal (Study IV)

We assessed the treatment of the participants by assessing their online shared medication record and, for the IG, their electronic health journal. The shared medication record is a system that securely stores all information about a patient's current and past prescribed medications, which authorized healthcare professionals can access. The electronic health journal stores information about all hospital visits and was therefore only assessed for the IG. The medical treatment within the last year of the participants was assessed at baseline, and within the last three months at 3-months follow-up.

4.8 Statistics

Details regarding the statistical analyses employed in studies I-IV are outlined in the subsequent section. A significance level of $P < .05$ was used.

4.9 Methodology for the Individual Studies

4.9.1 Study I

Study I was a register-based study, using data from all recognized cases of OCD in Denmark between January 1st 2007 and December 31st 2018 within the 28 most affected occupations (n= 10 235), as well as population data from Statistics Denmark entailing all full- and part-time workers in the same occupations and time period.

Statistics

We calculated the IRs as the number of recognized OCD cases per 10 000 workers per year. In order to identify any development in the IRs of OCD within the occupations, we divided the study period into two six-year periods: Period I – spanning from January 1st 2007 to December 31st 2012, and Period II – spanning from January 1st 2013 to 31st December 2018. We assumed constant IRs within the two study periods. Subsequently, we used asymptotic chi-square test to compare the IRs between period I and II.

4.9.2 Study II

Study II was a questionnaire study, where a questionnaire was sent to all individuals with recognized OCD between January 1st 2010 and December 31st 2019, who were under the age of 35 at the time of notification (n=6251). The questionnaire was sent electronically via secure email (eBoks) to the participants on January 21st 2021, with two reminders sent out at monthly intervals. The response rate was 47% (n=2942).

Statistics

We conducted a non-responder analysis using chi-square test and Wilcoxon rank sum test. For assessing the association between the explanatory variables and the different outcomes, we used binary logistic regression models to calculate odds ratios (ORs) and 95% confidence intervals (CIs). Models were adjusted for age, sex, AD and time between notification and the time of the questionnaire.

4.9.3 Study III

Study III was a register-based study using data from all recognized cases of OCD in Denmark between January 1st, 2010 and December 31st, 2015. The data was merged with information about social transfer payments and the degree of employment (work hours/month) in the two years preceding and following the notification (n=8940).

In this study, we compared the number of weeks on different types of social transfer payments and the degree of employment during the two years after notification with the two years before the notification of OCD. Cases were excluded from the analysis if the worker was below 18 years of age, on maternity leave, retired, emigrated, or died within two years before or after notification (n=6685).

Statistics

We compared the degree of employment and average number of weeks on different social transfer payments during the two years prior to and following notification using paired samples t-test. Due to the varying length of the employer-covered sick leave period during the study period, only data on workers who were subject to the same sick-leave legal reform during the two years before and after notification were included in the analysis comparing the amount of paid long-term sick leave before and after notification (n=2171).

We used two-way analysis of variance to study the effect of long versus short duration of time between notification and recognition (case-processing time) on the degree of employment and number of weeks spent on different social transfer payments during the two years after notification. This analysis was adjusted for age and sex and only included workers who were subject to the same sick-leave legal reform (n=4503).

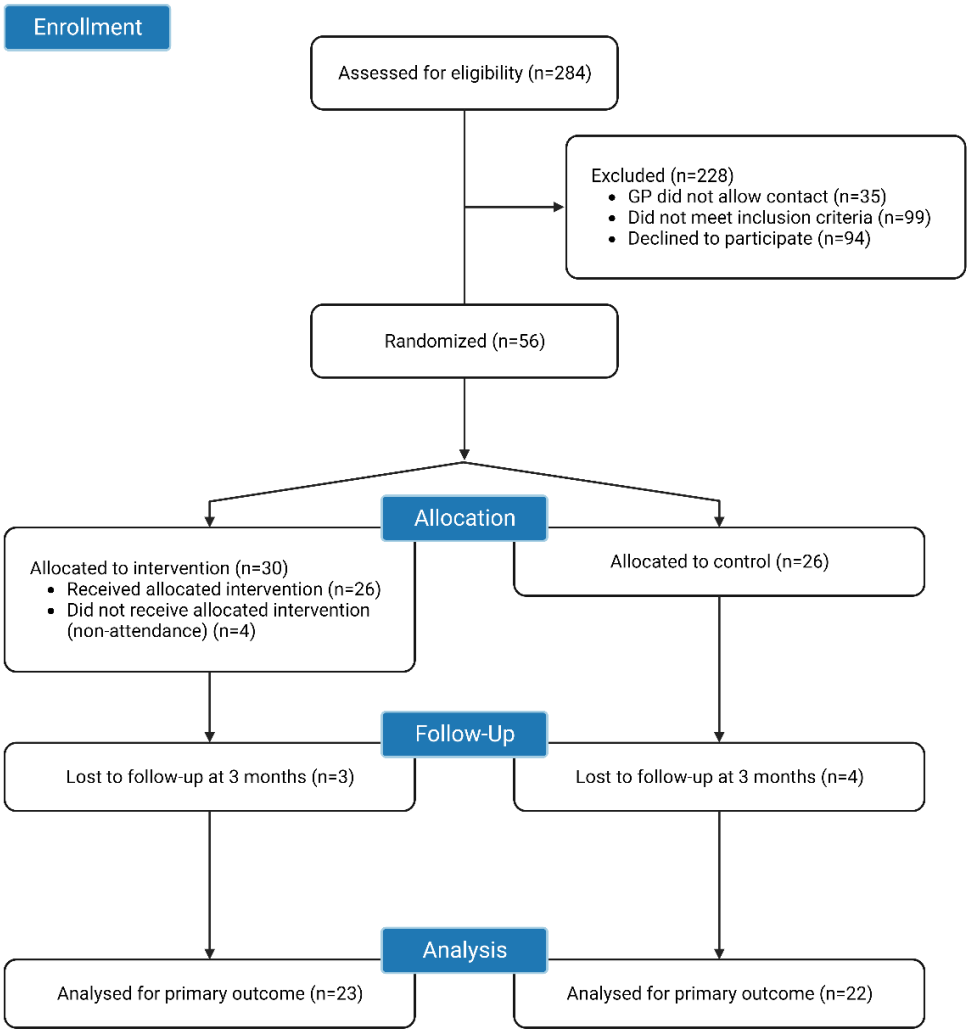
4.9.4 Study IV

Study IV was a randomized controlled trial. Participants were enrolled from the Danish National Referral Database upon their first referral to a dermatologist for suspected OCD on the hands (OHE). Inclusion criteria consisted of an age range of 15-65 years, an active dermatologist referral, HE presence within the past three months, a suspected occupational cause, and the ability to provide informed consent. Exclusion criteria included current pregnancy, breastfeeding, or any severe psychiatric illness, that might overshadow the OHE issue.

Participants were block-randomized into either the CG or IG, with stratification by sex and age, in blocks of six. Prior to the study, we conducted a power calculation anticipating a 75% improvement in HE for the IG and 50% of the CG during the follow-up period, with a chosen power of 80%. The calculation recommended a total sample size of 116 participants.

Figure 4 details participant flow in the study. Of the 284 workers assessed for eligibility, 228 were excluded due to failing to meet the inclusion criteria, declining to participate, or their general practitioner not authorizing participant contact. Subsequently, 56 participants were randomized into the IG (30 participants) or CG (26 participants). Non-attendance led to four participants in the IG not receiving the intervention. At the 3-month follow-up, three participants in the IG and four in the CG were lost to follow-up, leaving 23 participants in the IG and 22 in the CG eligible for primary outcome analysis.

Figure 4. *Participant flow in study IV. Created with BioRender.com.*



The primary analysis was conducted in accordance with a per-protocol approach, including only the participants from the IG and CG who adhered to the study protocol. This enabled the evaluation of participants based on their assigned group and their protocol compliance. An attrition analysis was conducted, showing no significant differences between the two groups, except for the dropouts having a shorter duration of disease at the time of inclusion in the study.

Statistics

Baseline characteristic distributions between the IG and CG, as well as the attrition analysis, were evaluated using Fisher's exact test and the Wilcoxon rank-sum test. Ordinal and binary outcome variables employed ordinal or binary logistic regression models for OR and 95% CI calculation, respectively, while continuous outcome variables used linear regression models to examine group differences. The analyses were adjusted for age, sex, AD and baseline variable values where relevant.

4.10 Data Storage and Analysis of Data

Study data were collected and managed using REDCap electronic data capture tools hosted at the Capital Region of Denmark.[100,101]

The statistical analyses for the earlier studies (Studies I and III) were made in SPSS version 24, whereas the statistical analyses for the more recent studies (Studies II and IV) were made in R version 4.2.2.

4.11 Ethical Approvals and Data Permissions

Studies I and III: Approval granted by the Danish Data Protection Board (no. HGH-2017-093, I-suite no. 05911).

Study II: Approval granted by the Knowledge Centre on Data Protection Compliance in the Capital Region of Denmark on behalf of the Danish Data Protection Board (P-2020-508).

Study IV: Approval granted by the Danish Patient Safety Authority (31-1521-161) and the Knowledge Centre on Data Protection Compliance in the Capital Region of Denmark on behalf of the Danish Data Protection Board (P-2019-650).

5. Main Results

The main results of the studies are summarized in this section. More comprehensive data is available in the appended manuscripts I-IV.

5.1 High-Risk Occupations for the Development of Occupational Contact Dermatitis (Study I)

We identified 17 occupations with exceedingly high-risk (IR ≥ 7 per 10 000 workers per year) and 11 occupations with high-risk (IR 3-7 per 10 000 workers per year) for OCD development, as per Dickel et al.'s[7] classification. The highest IR was found among hairdressers and beauticians (42.5 per 10 000 per year), followed by bakers (26.5 per 10 000 workers per year), dentists and dental assistants (18.0 per 10 000 workers per year) and manufacturing of windmills (17.5 per 10 000 workers per year).

5.2 Occupations with the youngest workers with Occupational Contact Dermatitis (Study I)

The lowest median age at OCD notification was observed among bakers (median 24 years), vocational schools (24.5 years), hairdressers and beauticians (25 years), restaurant workers (25 years), hotel workers (25 years), retail sale of cars, vans, and minibuses (25 years), pig and dairy cattle breeders (25 years), and auto mechanics (26 years).

5.3 Development in Incidence Rates of Occupational Contact Dermatitis between 2007-2012 and 2013-2018 (Study I)

A statistically significant decrease in OCD IRs in several occupations was observed between the two comparison periods (Figure 5). Hairdressers and beauticians saw the largest decline in IR, from 51.8 to 33.4 per 10 000 workers per year ($P < .001$). Windmill manufacturers also exhibited a substantial decrease in IR from 22.4 to 13.2 per 10 000 workers per year ($P<.001$). However, an increase in IR was found among child/nursery care workers from 3.6 to 5.8 per 10 000 workers per year ($P<.001$). Differences in IRs between the two examined time periods are also presented in Figure 6.

Figure 5 (A,B). *Incidence rates of occupational contact dermatitis within the 28 most afflicted occupations in 2007-2012 and 2013-2018. © 2021 John Wiley & Sons A/S. Published by John Wiley & Sons Ltd.*

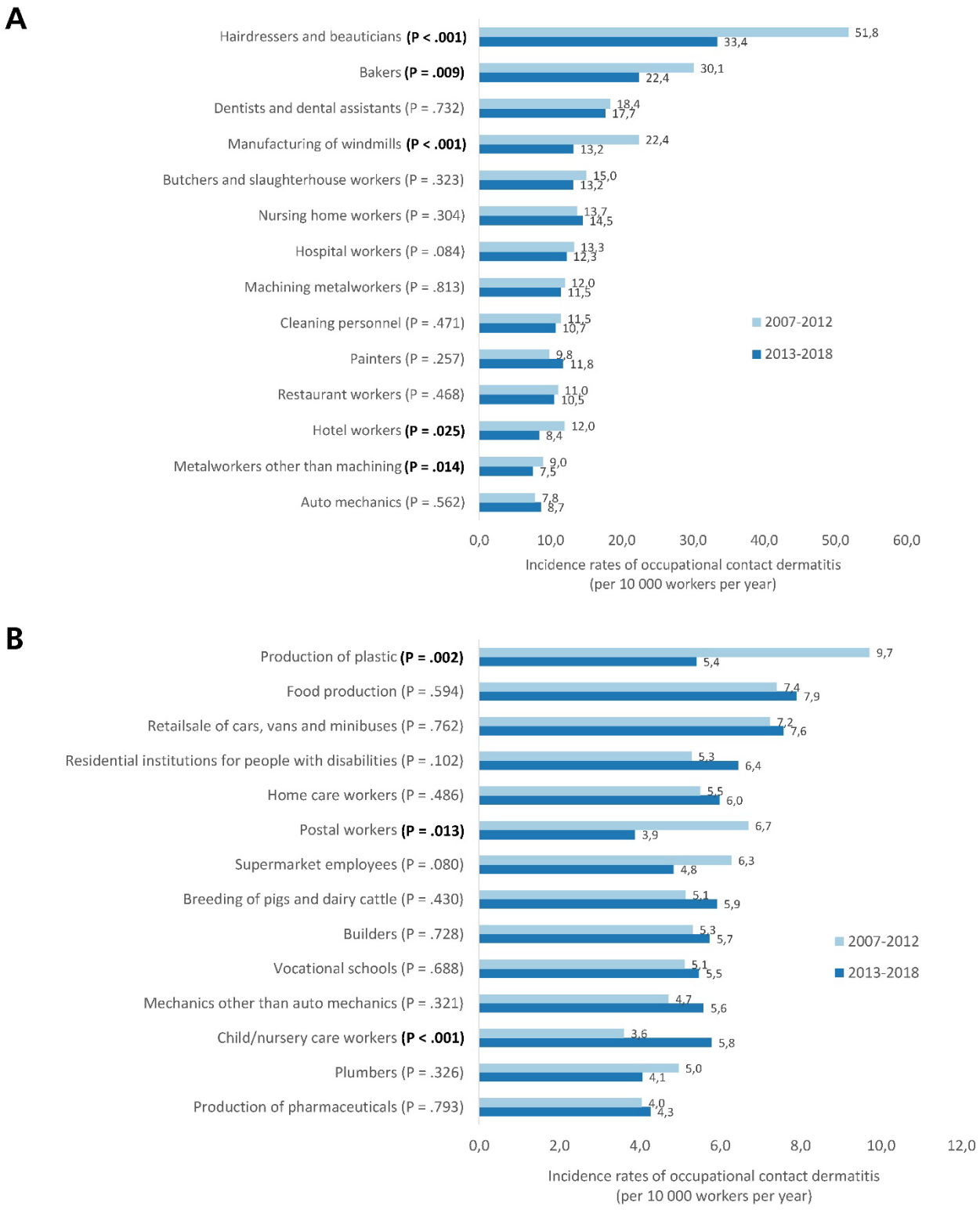
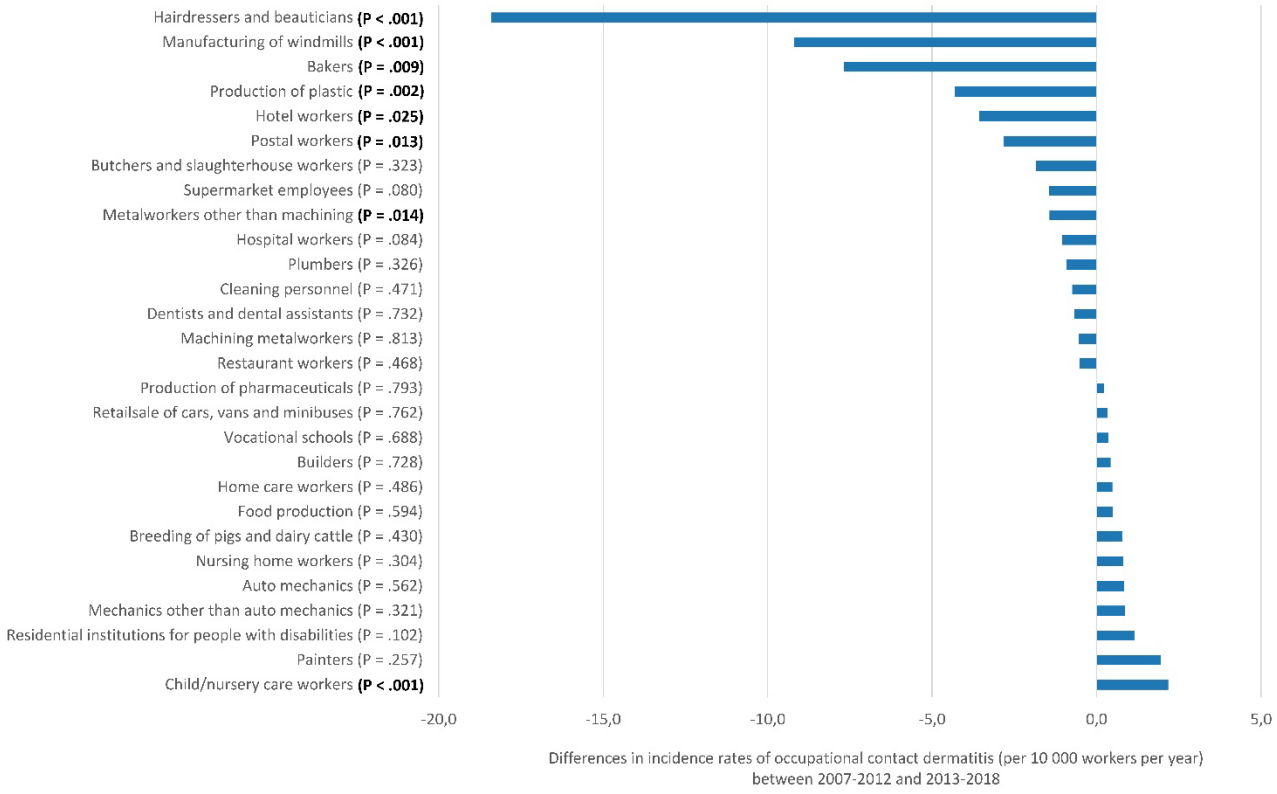


Figure 6. *Differences in incidence rates (IRs) of occupational contact dermatitis (OCD) between the two examined time periods (2007-2012 and 2013-2018)*



5.4 Occupational Contact Dermatitis long-term consequences on young workers (Study II)

Survey responses collected a median of six years after notification revealed that 76% of respondents still had eczema, of which 77% reported persistent eczema equal to or more than half the time within the last three months, and 61% had moderate to severe eczema (Table 1). Job loss was reported by 42.5% due to their OCD, and 35.1% believed their career choices were negatively impacted by their OCD (Table 2).

Table 1. *Current eczema status reported by respondents in study II (n=2942).*

Current eczema status	n (%)
Eczema within the last 3 months (n=2501)	1901 (76%)
Duration of eczema within the last 3 months (n=1793)	
All the time	650 (36%)
More than half the time	414 (23%)
Half the time	320 (18%)
Less than half the time	409 (23%)
Photographic guide (n=1763)	
Almost clear	686 (39%)
Moderate	815 (46%)
Severe	227 (13%)
Very severe	35 (2%)

Table 2. *Occupational consequences of occupational contact dermatitis reported by respondents in study II (n=2942).*

Occupational consequences	n (%)
Changed occupational field (n=2015)	1064 (52.8%)
Experienced job loss due to OCD (n=2336)	993 (42.5%)
Other consequences of OCD (n=2333)	
Choice of jobs and occupations is negatively affected	818 (35.1%)
Work tasks have been changed	533 (22.8%)
Sick leave	332 (14.2%)
Decrease in income	276 (11.8%)
Difficulties finding work	192 (8.2%)
Colleagues and/or employer have a negative attitude	139 (6.0%)
Retirement	7 (0.3%)

Notably, younger respondents (≤ 25 years at notification) had a significantly higher OR of experiencing job loss or negative career choice impacts (OR 1.3, 95% CI: 1.1-1.6, P<.05, and OR 1.4, 95% CI: 1.2-1.7, P<.05, respectively). Over half of the respondents (53%) had changed their occupation post-OCD development. Specifically, among the various occupations, certain professions had significantly higher ORs for facing specific occupational consequences due to OCD. Bakers and pastry chefs were found to have an increased OR for having difficulty finding work because of OCD. Hairdressers and beauticians had increased OR for experiencing a decrease

in income because of OCD. Moreover, butchers and slaughterhouse workers exhibited a higher OR for job loss due to OCD.

5.5 Socioeconomic Consequences of Occupational Contact Dermatitis (Study III)

During the two years after notification, the average degree of employment fell by 8.9 work hours/month (95% CI: 7.8-10.0, P < .001, n = 6685), corresponding to an annual income loss of €1570 per worker, assuming minimum wage (€14.72/hour in 2015). Further, workers showed reduced financial self-supporting two years after notification (mean difference 7.4 weeks, 95% CI: 6.6-8.2, P<.001), spent more weeks on unemployment benefits and paid long-term sick leave (mean difference 2.5 and 2.8 weeks, respectively).

5.6 Impact of Case-Processing Time on Socioeconomic Consequences of Occupational Contact Dermatitis (Study III)

Longer case-processing time (> 1 year) was associated with a reduction in working hours per month (-5.5 hours) two years after notification (95% CI: 2.6-8.3, P < .001), equating to an annual income loss of €970, assuming minimum wage. Additionally, workers with longer case-processing time showed reduced financial self-supporting and had increased durations on unemployment benefits of paid long-term sick leave after notification.

5.7 The Effect of a German-Inspired Intervention on Occupational Hand Eczema at 3-Months Follow-Up (Study IV)

The severity of OHE was self-assessed at baseline and at 3-months follow-up by considering the degree of eczema within the last three months, severity as per VAS and the photographic guide (Table 3).

Table 3. *Self-assessed severity of hand eczema within the last three months at baseline and at 3-months follow-up in the intervention and control group in Study IV (n=45).*

Severity of hand eczema	**Intervention group. n(%)**		**Control group, n(%)**	
	Baseline	**3-months**	**Baseline**	**3-months**
Degree of eczema within the last three months				
No eczema	0 (0%)	1 (4.3%)	1 (4.5%)	0 (0%)
Less than half the time	3 (13%)	4 (17.4%)	0 (0%)	2 (9.1%)
Half the time	3 (13%)	4 (17.4%)	1 (4.5%)	3 (13.6%)
More than half the time	4 (17.4%)	7 (30.4%)	9 (40.9%)	4 (18.2%)
All the time	13 (56.5%)	7 (30.4%)	11 (50%)	13 (59.1%)
Crude OR for having larger amount of hand eczema (control group), OR (95% CI)				2.9 (1-9.1)
Adjusted OR for having larger amount of hand eczema (control group), OR (95% CI)†				**4.6 (1.3-18)***
Severity of eczema within the last three months on the VAS scale ($n^{baseline}$=44)				
Mean ± SD	5.9 ± 2	4.1 ± 2.3	6.8 ± 2	4.8 ± 2.7
Crude mean difference (95% CI)				0.3 (-1.2;1.8)
Adjusted mean difference (95% CI)†				0.6 (-1;2.1)
Severity of hand eczema within the last three months self-assessed by the photographic guide				
No eczema	0 (0%)	1 (4.3%)	0 (0%)	0 (0%)
Almost clear (group 1)	5 (21.7%)	9 (39.1%)	2 (9.1%)	5 (22.7%)
Moderate eczema (group 2)	9 (39.1%)	3 (13%)	12 (54.5%)	11 (50%)
Severe eczema (group 3)	9 (39.1%)	3 (13%)	5 (22.7%)	3 (13.6%)
Very severe eczema (group 4)	1 (4.3%)	0 (0%)	3 (13.6%)	3 (13.6%)
Crude OR for having higher severity of hand eczema (control group), OR (95% CI)				2.8 (0.9-9)
Adjusted OR for having higher severity of hand eczema (control group), OR (95% CI)†				**7 (1.9-29.2)****

*†Adjusted for age, sex and atopic dermatitis. * P < .05, ** P < .01, *** P < .001*

The IG showed a decrease in participants reporting continuous eczema from 56.5% at baseline to 30.4% at follow-up. In contrast, the CG saw an increase from 50% to 59.1%. Consequently, a statistically significant difference in the degree of eczema was found between the two groups favoring the IG. When adjusted for sex, age, AD and baseline eczema degree, the CG had an increased adjusted OR of 4.6 (95% CI 1.3-18, $P < .05$). Both groups saw a decrease in self-reported eczema severity assessed by VAS over the last three months, although the IG had a lower mean VAS score (4.1 ± 2.3) than the CG (4.8 ± 2.7) at follow-up, the difference was not statistically significant. The photographic guide-based severity assessment revealed noticeable improvement in the IG at follow-up, with an increase in participants reporting no eczema or almost clear eczema, and a decrease in those reporting moderate, severe or very severe eczema. Conversely, changes in the CG were less marked, and the CG had a statistically significantly higher adjusted OR of 7 (95% CI 1.9-29.2, $P < .01$) for more severe OHE at follow-up.

We also found moisturizer to be used more frequently in the IG than the CG at 3-months follow-up, albeit this difference did not reach statistical significance.

Moreover, all participants in the IG (100%, n=23) had consulted a dermatologist, compared to 68.2% of the CG (n=15) at 3-months follow-up ($P<.01$).

Regarding the treatment of OHE, potent topical steroids such as mometasone furoate were the most commonly prescribed treatments in both groups. It was prescribed to 87% (n=20) of the IG participants and 50% (n=11) of the CG participants. The IG had more participants prescribed tacrolimus (21.7% compared to 9.1% in the CG), and the CG had more participants prescribed very potent steroids (13.6% compared to 4.3% in the IG). When asked about self-assessed use of topical steroids, the IG participants tended to have used topical steroid treatment for a longer period of time within the last three months compared to the CG, but this difference did not reach statistical significance.

Finally, there was no difference in quality of life or occupational consequences between the two groups at the 3-month follow-up, with few occupational consequences being reported.

6. General Discussion

6.1 High-Risk Occupations

In study I, we evaluated 28 occupations, all classified as either exceedingly high-risk or high-risk for the development of OCD. Our findings align with existing research, both within Denmark and internationally, in identifying these occupations as significant contributors to OCD prevalence. Notably, Aalto-Korte et al.'s[102] Finnish study and a study conducted in Northern Bavaria on OCD between 1990 and 1999 both identified similar occupations as high-risk.[7] Furthermore, a previous Danish study from 2004 also highlighted similar occupations as key drivers of the high IRs of OCD in Denmark.[6] Thus, our findings confirm these occupations continue to represent high-risk areas for OCD in Denmark, emphasizing the importance of sustained and targeted preventive strategies.

6.1.1 Hairdressers

We observed a significant reduction in the IRs of OCD among hairdressers and beauticians, with rates declining approximately 35% between the two examined time periods (2007-2012 and 2013-2018). This decrease may largely be attributed to the preventive measures implemented in hairdressing schools in 2011, though a definitive causal relationship cannot be conclusively established from our data. This hypothesis is supported by Havmose et al.'s [82] study, which reported a parallel reduction in the career time prevalence of occupational HE, decreasing from 42.8% to 29.0%, for hairdressers educated before and after the implementation of the preventive measures.

Moreover, in study II, we found young hairdressers and beauticians to have a higher OR for job loss and decreased income due to OCD than the other examined occupations. Specifically, 65.4% of young hairdressers and beauticians reported job loss due to OCD, which aligns with earlier research, where 44.3% of hairdressers left their profession after an average of 8.4 years, with 45.5% citing eczema as the primary reason for their career change.[10]

Despite the positive development in IR, hairdressing and beauty care occupations continue to report the highest IRs of OCD. Furthermore, young workers with OCD, particularly in high-risk professions like hairdressing, face the risk of marginalization and unemployment, which has implications for society at large. Beyond the personal impact, the broader socioeconomic implications include the costs of retaining for a different occupation, lost productivity, and potential reliance on social security systems.

6.1.2 Windmill Manufacturers

Windmill manufacturers were found to have the fourth-highest IR in our dataset. OACD due to epoxy resins is a recognized hazard for this occupation.[103,104] A 2010 Danish study found that half of the patients with epoxy resin-induced OCD were employed in the windmill industry. [29] Regulatory measures implemented in 1985 mandated training on safety measures before working with epoxy resins. Nonetheless, a 2012 study revealed that only 50.5% of workers exposed to epoxy resins, who also tested positive for an epoxy resin allergy, had participated in an educational program.[75] This educational compliance deficit was highlighted in 2015-2016 when an epidemic of contact allergies to epoxy resins broke out, exposing flaws in safety compliance at several Danish windmill companies. Our findings showed a significant decrease in OCD rates among windmill manufacturers, approximately 41%, between the two studied periods, suggesting improved working conditions. However, a recent Danish study examining 180 windmill manufacturers found that, despite the use of skin protective measures, 8.9% of windmill manufacturers still became sensitized to an epoxy component, most of them within the first year of exposed employment.[105]

Considering these findings and the persistently high IRs found in our study, the need for increased preventive measures and stricter enforcement of safety regulations is apparent.

6.1.3 Workers in the Food Industry

Workers in the food industry, such as kitchen staff, bakers, pastry chefs, butchers and slaughterhouse workers, are typically exposed to high levels of wet work, making them vulnerable to the development of OCD. [45] The manifestation of OCD can have severe occupational consequences in this sector due to the strict sanitary requirements prohibiting work with broken skin. Both study II and previous research by Cvetkovski et al.[3] have shown that these workers have higher odds of experiencing prolonged sick leave and job loss due to OCD compared to other workers with OCD. Previous studies have also noted a lower rate of eczema clearance and long-term healing in these occupations, with butcher and kitchen personnel among the most severely affected.[106,107]

6.1.4 Child/Nursery Care Workers

Child/nursery care workers demonstrated the most substantial increase in OCD IRs, a 60% rise, between the two time periods. These workers have frequent exposure to wet work and irritant substances like soaps and cleaning agents, as well as exposure to wet wipes – many of which have been found to contain the preservative MI.[108] Following its approval as a stand-alone preservative in

cosmetics and household products in 2005, an increase in allergic reactions to MI was observed across Europe,[109] possibly also contributing to the elevated IRs among child/nursery care workers. In response to the rising trend of MI allergies, the European Union implemented restrictions on the use of MI in 2017, banning it in leave-on cosmetics and greatly reducing the allowed concentration in rinse-off products. These changes may help mitigate the rise in OCD IRs among child/nursery care workers. However, the factors causing the substantial increase observed in this study need further investigation.

6.2 Occupational Contact Dermatitis and Young People

In study I, we discovered that the median age at OCD notification for several of the examined occupations was in the early to mid-twenties. This underscores the fact that OCD often affects young individuals at the outset of their careers, and it is consistent with earlier findings that IRs of OCD are highest during the training period in high-risk occupations.[8,9] Moreover, we found a high prevalence of severe eczema in study III reported a median of six years after notification among young workers. A considerable proportion of these individuals also experience job loss or difficulties finding employment due to their OCD. This was particularly pronounced in workers who were ≤ 25 years at notification, who exhibited a higher OR for job loss and negative impacts on their career choices due to OCD. These findings underscore the necessity for heightened vigilance and prevention measures targeting young workers at risk of developing OCD.

6.3 The Socioeconomic Consequences of Occupational Contact Dermatitis

OCD was found to present a substantial economic burden for affected workers and society at large. Previous studies corroborate the significant economic repercussions of OCD. Meding et al.[27] found 32% of workers with OCD experienced deterioration in their personal economic situation, with 45% of these workers reporting a loss of income of 25% or more. Similarly, Mälkönen et al.[107] reported worsened economic conditions for 23% of OCD patients. These consistent findings of adverse economic impact of OCD underline the need for effective interventions and support to mitigate the socioeconomic costs of OCD.

6.4 Effect of Intervention

We found the self-assessed severity of OHE in the IG to be statistically significantly more reduced compared to the CG. Furthermore, the study findings suggest that the IG received more extensive

treatment by the 3-month follow-up point, with 100% having consulted a dermatologist, a higher prescription rate for local steroid treatment, and greater self-reported usage of local steroid treatment. These results indicate a positive effect of the intervention, possibly due to the immediate initiation of highly specialized diagnostics and treatment provided in the intervention setting. This aligns with prior research demonstrating that a delay in medical attention for HE is associated with a poorer prognosis.[110] German studies, although lacking a control group, also reported a significant reduction in OHE severity one month, one year and three years after intervention compared to baseline.[85,111,112]

These results underscore the potential value of immediate, specialized intervention in managing OHE.

7. Considerations on Methodology

7.1 Research on Data from the Danish Labour Market Insurance (Studies I, II and III)

7.1.1 Analysis of Data on Recognized Occupational Contact Dermatitis Cases (Studies I, II and III)

The analysis of recognized OCD cases inherently carries the risk of underestimation. This is largely attributed to the underdiagnosis and underreporting of OCD. Studies have found that merely 12% of HE cases among healthcare workers, and 20% among hairdressers are reported as occupational HE to the DLMI.[35,113] Furthermore, a multicenter study across 10 European dermatology departments found that 51.7% of all HE cases were occupational in nature.[56] Thus, this inherent underestimation is not unique to the present study but is a recognized limitation prevalent in OCD research that relies on data from insurance institutions like DLMI. Despite these limitations, there are currently no reliable alternatives for this type of research, and data from the DLMI and similar registries are generally considered high quality, providing an invaluable resource for OCD research. This suggests that the actual burden of OCD could be considerably higher than what the research carried out on recognized cases of OCD suggest.

Additionally, difficulties arise when attempting to compare studies examining the IRs of OCD in different countries, as there are differences with regard to the definition of the diagnoses, medical examination methods, recognition criteria, and the quality of the registries.[114]

7.1.2 The Danish Industry Code year 2007 classification (Study I)

The DB07 classification, primarily industry-based and used in the DLMI registry, has its limitations. Its primary concern is that it categorizes individuals based on their industry rather than their specific job functions. As a result, a person classified under “Cleaning personnel” might be performing administrative tasks within a cleaning company rather than cleaning itself. The challenge becomes particularly significant in categories like “Vocational schools” and “Retain sale of cars, vans, and minibuses”, where most individuals are likely students of craftsmanship or auto mechanics working in affiliated repair shops. Although administrative roles are less common and rarely associated with OCD, this categorization method could lead to conservative IRs. Despite these concerns, the DB07 code was selected for use in study I, as it remains the only available occupational indicator in the DLMI registry.

7.2 Incidence Rates (Study I)

In order to assess the development of OCD incidence, we chose to pool recognition numbers over two six-year periods rather than calculate annual IRs. Although annual rates could potentially provide a more detailed perspective of changing OCD patterns, they also increase susceptibility to variability in case-processing times at the DLMI, due to external factors not related to OCD.

7.2.1 Multiple Comparison Corrections

In study I, we conducted 28 statistical tests on a single dataset, a scenario that presents a risk of type I errors, or false positives. It is, therefore, important to consider appropriate methodologies for multiple comparison correction.

A common method for multiple comparison correction is the Bonferroni correction, which adjusts the alpha level based on the number of tests conducted.[115] For our dataset, this approach would require a p-value of $0.05/28 = 0.00179$ for a result to be considered statistically significant. While effective at minimizing the risk of type I errors, the Bonferroni correction is considered conservative, as it significantly reduces the likelihood of falsely identifying an effect where there is none at the cost of a higher risk of missing a true effect (type II errors, or false negatives).

Applying the Bonferroni correction to our results would mean only the occupations of hairdressers and beauticians, manufacturing of windmills, and child/nursery care workers would have shown a statistically significant change in IRs between the two time periods examined.

However, there are less conservative methods for multiple comparison correction, such as the Benjamini-Hochberg correction.[116] Accepting a false discovery rate of 5% with the Benjamini-Hochberg correction allows for a higher rate of false positives, with the trade-off being greater statistical power to detect true effects. When applied to our data, we found that we could reject the null hypothesis for all tests with p-values ≤ 0.025, meaning that the change in IRs over the two time periods was statistically significant for hairdressers and beauticians, manufacturing of windmills, child/nursery care workers, production of plastic, bakers, postal workers, metalworkers other than machining, and hotel workers, as reported in manuscript I and the result section of this thesis. 7.4 The questionnaire study (Study II)

The achieved response rate of 47% in study II, while not exceptionally high, is acceptable. We detected no significant differences between the responders and non-responders, leading us to consider it unlikely that the associations found in the study were influenced by selection bias.

The questionnaire comprised a substantial 263 questions. In hindsight, a more concise questionnaire might have been beneficial in improving the response rate.

A potential limitation of study II is recall bias, a common issue in retrospective questionnaire studies. Participants were asked to remember and report events from several years prior, which could have led to inaccuracies due to faded or distorted memories.

7.3 Socioeconomic Calculations using the Danish Register for Evaluation of Marginalization Database (Study III)

7.3.1 Paid Long-Term Sick Leave

Using the DREAM database to estimate the socioeconomic consequences of OCD poses several challenges, particularly regarding the assessment of sick leave. Only paid long-term sick leave is recorded in this database, with workers only becoming eligible after an extended period of sickness absence covered by their employer. A Danish report indicated that long-term sickness absence (> 30 days) only accounts for 39% of the total sickness absence in Denmark.[117] This suggests that the majority of sick leaves are shorter than 30 days and thus remain unregistered in the DREAM database.

Additionally, the period of sickness absence required to qualify for paid long-term sick leave varies with differing legal reforms on the subject. This variability complicates comparisons of sick leave across different time periods, as attempted in study III. Moreover, the DREAM database does not record the specific reason for paid long-term sick leave, which may not always be related to OCD.

To capture a more comprehensive picture of sick leave, an alternative methodology is required, as a substantial portion of sick leave goes unnoticed in the current approach. Previous studies highlight high levels of sick leave due to OCD. For instance, a German study found that sickness absence was recorded for 62.9% of workers with OCD, with an average absence of 76.4 days.[118] Furthermore, Meding et al.[27] found that 48% of workers with occupational skin disease had been on sick leave for at least one period of 7 days due to their occupational skin disease during a 12-year follow-up period. Additionally, a Danish study reported that 19.9% of workers with recognized OCD had prolonged sick leave of >5 weeks per year due to OCD.[3]

Despite these limitations, the DREAM database offers an advantage as it is not prone to recall bias, unlike questionnaire-based data. This advantage, however, does not entirely compensate for the

underestimation of sick leave due to OCD, a concern that is substantiated by several studies suggesting high levels of sick leave due to OCD.

7.3.2 Methodology in Study III

In study III, we analyzed the extent of different social transfer payments and degree of employment two years before and after OCD notification. Given previous reports that the average delay from OCD onset to notification to the DLMI is around 4.5 years (median 2 years),[6] it is reasonable to infer that OCD might have affected the degree of employment not only in the two years following notification, but also in the two years prior. Consequently, the calculated decrease in degree of employment and increase in social transfer payments between these two time periods are likely an underestimation of OCD's true impact.

While a decline in degree of employment could naturally occur with age, such changes are unlikely to significantly affect the results within the relatively short time span of a four-year period.

To gain a comprehensive understanding of the true economic burden of OCD, additional costs such as medical treatment (medications, doctor consultations, and hospital visits), absenteeism, and presenteeism should be taken into account in cost-of-illness calculations. According to a systematic review, [119] sickness absenteeism is a significant contributor to the total costs of HE. Interestingly, a Dutch study from 2017,[120] reported a one-year prevalence of absenteeism of 41% in HE patients, indicating a high and often overlooked contribution of the facet of economic costs of OCD.

To facilitate such comprehensive calculations, additional data, potentially obtained through questionnaires, would be necessary to inform these multiple dimensions of costs.

7.4 Methodology in Study IV

7.4.1 Loss of Power Due to Recruitment Challenges

Our study faced recruitment challenges, impacting the statistical power of the results. These issues included technical difficulties with the Danish national referral database, several national lockdowns due to the COVID-19 pandemic, and a nursing strike, all of which affected the flow of patients. Additionally, the legislative requirement to secure permission from the referring general practitioner prior to contacting patients further hindered the recruitment process, leading to an inability to reach the desired sample size. Consequently, future studies with larger cohorts are needed to provide more robust results.

7.4.2 Length of the Follow-Up Period

Reflecting on our study design, a more extended follow-up period would have been beneficial. While we followed up on participants through questionnaires for one year, the active treatment phase for the IG, which included consultations with dermatologists, was confined to the initial three months. A longer active treatment duration, such as a year of regular consultations with dermatologists, would have made the intervention more akin to the comprehensive German TIP approach. This might lead to better outcomes for the IG. Future studies should consider extending the duration of the active treatment phase to enhance the effectiveness of the intervention.

7.4.3 Per-Protocol Analysis and Risk of Bias

In study IV, a per-protocol analysis was employed due to the study's relatively small sample size and challenges in participant adherence and data completion. While this approach has the advantage of providing a more precise estimate of the intervention's effect among adherent participants, it also carries the risk of bias. Specifically, per-protocol analysis can introduce attrition bias since participants who complete the study may systematically differ from those who do not, which can bias the estimated intervention effect.

To mitigate potential bias, an attrition analysis was conducted to identify systematic differences between the retained participants and the dropouts. This analysis revealed a significant difference in disease duration, which was shorter among dropouts. Given that shorter disease duration is associated with a better prognosis,[110] this difference could lead to an underestimation of the intervention's effect.

Even though intention-to-treat analysis is often preferred to maintain the benefits of randomization and reduce the risk of confounding bias, it might introduce a dilution bias or bias towards the null in situations with significant non-adherence to the protocol. In this specific context, considering the potential biases and the nature of our data and study protocol, a per-protocol analysis was deemed the most suitable approach.[121]

8. Conclusions

The research on OCD conducted in this thesis confirms its pervasiveness, poor prognosis and the significant negative impact it has on the occupational and economic situations of afflicted workers, leading to subsequent substantial costs for society.

Specific professions, such as hairdressers and beauticians, cleaning personnel, food industry workers, and metal workers, continue to have the highest IRs in Denmark, underscoring the need for intensified primary preventive measures in the known at-risk occupations.

We observed a low median age at OCD notification across several occupations, which aligns with previous studies suggesting that OCD particularly affects young people during training or at the outset of their careers. This finding emphasizes the need for a national action plan focused on preventive efforts, particularly during professional training in at-risk occupations.

A notable example of such a preventive strategy is evident in the hairdressing field. We found a significant reduction of approximately 35% in the IR of OCD among hairdressers and beauticians, which is likely attributable to the implementation of an educational program on skin protective behavior implemented nationwide in hairdressing schools in 2011. The success of this initiative suggests that integrating similar educational programs and safety training into the professional training curriculum of other high-risk sectors could be a promising avenue for reducing the prevalence of OCD among workers.

A significant increase of around 60% in the IR of OCD among child/nursery care workers was detected. However, the exact factors causing this increase are unknown and need further investigation.

We found that the degree of employment falls, while the unemployment and sick leave rises after notification of OCD. We also noted that the duration of the case-processing time is associated with worsened outcomes for the worker, indicating a need to lower the case-processing time, most likely achievable through expedited diagnostics and treatment.

The severe, long-term consequences of OCD, found a median of 6 years after notification among young workers, underline the necessity of secondary and tertiary preventive efforts to mitigate the effects of OCD. Rapid detection of OCD cases and swift initiation of diagnostics and treatment are

warranted, especially in known at-risk occupations, along with improved follow-up for workers diagnosed with OCD.

Lastly, we tested an intervention inspired by the German TIP approach and observed significant improvement in severity of eczema at 3-months follow-up, possibly due to the effect of early intervention and treatment, proposing a possible action plan for secondary/tertiary prevention in Denmark.

9. Future Perspectives

9.1 Future Research

Continuous surveillance of IRs of OCD is necessary in order to evaluate implemented preventive strategies and to identify emerging high-risk occupations.

The prevention strategy developed and tested in study IV of this PhD needs further exploration in a larger study with a substantially larger study population in order to add robustness to the findings.

Future studies should include a cost-of-illness analysis of OCD. Cost-of-illness calculations for OCD are essential for suggesting and implementing informed changes in its management. These calculations, encompassing both the direct costs of treatment and healthcare services, and the indirect costs associated with productivity loss due to illness, would serve to illustrate the true socioeconomic burden of OCD.

The majority of studies examining OCD rely on data from recognized cases, posing a risk for the underestimation of the prevalence and incidence of OCD. Establishing a prospective cohort of young adults attending vocational schools could add valuable insight into the true prevalence and incidence of OCD. A follow-up after 3-5 years with both dermatological assessment and questionnaire could help give a more comprehensive picture of the causative reasons and consequences of OCD among young workers.

Furthermore, it could be beneficial to associate this proposed cohort study with the development and testing of an educational program similar to the one implemented in Danish hairdressing schools. However, the program would need to be tailored to occupations relevant to the vocational schools. This would enable an intervention study design, with other vocational schools potentially acting as controls.

In the field of dermatological research, much future potential lies in identifying biomarkers to distinguish between irritant and allergic contact dermatitis. This research could also be highly beneficial in the field of OCD, as there is a possibility for cases of OACD to go undiagnosed and be falsely classified as OICD. This misclassification would potentially complicate treatment, given that allergen avoidance is the primary treatment strategy for OACD.

Furthermore, attention should be given to the legislative constraints faced by researchers in Denmark. In study IV, we experienced the challenges of the Danish law, which stipulates that

before a researcher can contact a patient using obtained health-related personal data, permission must first be secured from the patient's treating physician. This requirement, intended to protect patient privacy, added a layer of complexity to the recruitment process and contributed to our inability to reach the desired sample size. It is essential that future legislative considerations balance the need for patient privacy with the efficient facilitation of health research. A reconsideration of this legislative aspect could enhance the feasibility and efficiency of similar future research efforts.

9.2 Future Prevention Strategies

The research on OCD presented in this thesis suggests several directions for future interventions. Given the particularly high IRs of OCD in specific at-risk profession, targeted preventive efforts at the known at risk-occupations is warranted.

9.2.1 Suggestions for Primary Prevention

Increased guidance of individuals with AD, a known risk factor for the development of OCD, is recommended. This could include information about the risk of OCD in certain professions, along with advice on precautionary measures if they should choose a high-risk occupation.

The introduction of preventive educational programs at an earlier age, perhaps in the 8th or 9th grade of elementary schools as part of the curriculum, could be beneficial. Many individuals start their first part-time job around the ages of 16-18, often in skin-hazardous occupations; why early education about skin protective behavior, awareness of irritants and allergens in the workplace and appropriate glove use could aid in preventing the development of OCD. It could be argued that it is our societal responsibility to protect the young workforce, who may not always be aware of the long-term consequences of their chosen work.

Implementation of education programs in vocational schools, drawing inspiration from the educational program implemented in hairdressing schools, could be effective.

9.2.2 Suggestions for Secondary Prevention

Information campaigns about OCD in high-risk occupations could increase awareness of the disease and maybe urge affected individuals to seek medical help earlier in their disease course.

Furthermore, adopting a rapid, specialized response to suspected OCD, similar to the practices in Germany, could be valuable. Our intervention study demonstrated a positive impact after three months, and other studies have shown a long-term impact on the prognosis of HE based on the speed of initiating treatment,[110] which could help prevent the condition from becoming chronic.

Consideration could be given to enabling direct referrals from general practitioners to specialized hospital units with expertise in OCD.

9.2.3 Suggestions for Tertiary Prevention

It is necessary to increase efforts to prevent the consequences of OCD and enhance the follow-up of patients with OCD, such as monitoring of workers with recognized OCD, perhaps one, two and three years after recognition. This approach would aim at alleviating the severity of long-term eczema, thereby mitigating its impact on quality of life and occupational status.

9. References

1. Arbejdsmarkedets Erhvervssikring. *Arbejdsskadestatistik 2022*.; 2022.

2. Adisesh A, Meyer JD, Cherry NM. Prognosis and work absence due to occupational contact dermatitis. Outcome of cases reported to EPIDERM. *Contact Dermatitis*. 2002;46(5):273-279. doi:10.1034/j.1600-0536.2002.460505.x

3. Cvetkovski RS, Rothman KJ, Olsen J, et al. Relation between diagnoses on severity, sick leave and loss of job among patients with occupational hand eczema. *British Journal of Dermatology*. 2005;152(1):93-98. doi:10.1111/j.1365-2133.2005.06415.x

4. Hutchings C V, Shum KW, Gawkrodger DJ. Occupational contact dermatitis has an appreciable impact on quality of life. *Contact Dermatitis*. 2001;45:17-20.

5. Cvetkovski RS, Zachariae R, Jensen H, Olsen J, Johansen JD, Agner T. Quality of life and depression in a population of occupational hand eczema patients. *Contact Dermatitis*. 2006;54(2):106-111. doi:10.1111/j.0105-1873.2006.00783.x

6. Skoet R, Olsen J, Mathiesen B, Iversen L, Johansen JD, Agner T. A survey of occupational hand eczema in Denmark. *Contact Dermatitis*. 2004;51(4):159-166. doi:10.1111/j.0105-1873.2004.00423.x

7. Dickel H, Kuss O, Blesius CR, Schmidt A, Diepgen TL. *Occupational Skin Diseases in Northern Bavaria between 1990 and 1999: A Population-Based Study*. Vol 145.; 2001.

8. Uter W, Pfahlberg A, Gefeller O, Schwanitz HJ. Prevalence and incidence of hand dermatitis in hairdressing apprentices: results of the POSH study. Prevention of occupational skin disease in hairdressers. *Int Arch Occup Environ Health*. 1998;71(7):487-492.

9. Bauer A, Bartsch R, Hersmann C, et al. Occupational hand dermatitis in food industry apprentices: Results of a 3-year follow-up cohort study. *Int Arch Occup Environ Health*. 2001;74(6):437-442. doi:10.1007/s004200100241

10. Lysdal SH, Søsted H, Andersen KE, Johansen JD. Hand eczema in hairdressers: A Danish register-based study of the prevalence of hand eczema and its career consequences. *Contact Dermatitis*. 2011;65(3):151-158. doi:10.1111/j.1600-0536.2011.01935.x

11. Havmose M, Thyssen JP, Zachariae C, Uter W, Johansen JD. Occupational hand eczema reduces career length in hairdressers: a prospective cohort study of Danish hairdressers graduating from 1985 to 2007. *Occup Environ Med*. 2022;79(10):649-655. doi:10.1136/oemed-2022-108230

12. Foss-Skiftesvik MH, Winther L, Johnsen CR, Zachariae C, Johansen JD. Incidence of skin and respiratory diseases among Danish hairdressing apprentices. *Contact Dermatitis*. 2017;76(3):160-166. doi:10.1111/cod.12744

13. Johansen JD, Hald M, Andersen BL, et al. Classification of hand eczema: clinical and aetiological types. Based on the guideline of the Danish Contact Dermatitis Group. *Contact Dermatitis*. 2011;65(1):13-21. doi:10.1111/j.1600-0536.2011.01911.x

14. Johansen JD, Bonefeld CM, Schwensen JFB, Thyssen JP, Uter W. Novel insights into contact dermatitis. *Journal of Allergy and Clinical Immunology*. 2022;149(4):1162-1171. doi:10.1016/j.jaci.2022.02.002

15. Pesonen M, Koskela K, Aalto-Korte K. Contact urticaria and protein contact dermatitis in the Finnish Register of Occupational Diseases in a period of 12 years. *Contact Dermatitis*. 2020;83(1):1-7. doi:10.1111/cod.13547

16. Patel V, Atwater AR, Reeder M. Contact dermatitis of the hands: Is it irritant or allergic? *Cutis*. 2021;107(3):129-132. doi:10.12788/cutis.0204

17. Weidinger S, Novak N. Atopic dermatitis. *The Lancet*. 2016;387(10023):1109-1122. doi:10.1016/S0140-6736(15)00149-X

18. Mortz CG, Andersen KE, Dellgren C, Barington T, Bindslev-Jensen C. Atopic dermatitis from adolescence to adulthood in the TOACS cohort: Prevalence, persistence and comorbidities. *Allergy: European Journal of Allergy and Clinical Immunology*. 2015;70(7):836-845. doi:10.1111/all.12619

19. Bylund S, Von Kobyletzki LB, Svalstedt M, Svensson Å. Prevalence and incidence of atopic dermatitis: A systematic review. *Acta Derm Venereol*. 2020;100(100-year theme Atopic dermatitis):320-329. doi:10.2340/00015555-3510

20. Weidinger S, Illig T, Baurecht H, et al. Loss-of-function variations within the filaggrin gene predispose for atopic dermatitis with allergic sensitizations. *Journal of Allergy and Clinical Immunology*. 2006;118(1):214-219. doi:10.1016/j.jaci.2006.05.004

21. Jungersted JM, Scheer H, Mempel M, et al. Stratum corneum lipids, skin barrier function and filaggrin mutations in patients with atopic eczema. *Allergy: European Journal of Allergy and Clinical Immunology*. 2010;65(7):911-918. doi:10.1111/j.1398-9995.2010.02326.x

22. Bjerre RD, Bandier J, Skov L, Engstrand L, Johansen JD. The role of the skin microbiome in atopic dermatitis: a systematic review. *Br J Dermatol*. 2017;177(5):1272-1278. doi:10.1111/bjd.15390

23. Brunner PM, Guttman-Yassky E, Leung DYM. The immunology of atopic dermatitis and its reversibility with broad-spectrum and targeted therapies. *Journal of Allergy and Clinical Immunology*. 2017;139(4):S65-S76. doi:10.1016/j.jaci.2017.01.011

24. Mortz CG, Bindslev-Jensen C, Andersen KE. Hand eczema in The Odense Adolescence Cohort Study on Atopic Diseases and Dermatitis (TOACS): prevalence, incidence and risk factors from adolescence to adulthood. *Br J Dermatol*. 2014;171(2):313-323. doi:10.1111/bjd.12963

25. Meding B, Swanbeck G. Predictive factors for hand eczema. *Contact Dermatitis*. 1990;23(3):154-161. doi:10.1111/j.1600-0536.1990.tb04776.x

26. Coenraads PJ, Diepgen TL. Risk for hand eczema in employees with past or present atopic dermatitis. *Int Arch Occup Environ Health*. 1998;71(1):7-13. doi:10.1007/s004200050243

27. Meding B, Lantto R, Lindahl G, Wrangsjö K, Bengtsson B. Occupational skin disease in Sweden - A 12-year follow-up. *Contact Dermatitis*. 2005;53(6):308-313. doi:10.1111/j.0105-1873.2005.00731.x

28. Friis UF, Menné T, Schwensen JF, Flyvholm MA, Bonde JPE, Johansen JD. Occupational irritant contact dermatitis diagnosed by analysis of contact irritants and allergens in the work environment. *Contact Dermatitis*. 2014;71(6):364-370. doi:10.1111/cod.12290

29. Carøe TK, Ebbehøj N, Agner T. A survey of exposures related to recognized occupational contact dermatitis in Denmark in 2010. *Contact Dermatitis*. 2014;70(1):56-62. doi:10.1111/cod.12134

30. Dickel H, Bruckner T, Bernhard-Klimt C, Koch T, Scheidt R, Diepgen TL. Surveillance scheme for occupational skin disease in the Saarland, FRG First report from BKH-S. *Contact Dermatitis*. 2002;46:197-206.

31. Jacobsen G, Rasmussen K, Bregnhøj A, Isaksson M, Diepgen TL, Carstensen O. Causes of irritant contact dermatitis after occupational skin exposure: a systematic review. *Int Arch Occup Environ Health*. 2022;95(1):35-65. doi:10.1007/s00420-021-01781-0

32. Behroozy A, Keegel TG. Wet-work exposure: A main risk factor for occupational hand dermatitis. *Saf Health Work*. 2014;5(4):175-180. doi:10.1016/j.shaw.2014.08.001

33. Jungbauer FHW, Lensen GJ, Groothoff JW, Coenraads PJ. Exposure of the hands to wet work in nurses. *Contact Dermatitis*. 2004;50(4):225-229. doi:10.1111/j.0105-1873.2004.0314.x

34. Aalto-Korte K, Koskela K, Pesonen M. 12-year data on dermatologic cases in the Finnish Register of Occupational Diseases I: Distribution of different diagnoses and main causes of allergic contact dermatitis. *Contact Dermatitis*. 2020;82(6):337-342. doi:10.1111/cod.13488

35. Ibler KS, Jemec GBE, Flyvholm MA, Diepgen TL, Jensen A, Agner T. Hand eczema: Prevalence and risk factors of hand eczema in a population of 2274 healthcare workers. *Contact Dermatitis*. 2012;67(4):200-207. doi:10.1111/j.1600-0536.2012.02105.x

36. Smit HA, Rijssen A Van, Vandenbroucke JP, Coenraads PJ. Susceptibility to and incidence of hand dermatitis in a cohort of apprentice hairdressers and nurses. *Scand J Work Environ Health*. 1994;20(2):113-121.

37. Lysdal SH, Johansen JD, Flyvholm MA, Søsted H. A quantification of occupational skin exposures and the use of protective gloves among hairdressers in Denmark. *Contact Dermatitis*. 2012;(11):no-no. doi:10.1111/j.1600-0536.2011.02050.x

38. Søsted H, Rustemeyer T, Gonçalo M, et al. Contact allergy to common ingredients in hair dyes. *Contact Dermatitis*. 2013;69(1):32-39. doi:10.1111/cod.12077

39. Schwensen JF, Johansen JD, Veien NK, et al. Occupational contact dermatitis in hairdressers: An analysis of patch test data from the Danish Contact Dermatitis Group, 2002-2011. *Contact Dermatitis*. 2014;70(4):233-237. doi:10.1111/cod.12176

40. Uter W, Hallmann S, Gefeller O, et al. Contact allergy to ingredients of hair cosmetics in female hairdressers and female consumers—An update based on IVDK data 2013–2020. *Contact Dermatitis*. Published online 2023. doi:10.1111/cod.14363

41. Pesonen M, Koskela K, Aalto-Korte K. Hairdressers' occupational skin diseases in the Finnish Register of Occupational Diseases in a period of 14 years. *Contact Dermatitis*. 2021;84(4):236-239. doi:10.1111/cod.13732

42. Warshaw EM, Wang MZ, Mathias T, et al. Occupational contact dermatitis in hairdressers/ cosmetologists: Retrospective analysis of North American contact dermatitis group data, 1994 to 2010. *Dermatitis*. 2012;23(6):258-268. doi:10.1097/DER.0b013e318273a3b8

43. Gonçalo M, Pinho A, Agner T, et al. Allergic contact dermatitis caused by nail acrylates in Europe. An EECDRG study. *Contact Dermatitis*. 2018;78(4):254-260. doi:10.1111/cod.12942

44. Havmose M, Thyssen JP, Zachariae C, Johansen JD. Use of protective gloves by hairdressers: A review of efficacy and potential adverse effects. *Contact Dermatitis*. 2020;83(2):75-82. doi:10.1111/cod.13561

45. Meding B, Anveden Berglind I, Alderling M, Lindahl G, Wrangsjö K. Water exposure - Challenging differences between occupations. *Contact Dermatitis*. 2016;74(1):22-28. doi:10.1111/cod.12479

46. Flyvholm MA, Mygind K, Sell L, Jensen A, Jepsen KF. A randomised controlled intervention study on prevention of work related skin problems among gut cleaners in swine slaughterhouses. *Occup Environ Med*. 2005;62(9):642-649. doi:10.1136/oem.2004.016576

47. Barbaud A, Poreaux C, Penven E, Waton J. Occupational protein contact dermatitis. *European Journal of Dermatology*. 2015;25(6):527-534. doi:10.1684/ejd.2015.2593

48. Bauer A. Contact dermatitis in the cleaning industry. *Curr Opin Allergy Clin Immunol*. 2013;13(5):521-524. doi:10.1097/ACI.0b013e328364ec21

49. Sedeh FB, Michaelsdóttir TE, Christiensen KB, Mortensen OS, Jemec GBE, Ibler KS. Prevalence and risk factors for hand eczema among professional hospital cleaners in Denmark: A cross-sectional questionnaire-based study. *Contact Dermatitis*. Published online July 12, 2023. doi:10.1111/cod.14379

50. Magnano M, Silvani S, Vincenzi C, Nino M, Tosti A. Contact allergens and irritants in household washing and cleaning products. *Contact Dermatitis*. 2009;61(6):337-341. doi:10.1111/j.1600-0536.2009.01647.x

51. Ibler KS, Jemec GBE, Agner T. Exposures related to hand eczema: A study of healthcare workers. *Contact Dermatitis*. 2012;66(5):247-253. doi:10.1111/j.1600-0536.2011.02027.x

52. Schwensen JF, Menné T, Sommerlund M, et al. Contact allergy in danish healthcare workers: A retrospective matched case-control study. *Acta Derm Venereol*. 2016;96(2):237-240. doi:10.2340/00015555-2202

53. Warshaw EM, Hagen SL, Sasseville D, et al. Occupational Contact Dermatitis in Mechanics and Repairers Referred for Patch Testing: Retrospective Analysis from the North American Contact Dermatitis Group 1998-2014. *Dermatitis*. 2017;28(1):47-57. doi:10.1097/DER.0000000000000231

54. Kütting B, Weistenhöfer W, Baumeister T, Uter W, Drexler H. Current acceptance and implementation of preventive strategies for occupational hand eczema in 1355 metalworkers in Germany. *British Journal of Dermatology*. 2009;161(2):390-396. doi:10.1111/j.1365-2133.2009.09085.x

55. Havmose M, Thyssen JP, Zachariae C, Johansen JD. Long-term follow-up of hand eczema in hairdressers: a prospective cohort study of Danish hairdressers graduating from 1985 to 2007. *Journal of the European Academy of Dermatology and Venereology*. 2022;36(2):263-270. doi:10.1111/jdv.17794

56. Agner T, Andersen KE, Brandao FM, et al. Hand eczema severity and quality of life: A cross-sectional, multicentre study of hand eczema patients. *Contact Dermatitis*. 2008;59(1):43-47. doi:10.1111/j.1600-0536.2008.01362.x

57. Thyssen JP, Schuttelaar MLA, Alfonso JH, et al. Guidelines for diagnosis, prevention, and treatment of hand eczema. *Contact Dermatitis*. 2022;86(5):357-378. doi:10.1111/cod.14035

58. Johansen JD, Aalto-Korte K, Agner T, et al. European Society of Contact Dermatitis guideline for diagnostic patch testing - Recommendations on best practice. *Contact Dermatitis*. 2015;73(4):195-221. doi:10.1111/cod.12432

59. Cronin E. Clinical prediction of patch test results. *Trans St Johns Hosp Dermatol Soc*. 1972;58(2):153-162.

60. Podmore P, Burrows D, Bingham EA. Prediction of patch test results. *Contact Dermatitis*. 1984;11(5):283-284. doi:10.1111/j.1600-0536.1984.tb01010.x

61. Bruynzeel DP, Andersen KE, Camarasa JG, Lachapelle J -M, Menné T, White IR. The European standard series. *Contact Dermatitis*. 1995;33(3):145-148. doi:10.1111/j.1600-0536.1995.tb00534.x

62. Wilkinson SM, Badulici S, Giménez-Arnau A, et al. The European baseline series: Criteria for allergen inclusion with reference to formaldehyde releasers. *Contact Dermatitis*. 2021;85(2):125-128. doi:10.1111/cod.13836

63. Ansotegui IJ, Melioli G, Canonica GW, et al. IgE allergy diagnostics and other relevant tests in allergy, a World Allergy Organization position paper. *World Allergy Organization Journal*. 2020;13(2). doi:10.1016/j.waojou.2019.100080

64. Christoffers WA, Coenraads PJ, Svensson Å, et al. Interventions for hand eczema. *Cochrane Database of Systematic Reviews*. 2019;2019(4). doi:10.1002/14651858.CD004055.pub2

65. Oosterhaven JAF, Voorberg AN, Romeijn GLE, de Bruin-Weller MS, Schuttelaar MLA. Effect of dupilumab on hand eczema in patients with atopic dermatitis: An observational study. *Journal of Dermatology*. 2019;46(8):680-685. doi:10.1111/1346-8138.14982

66. Voorberg AN, Romeijn GLE, de Bruin-Weller MS, Schuttelaar MLA. The long-term effect of dupilumab on chronic hand eczema in patients with moderate to severe atopic dermatitis—52 week results from the Dutch BioDay Registry. *Contact Dermatitis*. 2022;87(2):185-191. doi:10.1111/cod.14104

67. Worm M, Bauer A, Elsner P, Mahler V, Molin S, Nielsen TSS. Efficacy and safety of topical delgocitinib in patients with chronic hand eczema: data from a randomized, double-blind, vehicle-controlled phase IIa study. *British Journal of Dermatology*. 2020;182(5):1103-1110. doi:10.1111/bjd.18469

68. Worm M, Thyssen JP, Schliemann S, et al. The pan-JAK inhibitor delgocitinib in a cream formulation demonstrates dose response in chronic hand eczema in a 16-week randomized phase IIb trial*. *British Journal of Dermatology*. 2022;187(1):42-51. doi:10.1111/bjd.21037

69. Arbejdsmarkedets Erhvervssikring. Arbejdsskadestatistik 2016.

70. Avnstorp C. Prevalence of cement eczema in Denmark before and since addition of ferrous sulfate to Danish cement. *Acta Derm Venereol*. 1989;69(2):151-155. doi:10.2340/0001555569151155

71. Lejding T, Persson L, Andersen KE, et al. Analysis of Hexavalent Chromium in Cement Samples From Countries Within and Outside the EU: A Study From the International Contact Dermatitis Research Group. *Dermatitis®*. Published online March 31, 2023. doi:10.1089/derm.2022.0053

72. Zachariae COC, Agner T, Menné T. Chromium allergy in consecutive patients in a country where ferrous sulfate has been added to cement since 1981. *Contact Dermatitis*. 1996;35(2):83-85. doi:10.1111/j.1600-0536.1996.tb02295.x

73. Stocks SJ, McNamee R, Turner S, Carder M, Agius RM. Has European Union legislation to reduce exposure to chromate in cement been effective in reducing the incidence of allergic contact dermatitis attributed to chromate in the UK? *Occup Environ Med*. 2012;69(2):150-152. doi:10.1136/oemed-2011-100220

74. Beskæftigelsesministeriet. *BEK Nr 199 Af 26/03/1985 - Bekendtgørelse Om Epoxyharpikser Og Isocyanater m.v.*; 1985.

75. Bangsgaard N, Thyssen JP, Menné T, et al. Contact allergy to epoxy resin: Risk occupations and consequences. *Contact Dermatitis*. 2012;67(2):73-77. doi:10.1111/j.1600-0536.2012.02072.x

76. Held E, Mygind K, Wolff C, Gyntelberg F, Agner T. Prevention of work related skin problems: An intervention study in wet work employees. *Occup Environ Med*. 2002;59(8):556-561. doi:10.1136/oem.59.8.556

77. Held E, Wolff C, Gyntelberg F, Agner T. Prevention of work-related skin problems in student auxiliary nurses: An intervention study. *Contact Dermatitis*. 2001;44(5):297-303. doi:10.1034/j.1600-0536.2001.440509.x

78. Sell L, Flyvholm MA, Lindhard G, Mygind K. Implementation of an occupational skin disease prevention programme in Danish cheese dairies. *Contact Dermatitis*. 2005;53(3):155-161. doi:10.1111/j.0105-1873.2005.00674.x

79. Ibler KS, Jemec GBE, Diepgen TL, et al. Skin care education and individual counselling versus treatment as usual in healthcare workers with hand eczema: Randomised clinical trial. *BMJ (Online)*. 2012;345(7887). doi:10.1136/bmj.e7822

80. Bregnhøj A, Menné T, Johansen JD, Søsted H. Prevention of hand eczema among Danish hairdressing apprentices: An intervention study. *Occup Environ Med*. 2012;69(5):310-316. doi:10.1136/oemed-2011-100294

81. Børne- og Undervisningsministeriet. *BEK Nr 1634 Af 15/12/2915 Bekendtgørelse Om Erhvervsuddannelsen Til Frisør*.; 2015.

82. Havmose M, Uter W, Gefeller O, et al. A nationwide skin protection program introduced in hairdressing vocational schools was followed by a decreased risk of occupational hand eczema. *Contact Dermatitis*. 2022;87(6):511-520. doi:10.1111/cod.14207

83. Sundhedsstyrelsen. *Forebyggelse Af Kontakteksemer*. 1st ed.; 1998.

84. Arbejdsmarkedets Erhvervssikring. Arbejdsskadestatistik 2019. Published online 2019.

85. Brans R, Skudlik C, Weisshaar E, et al. Multicentre cohort study 'Rehabilitation of Occupational Skin Diseases – Optimization and Quality Assurance of Inpatient Management (ROQ)': results from a 3-year follow-up. *Contact Dermatitis*. 2016;75(4):205-212. doi:10.1111/cod.12614

86. Skudlik C, Weisshaar E, Scheidt R, et al. Multicenter study „Medical-Occupational Rehabilitation Procedure Skin - optimizing and quality assurance of inpatient-management (ROQ)". *Journal der Deutschen Dermatologischen Gesellschaft*. 2009;7(2):122-126. doi:10.1111/j.1610-0387.2008.06864.x

87. Ahlström MG, Dietz JB, Wilke A, Johansen JD, John SM, Brans R. Evaluation of the secondary and tertiary prevention strategies against occupational contact dermatitis in Germany: A systematic review. *Contact Dermatitis*. 2022;87(2):142-153. doi:10.1111/cod.14099

88. Wilfinger D, Kummer M, Aberer W, Takacs S, Galli-Novak E. BK-19 new - Establishment of a successful prevention model in Austria for occupational skin diseases. *Dermatologie in Beruf und Umwelt*. 2018;66(3):135-139. doi:10.5414/DBX00326E

89. Statistics Denmark. *Statistikdokumentation for Dagpenge Ved Sygdom Eller Fødsel Mv . 2019*.; 2019.

90. Susitaival P, Flyvholm MA, Meding B, et al. Nordic Occupational Skin Questionnaire (NOSQ-2002): A new tool for surveying occupational skin diseases and exposure. *Contact Dermatitis*. 2003;49(2):70-76. doi:10.1111/j.0105-1873.2003.00159.x

91. Hald M, Berg ND, Elberling J, Johansen JD. Medical consultations in relation to severity of hand eczema in the general population. *British Journal of Dermatology*. 2008;158(4):773-777. doi:10.1111/j.1365-2133.2007.08431.x

92. Coenraads PJ, Van Der Walle H, Thestrup-Pedersen K, et al. Construction and validation of a photographic guide for assessing severity of chronic hand dermatitis. *British Journal of Dermatology*. 2005;152(2):296-301. doi:10.1111/j.1365-2133.2004.06270.x

93. Silverberg JI, Patel N, Immaneni S, et al. Assessment of atopic dermatitis using self-report and caregiver report: a multicentre validation study. *British Journal of Dermatology*. 2015;173(6):1400-1404. doi:10.1111/bjd.14031

94. Finlay AY, Khan GK. Dermatology Life Quality Index (DLQI)—a simple practical measure for routine clinical use. *Clin Exp Dermatol*. 1994;19(3):210-216. doi:10.1111/j.1365-2230.1994.tb01167.x

95. Chren M, Lasek RJ, Flocke SA, Zyzanski SJ. Improved Discriminative and Evaluative Capability of a Refined Version of Skindex, a Quality-of-Life Instrument for Patients With Skin Diseases. *Arch Dermatol*. 1997;133(11):1433-1440.

96. Janssen MF, Pickard AS, Golicki D, et al. Measurement properties of the EQ-5D-5L compared to the EQ-5D-3L across eight patient groups: A multi-country study. *Quality of Life Research*. 2013;22(7):1717-1727. doi:10.1007/s11136-012-0322-4

97. Nijsten T, Sampogna F, Abeni D. Categorization of Skindex-29 scores using mixture analysis. *Dermatology*. 2009;218(2):151-154. doi:10.1159/000182253

98. Dietz JB, Flyvholm M, Menné T, et al. *En Sammenligning Mellem Dansk Og Tysk Arbejdsskadesystem Med Fokus På Håndeksem*.; 2018. https://www.videncenterforallergi.dk/wp-content/uploads/files/rapporter/Rapport-finalfeb2018-

En_sammenligning_mellem_dansk_og_tysk_arbejdsskadesystem_med_fokus_på_håndeksem.pdf

99. *LBK Nr 191 Af 28/02/2018 Bekendtgørelse Af Sundhedsloven*.

100. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform*. 2019;95. doi:10.1016/j.jbi.2019.103208

101. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap) – A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377-381.

102. Aalto-Korte K, Koskela K, Pesonen M. Allergic contact dermatitis and other occupational skin diseases in health care workers in the Finnish Register of Occupational Diseases in 2005–2016. *Contact Dermatitis*. 2021;84(4):217-223. doi:10.1111/cod.13753

103. Rasmussen K, Carstensen O, Pontén A, Gruvberger B, Isaksson M, Bruze M. Risk of contact allergy and dermatitis at a wind turbine plant using epoxy resin-based plastics. *Int Arch Occup Environ Health*. 2005;78(3):211-217. doi:10.1007/s00420-004-0575-5

104. Pontén A, Carstensen O, Rasmussen K, Gruvberger B, Isaksson M, Bruze M. Epoxy-based production of wind turbine rotor blades: Occupational dermatoses. *Contact Dermatitis*. 2004;50(6):329-338. doi:10.1111/j.0105-1873.2004.00346.x

105. Christiansen AG, Carstensen O, Sommerlund M, et al. Prevalence of skin sensitization and dermatitis among epoxy-exposed workers in the wind turbine industry*. *British Journal of Dermatology*. 2022;187(6):988-996. doi:10.1111/bjd.21830

106. Cvetkovski RS, Zachariae R, Jensen H, Olsen J, Johansen JD, Agner T. Prognosis of Occupational Hand Eczema. *Arch Dermatol*. 2006;142:305-311.

107. Mälkönen T, Alanko K, Jolanki R, et al. Long-term follow-up study of occupational hand eczema. *British Journal of Dermatology*. 2010;163(5):999-1006. doi:10.1111/j.1365-2133.2010.09987.x

108. Boyapati A, Tam M, Tate B, Lee A, Palmer A, Nixon R. Allergic contact dermatitis to methylisothiazolinone: Exposure from baby wipes causing hand dermatitis. *Australasian Journal of Dermatology*. 2013;54(4):264-267. doi:10.1111/ajd.12062

109. Havmose M, Thyssen JP, Zachariae C, Menné T, Johansen JD. The epidemic of contact allergy to methylisothiazolinone—An analysis of Danish consecutive patients patch tested between 2005 and 2019. *Contact Dermatitis*. 2021;84(4):254-262. doi:10.1111/cod.13717

110. Hald M, Agner T, Blands J, Johansen JD. Delay in medical attention to hand eczema: A follow-up study. *British Journal of Dermatology*. 2009;161(6):1294-1300. doi:10.1111/j.1365-2133.2009.09402.x

111. Skudlik C, Weisshaar E, Scheidt R, et al. First results from the multicentre study Rehabilitation of Occupational Skin Diseases - Optimization and Quality Assurance of Inpatient Management (ROQ). *Contact Dermatitis*. 2011;66:140-147.

112. Weisshaar E, Skudlik C, Scheidt R, et al. Multicentre study 'rehabilitation of occupational skin diseases -optimization and quality assurance of inpatient management (ROQ)'-results from 12-month follow-up. *Contact Dermatitis*. 2013;68(3):169-174. doi:10.1111/j.1600-0536.2012.02170.x

113. Lysdal SH, Søsted H, Johansen JD. Do hairdressers in Denmark have their hand eczema reported as an occupational disease? Results from a register-based questionnaire study. *Contact Dermatitis*. 2012;66(2):72-78. doi:10.1111/j.1600-0536.2011.01997.x

114. Mahler V, Aalto-Korte K, Alfonso JH, et al. Occupational skin diseases: actual state analysis of patient management pathways in 28 European countries. *Journal of the European Academy of Dermatology and Venereology*. 2017;31:12-30. doi:10.1111/jdv.14316

115. Altman DG. *Practical Statistics for Medical Research*.; 1991.

116. Glickman ME, Rao SR, Schultz MR. False discovery rate control is a recommended alternative to Bonferroni-type adjustments in health studies. *J Clin Epidemiol*. 2014;67(8):850-857. doi:10.1016/j.jclinepi.2014.03.012

117. Flyvholm M ann, Thorsen SV, Bültmann U. *Sickness Absence Report 2019. Descriptive Analysis on Wage Earners' Sickness Absence in Denmark - Based on Register and Questionnaire Data.*; 2019.

118. Diepgen TL, Scheidt R, Weisshaar E, John SM, Hieke K. Cost of illness from occupational hand eczema in Germany. *Contact Dermatitis*. 2013;69(2):99-106. doi:10.1111/cod.12038

119. Politiek K, Oosterhaven JAF, Vermeulen KM, Schuttelaar MLA. Systematic review of cost-of-illness studies in hand eczema. *Contact Dermatitis*. 2016;75(2):67-76. doi:10.1111/cod.12590

120. Oosterhaven JAF, Flach PA, Bültmann U, Schuttelaar MLA. Presenteeism in a Dutch hand eczema population—a cross-sectional survey. *Contact Dermatitis*. 2018;79(1):10-19. doi:10.1111/cod.12993

121. Juul S, Bech BH, Dahm CC, Rytter D. *Epidemiologi Og Evidens*. 3rd ed. Munksgaard; 2017.

10. Manuscripts

10.1 Manuscript I: Incidence rates of occupational contact dermatitis in Denmark between 2007 and 2018: A population-based study

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ORIGINAL ARTICLE

CONTACT DERMATITIS WILEY

Incidence rates of occupational contact dermatitis in Denmark between 2007 and 2018: A population-based study

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Abstract

Background: Recent population-based studies on the incidence rates (IRs) of occupational contact dermatitis (OCD) are sparse.

Objectives: To determine the IRs of OCD and development thereof between 2007 and 2018 in known risk occupations.

Methods: Data on all recognized cases of OCD were used to calculate IRs as the number of recognized OCD cases per 10 000 workers per year. Asymptotic chi-square test was used to compare the IRs between 2007-2012 and 2013-2018.

Results: The median age at notification of OCD was below 30 years for several of the examined occupations. Hairdressers and beauticians, bakers, dentists and dental assistants, and manufacturing of windmills had the highest overall IRs of OCD. We found a statistically significant increase in the IRs of OCD for child/nursery care workers.

Conclusions: The median age at notification of OCD was low for several of the occupations, signifying the need for further preventive strategies among young people. Based on the IRs of OCD, future preventive efforts should be directed at hairdressers and beauticians, bakers, dentists and dental assistants, and manufacturing of windmills. Furthermore, the statistically significant increase in IRs of OCD among child/nursery care workers highlights the need for further preventive strategies in this field.

KEYWORDS
contact dermatitis, epidemiology, incidence rate, occupational, population-based study, trend in incidence rates

1 | INTRODUCTION

Occupational contact dermatitis (OCD) is the most frequently recognized occupational disease in many Western countries including Denmark, and constituted one-third of all recognized occupational diseases in Denmark in 2019.[1] The consequences of OCD for the affected individual are substantial with decreased quality of life,[2] job loss or unemployment,[3] and loss of income.[4] The Danish Labour Market Insurance (DLMI) uses approximately €23 million per year on compensation for permanent injury and reduction in earning capacity to afflicted workers with OCD alone, making OCD one of the most expensive occupational diseases in the DLMI system.[1]

Recent population-based epidemiological studies on the incidence rates (IRs) of OCD are sparse. To be able to target the prevention effort on the areas where it will have impact, recent data on the development in IRs of OCD within the known at-risk occupations are

warranted. The aim of this study is to investigate the trends in IRs of OCD in different occupational fields over a 12-year period, and the differences regarding age at recognition and gender. Detailed knowledge about the development of IRs of OCD in the known at-risk occupations may help to focus preventive measures directed at OCD.

2 | METHODS

2.1 | Data from the Danish Labour Market Insurance Register

The DLMI is the official entity for notification and recognition of occupational diseases in Denmark and is furthermore responsible for the granting of economic compensation to afflicted workers. The criteria for recognition of contact dermatitis as occupational in Denmark are typical symptoms, a relevant exposure at the workplace, and a relationship in time between the exposure and the onset or worsening of the contact dermatitis. The DLMI provided data on all cases of recognized OCD in Denmark between 1 January 2007 and 31 December 2018. The data included gender, age at onset, dates of notification and recognition, diagnosis (irritant or allergic contact dermatitis), and occupation. Some workers occurred several times in the register, and to avoid duplicates, workers with both a recognized occupational irritant contact dermatitis and a recognized occupational allergic contact dermatitis were coded as having an occupational allergic contact dermatitis.

2.2 | Data from statistics Denmark

Data on the number of employees between 2007 and 2018 in the different occupations were delivered by Statistics Denmark. We chose to include both part- and full-time employees in the analysis.

2.3 | Occupations

The occupations registered in the DLMI registry and at Statistics Denmark were based on the Danish Industry Code year 2007 (DB07). The DB07 is based on the industry of the workers' place of employment, but for the purpose of this study, we used the DB07 as an indicator of the workers occupation, that is, a worker registered with the DB07 code corresponding to "Cleaning within buildings" was translated as a worker having the occupation *Cleaning personnel*. Occupations with similar activities were grouped together. In order to evaluate the most afflicted occupations, the following criteria were used when choosing which occupations to focus on in this study: ≥90 recognized cases between 1 January 2007 and 31 December 2018, ≥5000 part- and full-time employees in Denmark on average between 2007 and 2018, and overall IR in 2007-2018 ≥4.0 per 10 000 workers per year. Among the occupations that met the aforementioned criteria were "General public services" and "Administration of healthcare, education, culture and social relations except social security." These two occupations were left out of the further analysis, as it is not clear which occupations are entailed in these. This resulted in 28 occupations that were selected for further examination in this study. Among these, two occupations require further explanation, namely, "Vocational school," which includes both teachers and students in schools focusing on craftsmanships, such as hairdressing, plumbing, flower binding, medical assistants, and more, and "Retail sale of cars, vans, and minibuses" that most likely includes auto mechanics working in auto repair shops affiliated with the car dealership.

2.4 | Data analysis and statistics

Statistical analyses were performed in SPSS version 24 (IBM, New York, New York). The IRs were defined and calculated as the number of recognized OCD cases per 10 000 workers per year. In order to examine any development in the IR, we divided the study period into two separate study periods: 2007-2012 (1 January 2007 to 31 December 2012) and 2013-2018 (1 January 2013 to 31 December 2018). We assumed constant IRs within the two study periods. Asymptotic chi-square test was then used to compare the IRs between 2007-2012 and 2013-2018. All *P*-values are two sided, and a 5% level of statistical significance was used.

2.5 | Data permissions

The study was approved by the Danish Data Protection Board (no. HGH-2017-093, I-suite no. 05911).

3 | RESULTS

3.1 | Characterization of the study population

The study population consisted of all recognized cases of OCD between 1 January 2007 and 31 December 2018 (n = 16 484). The characteristics of the study population are presented in Table 1. As described in the "Methods" section, 28 occupations were selected for further examination in this study. Workers employed in one of these 28 occupations were chosen for analysis and comprised 62% of the total cohort (n = 10 235). The distribution of gender, age, and diagnosis was comparable in the total cohort and the analysed cohort of the 28 occupations. In the analysed cohort of the 28 occupations, the female-to-male ratio was approximately 2:1, the mean age at notification was 36.3 years (median 34; quartiles 25-47): 36.2 years for women (median 34; quartiles 25-46.5) and 36.7 years for men (median 35; quartiles 25-47). About 71.6% were diagnosed with irritant contact dermatitis, and 28.4% were diagnosed with allergic contact dermatitis.

TABLE 1 Characteristics of the study population: workers with recognized occupational contact dermatitis between 1 January 2007 and 31 December 2018—Data are presented for both the total cohort (n = 16 484) and the analysed cohort of workers employed in one of the 28 occupations chosen for examination in this study (n = 10 235)

Characteristics	Total cohort (all occupations) (n = 16 484)	Analysed cohort (28 occupations) (n = 10 235)
Male, n (%)	5374 (32.6)	3146 (30.7)
Female, n (%)	11 110 (67.4)	7089 (69.3)
Age (years), mean ± standard deviation	37.6 ± 12.8	36.3 ± 12.8
Allergic contact dermatitis, n (%)	4698 (28.5)	2903 (28.4)
Irritant contact dermatitis, n (%)	11 786 (71.5)	7332 (71.6)

3.2 | Overall incidence rates

The overall IRs of OCD within the 28 occupations for the period 2007-2018 was 9.8 per 10 000 workers per year. The overall IRs per 10 000 workers per year for the 28 most afflicted occupations are listed in the decreasing order of their overall IR in Table 2. Following the classification used by Dickel et al[5] we found 17 occupations to be exceedingly high-risk (IR of OCD ≥7 cases per 10 000 workers per year), and 11 occupations to be high-risk occupations (IR of OCD 3-7 cases per 10 000 workers per year). The highest IRs were found among hairdressers and beauticians (IR 42.5 per 10 000 workers per year), bakers (IR 26.5 per 10 000 workers per year), dentists and dental assistants (IR 18.0 per 10 000 workers per year), and manufacturing of windmills (IR 17.5 per 10 000 workers per year).

3.3 | Difference in incidence rates between 2007-2012 and 2013-2018

We found a significant decline ($P < .001$) in the IRs of OCD within the 28 occupations: 10.1 per 10 000 workers per year for the period 2007-2012 and 9.5 per 10 000 workers per year for the period 2013-2018. In Figure 1A,B, the 28 most afflicted occupations are listed with their IRs for each study period in the decreasing order of their overall IR. A figure illustrating the difference in IRs of OCD between the two study periods can be found in the Supporting information (Figure S1). The decline in IRs of OCD between the two periods was statistically significant for hairdressers and beauticians (51.8-33.4 per year per 10 000 workers, $P < .001$), manufacturing of windmills (22.4-13.2 per year per 10 000 workers, $P < .001$), bakers (30.1-22.4 per year per 10 000 workers, $P = .009$), production of plastic (9.7-5.4 per year per 10 000 workers, $P = .002$), hotel workers (12.0-8.4 per year per 10 000 workers, $P = .025$), postal workers (6.7-3.9 per year per 10 000 workers, $P = .013$), and metalworkers other than machining (9.0-7.5 per year per 10 000 workers, $P = .014$). We only found a statistically significant increase in IRs of OCD between the two study periods among child/nursery care workers (3.6-5.8 per year per 10 000 workers, $P < .001$).

3.4 | Distribution of gender and age within the 28 occupations

The distribution of gender and the mean age at notification of the OCD within the 28 occupations are listed in Table 3 in the increasing order of the mean age at notification of the OCD.

The median age at notification was lowest among the following workers: bakers (24 years); vocational schools (24.5 years); hairdressers and beauticians (25 years); restaurant workers (25 years); hotel workers (25 years); retail sale of cars, vans, and minibuses (25 years); breeding of pigs and dairy cattle (25 years), and auto mechanics (26 years), whereas the median age at notification was highest among the following workers: postal workers (48 years), production of plastic (44 years), production of pharmaceuticals (43 years), metalworkers other than machining (42 years), food production (41 years), and home care workers (41 years).

Of the female cases nearly 58.8% occurred in hospital workers (22.7%), nursing home workers (17.2%), hairdressers and beauticians (10.2%), and restaurant workers (8.7%), whereas 43.7% of the male cases occurred in the following cases: metalworkers (machining metalworkers and metalworkers other than machining; 24.1%), mechanics (auto mechanics; mechanics other than auto mechanics; and retail sale of cars, vans, and minibuses; 13.2%), restaurant workers (10.8%), and manufacturing of windmills' workers (6.5%).

4 | DISCUSSION

4.1 | The overall tendencies in occupational contact dermatitis incidence rates

We found an overall IR within the 28 occupations of 9.8 per 10 000 workers per year (2007-2018). It is difficult to compare studies examining the IRs of OCD in different countries, as there are differences with regard to the definition of the diagnoses, medical examination methods, recognition criteria, and the quality of the registries, but considering all this, due to a similar reporting system, our findings are comparable to earlier estimations of IRs around 7 per 10 000 workers per year in Germany,[5,6] and the systematic review by Diepgen and Coenraads,[7] who found the IR of occupational skin diseases (whereof the large majority was OCD) to be 5 to 19 new cases per 10 000 full-time workers per year, based on collected data in different Western industrial countries.

All the chosen 28 occupations in our study were identified as either exceedingly high-risk or high-risk occupations based on the calculated IRs. Similar occupations were found to be risk occupations by Aalto-Korte et al[8] who examined a similar data set from Finland for the period 2005-2016.

TABLE 2 Overall incidence rates of occupational contact dermatitis (per year per 10 000 workers) for the 28 most afflicted occupations listed in the decreasing order of their overall incidence rate

Occupation	Number of OCD cases between 2007 and 2018	Number of employees in Denmark[a]	Overall IR of OCD during 2007-2018 (per 10 000 workers per year)
Hairdressers and beauticians	734	14 381	42.5
Bakers	325	10 221	26.5
Dentists and dental assistants	339	15 654	18.0
Manufacturing of windmills	250	11 897	17.5
Butchers and slaughterhouse workers	232	13 619	14.2
Nursing home workers	1262	74 539	14.1
Hospital workers	1750	114 007	12.8
Machining metalworkers	102	7253	11.7
Cleaning personnel	469	35 108	11.1
Painters	156	12 052	10.8
Restaurant workers	955	73 951	10.8
Hotel workers	163	13 362	10.2
Metalworkers other than machining	819	82 129	8.3
Auto mechanics	131	13 218	8.3
Production of plastic	127	13 633	7.8
Food production	271	29 560	7.6
Retail sale of cars, vans, and minibuses	179	20 148	7.4
Residential institutions for people with disabilities	276	39 007	5.9
Home care workers	282	40 802	5.8
Postal workers	105	15 512	5.6
Supermarket employees	184	27 502	5.6
Breeding of pigs and dairy cattle	125	18 841	5.5
Builders	82	12 397	5.5
Vocational schools	140	22 085	5.3
Mechanics other than auto mechanics	137	22 158	5.2
Child/nursery care workers	441	78 870	4.7
Plumbers	97	17 852	4.5
Production of pharmaceuticals	102	20 399	4.2
Total (within all 28 occupations)	**10 235**	**870 156**	**9.8**

Abbreviations: IR, incidence rate; OCD, occupational contact dermatitis.
[a]Information obtained from Statistics Denmark December 2020, and includes the average number of employees during 2007-2018.

The IRs reported in this study are most likely an underestimation of the actual OCD frequency, due to underdiagnosing and underreporting of OCD. Studies have found that only 12% of hand eczema cases among healthcare workers and 20% of hand eczema cases among hairdressers were reported to the Danish National Board of Industrial Injuries Register (the earlier DLMI) as having occupational hand eczema.[9,10]

We found a statistically significant ($P < .001$) decrease in the IR of OCD for the 28 occupations from 10.1 per 10 000 worker per year in 2007-2012 to 9.5 per 10 000 worker per year in 2013-2018, corresponding to a decrease of approximately 6%. Although positive, this decrease is not impressive, and the lack of real change in this area is a reflection of the missing attention and focus from the working environment authorities within the last 10 years.

4.2 | Occupational contact dermatitis and young people

We found the median age at notification to be in the early to mid-twenties for several of the examined occupations (ie, bakers, vocational schools, hairdressers and beauticians, restaurant workers, mechanics among others), stressing the fact that it is young people just in the beginning of the career of their choosing that are afflicted by OCD. This corresponds to the findings by Uter et al[11] that the IR of occupational skin disorders among hairdressing apprentices is highest within the first 3 years of training, and the results found in a German cohort study that 29% of apprentice bakers suffer from hand dermatitis within 6 months of commencing training.[12] Considering the

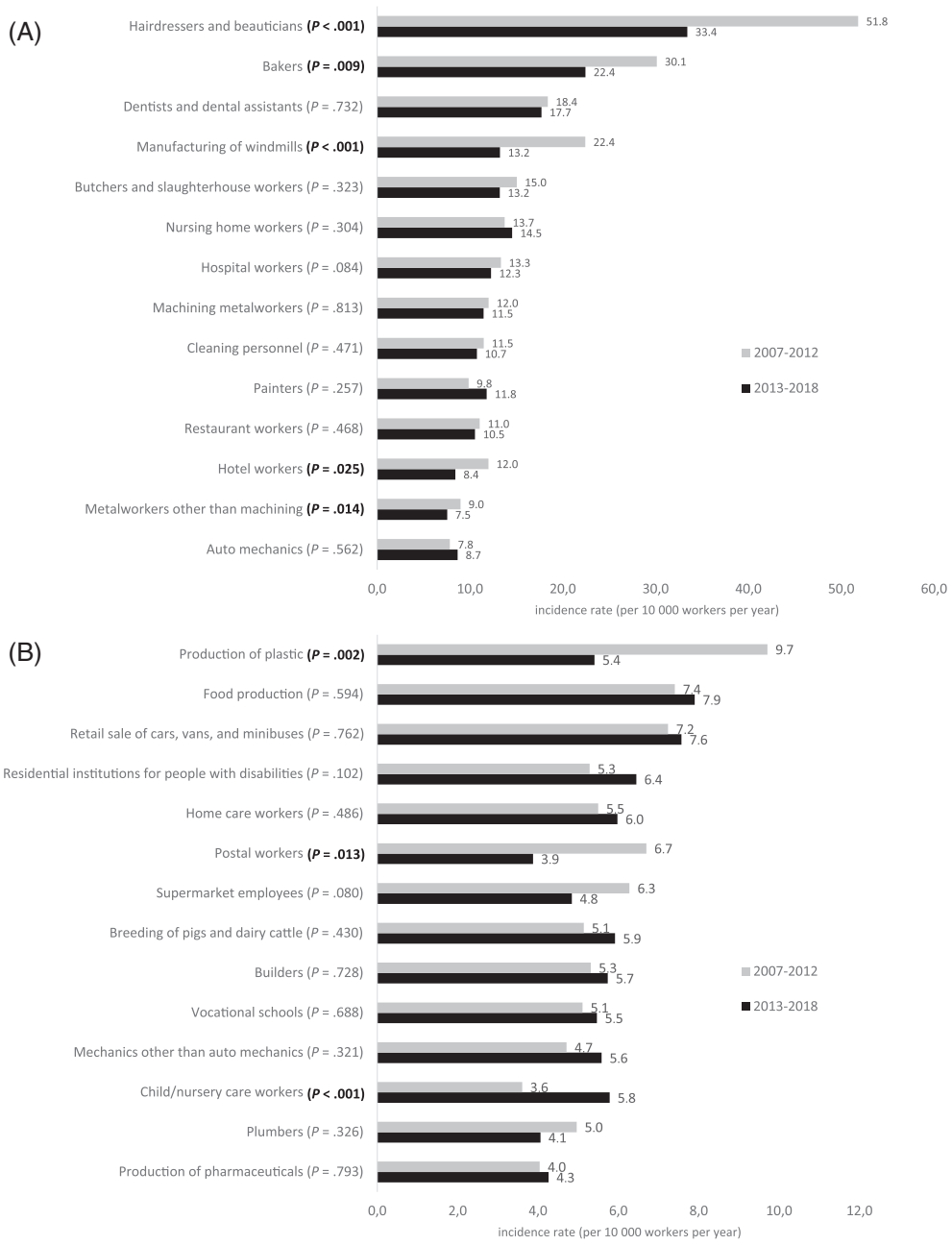

FIGURE 1 (**A**,**B**) incidence rates of occupational contact dermatitis within the 28 most afflicted occupations in the two study periods (2007-2012 vs 2013-2018) listed in decreasing order of their overall incidence rate. Statistically significant *P*-values are marked in bold. A different scale is used in panels

grave consequences of OCD on work life, income, and quality of life of the individual, these are very concerning facts.[2-4]

4.3 | Occupational contact dermatitis among hairdressers and beauticians

The highest overall IR was found not surprisingly among hairdressers and beauticians (overall IR 42.5 per 10 000 workers per year). This occupational field is known to have a high risk for the development of OCD, with high IRs of hand dermatitis.[11,13] The IR of OCD for hairdressers and beauticians found in this study is comparable to the annual IR of 48.2 per 10 000 workers found in Saarland, Germany,[6] and the IR of 56.1 per 10 000 workers per year reported in a Danish study examining the IR of recognized OCD in different occupations between 2001 and 2002.[14] We observed a statistically significant decrease in IR of OCD between 2007-2012 and 2013-2018 from 51.8 to 33.2 per 10 000 per year, corresponding to a reduction of approximately 35%. These results are in line with the findings in a not yet published study by Havmose et al[15] who detected that the lifetime prevalence of hand eczema among Danish hairdressers has decreased significantly from 45.1% to 39.1% for hairdressers certified in 1997-2007 and 2008-2018, respectively. One reason for this decrease could be the implementation of a nationwide prevention program in all hairdressing schools in Denmark in 2011, based on the positive results from an earlier intervention study.[16] Although we found a significant decrease in IR among hairdressers in the observed period, this is still a field that needs substantial attention with regard

TABLE 3 Distribution of gender and the median age at notification of the occupational contact dermatitis within the 28 most afflicted occupations listed in the increasing order of the mean age at notification of the occupational contact dermatitis

Occupation	Median age (years) at notification of OCD	Female, n (%)	Male, n (%)
Bakers	24	119 (61.2)	126 (38.8)
Vocational schools	24.5	99 (70.7)	41 (29.3)
Hairdressers and beauticians	25	723 (98.5)	11 (1.5)
Restaurant workers	25	615 (64.4)	340 (35.6)
Hotel workers	25	62.6 (102)	37.4 (61)
Retail sale of cars, vans, and minibuses	25	12 (6.7)	167 (93.3)
Breeding of pigs and dairy cattle	25	63 (50.4)	62 (49.6)
Auto mechanics	26	5 (3.8)	126 (96.2)
Supermarket employees	29	139 (75.5)	45 (24.5)
Plumbers	32	1 (1.0)	96 (99.0)
Painters	33.5	67 (42.9)	89 (57.1)
Dentists and dental assistants	34	325 (95.9)	14 (4.1)
Builders	34.5	2 (2.4)	80 (97.6)
Butchers and slaughterhouse workers	35	92 (39.7)	140 (60.3)
Hospital workers	38	1607 (91.8)	143 (8.2)
Cleaning personnel	38	365 (77.8)	104 (22.2)
Residential institutions for people with disabilities	38	256 (92.8)	20 (7.2)
Child/nursery care workers	38	413 (93.7)	28 (6.3)
Mechanics other than auto mechanics	38	15 (10.9)	122 (89.1)
Nursing home workers	39	1222 (96.8)	40 (3.2)
Machining metalworkers	40	9 (8.8)	93 (91.2)
Manufacturing of windmills	40.5	45 (18.0)	205 (82.0)
Food production	41	131 (48.3)	140 (51.7)
Home care workers	41	263 (93.3)	19 (6.7)
Metalworkers other than machining	42	156 (19.0)	663 (81.0)
Production of pharmaceuticals	43	74 (72.5)	28 (27.5)
Production of plastic	44	45 (35.4)	82 (64.6)
Postal workers	48	44 (41.9)	61 (58.1)

Abbreviation: OCD, occupational contact dermatitis.

to preventing OCD. An overall IR of 42.5 per 10 000 workers per year signifies that further targeted preventive efforts are necessary.

4.4 | Occupational contact dermatitis and manufacturing of windmills

It is well known that working in the windmill industry poses a severe risk for developing contact dermatitis. A Danish study examining the exposures related to recognized OCD in Denmark in 2010 found that half of patients with allergic OCD caused by epoxy resins were employed in the windmill industry.[17] In Denmark it is a legal requirement before working with epoxy to participate in an educational program about the hazards and required safety measures when working with epoxy.[18] Nevertheless, a scandal erupted in Denmark in 2015-2016 when it was brought to light that in several windmill companies workers were handling epoxy resins without the relevant safety measures, resulting in a small epidemic of contact allergies to epoxy.[19] In our study we found a substantial and significant decrease in IR of OCD between 2007-2012 and 2013-2018 from 22.4 to 13.2 per 10 000 workers per year, respectively, suggesting an improvement within the windmill industry, but with an overall IR of 17.5 per 10 000 workers per year, which ranks as the fourth highest overall IR. Thus, it is obvious that further improvement is still needed.

4.5 | The rise of occupational contact dermatitis among child/nursery care workers and painters: Consequences of the methylisothiazolinone epidemic?

The biggest increase in IR of OCD between 2007-2012 and 2013-2018 was found among childcare workers, where the IR of

OCD rose statistically significant from 3.6 to 5.8 per 10 000 workers per year, corresponding to an increase of approximately 60%, and painters, where the IR of OCD rose from 9.8 to 11.8 per 10 000 workers per year (not statistically significant), corresponding to an increase of approximately 20%. There can be many reasons for this increase in OCD, one of which could be the increasing use of methylisothiazolinone (MI) as a preservative. MI has been used in industrial products such as paint since 2000, and in 2005 it was approved as a standalone preservative in cosmetics and household products in the European Union, resulting in a subsequent epidemic of allergic contact dermatitis to MI. While the exposure of painters to MI through paint is a well-known fact,[20] the exposure of childcare workers is more obscure in its nature. Childcare workers are known to have a substantial exposure to wet work, including the use of soaps, cleaning agents, and wet wipes, all of which may contain MI as a preservative. A study from Australia found baby wipes to be an important source of exposure to MI among parents with hand dermatitis.[21] In comparison, hospital workers also have a substantial exposure to wet work, but are exposed to a more standardized selection of soaps, cleaning agents, and wet wipes bought collectively from the same supplier, whereas childcare workers are exposed to a more varying selection, as each childcare facility is responsible for buying its own supplies, making it vulnerable to products of more varying quality.

In 2017 the use of MI was substantially restricted in the European Union, but as we compare the two periods 2007-2012 and 2013-2018, the consequences of the restriction in the use of MI are not likely to manifest itself in our results. A Danish study from 2020 found a steep incline in the prevalence of MI patch test positivity from 2010 to 2013, and a decline from 2017 to 2019.[22]

4.6 | Strength and weakness

The strength of this study was the use of comprehensive register data of an entire country comprising a very large study population. When combining data on all recognized cases of OCD with reliable data from Statistics Denmark on the number of full- and part-time employed workers in the various examined occupations, it was possible to perform a population-based study on the IRs of OCD in Denmark. A weakness was the proxy use of DB07 classification in the DLMI register and Statistics Denmark. The problem with the DB07 classification in the context of this study is that it is primarily based on the industry of the persons place of employment, and not on the specific work tasks of the person. For this reason, we cannot be certain that a person registered with the DB07 code corresponding to "Cleaning personnel" is working with cleaning or working with administration within the cleaning company. This problem is especially apparent for the occupations "Vocational schools" and "Retail sale of cars, vans and minibuses," that most likely comprise students of craftmanships and auto mechanics working in affiliated auto repair shops, respectively. However, as administrative posts are rare and usually not related to OCD, this will mean that the incidence will be on the conservative side.

When calculating the IR based on the number of employees in Denmark in the same field and period, it is necessary to choose to either include both part- and full-time employees or only full-time employees. We chose to include both part- and full-time employees, as it is possible to get an OCD recognized from working a part-time job. Furthermore, having a part-time job is frequent among several of the high-risk occupations for developing OCD, that is, hairdressing and the cleaning industry. A problem with this approach is that the calculated IRs are only comparable to other studies that also include part-time employees.

4.7 | Conclusion

The data presented in this study are important for the planning of future preventive efforts. We found low median age at notification in several of the examined occupations, supporting previous findings that OCD affects young people in the beginning of their career.[11,12] Considering the grave consequences OCD can have on future work life and quality of life,[2-4] these findings stress the need for further preventive strategies among younger employees. The highest IR was found among hairdressers and beauticians, which are well-known at-risk occupations for the development of OCD, and even though we found a significant reduction in the IR rate of OCD among hairdressers and beauticians of approximately 35%, the IRs of OCD among hairdressers and beauticians remain the highest among the 28 most afflicted occupations, signifying the need for further prevention. Furthermore, we found bakers, dentists and dental assistants, and manufacturing of windmills among others to be high-risk occupations for the development of OCD, and as such future preventive efforts should also be directed towards these occupations. We detected a statistically significant increase in IR of OCD among childcare workers of approximately 60%, which could be the result of the use of MI in everyday products, but further research in this area is needed, as well as the development of preventive strategies in this field.

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AUTHOR CONTRIBUTIONS

Torkil Menné: Conceptualization; methodology; writing-review & editing. **Harald Meyer:** Writing-review & editing. **Sven Viskum:** Writing-review & editing. **Mari-Ann Flyvholm:** Conceptualization; funding acquisition; writing-review & editing. **Ulrik Ahrensbøll-Friis:** Writing-review & editing. **Swen Malte John:** Writing-review & editing.

CONFLICTS OF INTERESTS

The authors declare no conflict of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Danish Labour Market Insurance Register and Statistics Denmark

(DREAM). Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the Danish Labour Market Insurance and Statistics Denmark with the permission of the Danish Data Protection Board.

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REFERENCES

1. Arbejdsmarkedets Erhvervssikring. Arbejdsskadestatistik 2019. 2020. https://www.aes.dk/statistik/arbejdsskader/aarsstatistik.
2. Hutchings CV, Shum KW, Gawkrodger DJ. Occupational contact dermatitis has an appreciable impact on quality of life. *Contact Dermatitis*. 2001;45(1):17-20.
3. Carøe TK, Ebbehøj NE, Bonde JP, Agner T. Occupational hand eczema and/or contact urticaria: factors associated with change of profession or not remaining in the workforce. *Contact Dermatitis*. 2018;78(1):55-63. https://doi.org/10.1111/cod.12869
4. Dietz JB, Menné T, Meyer HW, et al. Degree of employment, sick leave, and costs following notification of occupational contact dermatitis—a register-based study. *Contact Dermatitis*. 2020;84(4):1-12. https://doi.org/10.1111/cod.13719
5. Dickel H, Kuss O, Blesius CR, Schmidt A, Diepgen TL. Occupational skin diseases in northern Bavaria between 1990 and 1999: a population-based study. *Br J Dermatol*. 2001;145(3):453-462. https://doi.org/10.1046/j.1365-2133.2001.04377.x
6. Dickel H, Bruckner T, Bernhard-Klimt C, Koch T, Scheidt R, Diepgen TL. Surveillance scheme for occupational skin disease in the Saarland, FRG: first report from BKH-S. *Contact Dermatitis*. 2002;46(4):197-206. https://doi.org/10.1034/j.1600-0536.2002.460403.x
7. Diepgen TL, Coenraads PJ. The epidemiology of occupational contact dermatitis. *Int Arch Occup Environ Health*. 1999;72(8):496-506. https://doi.org/10.1007/s004200050407
8. Aalto-Korte K, Koskela K, Pesonen M. 12-year data on skin diseases in the Finnish register of occupational diseases II: risk occupations with special reference to allergic contact dermatitis. *Contact Dermatitis*. 2020;82(6):343-349. https://doi.org/10.1111/cod.13510
9. Ibler KS, Jemec GBE, Flyvholm MA, Diepgen TL, Jensen A, Agner T. Hand eczema: prevalence and risk factors of hand eczema in a population of 2274 healthcare workers. *Contact Dermatitis*. 2012;67(4):200-207. https://doi.org/10.1111/j.1600-0536.2012.02105.x
10. Lysdal SH, Søsted H, Johansen JD. Do hairdressers in Denmark have their hand eczema reported as an occupational disease? Results from a register-based questionnaire study. *Contact Dermatitis*. 2012;66(2):72-78. https://doi.org/10.1111/j.1600-0536.2011.01997.x
11. Uter W, Pfahlberg A, Gefeller O, Schwanitz HJ. Prevalence and incidence of hand dermatitis in hairdressing apprentices: results of the POSH study. Prevention of occupational skin disease in hairdressers. *Int Arch Occup Environ Health*. 1998;71(7):487-492.
12. Bauer A, Bartsch R, Hersmann C, et al. Occupational hand dermatitis in food industry apprentices: results of a 3-year follow-up cohort study. *Int Arch Occup Environ Health*. 2001;74(6):437-442. https://doi.org/10.1007/s004200100241
13. Smit HA, Rijssen AV, Vandenbroucke JP, Coenraads PJ. Susceptibility to and incidence of hand dermatitis in a cohort of apprentice hairdressers and nurses. *Scand J Work Environ Heal*. 1994;20(2):113-121.
14. Skoet R, Olsen J, Mathiesen B, Iversen L, Johansen JD, Agner T. A survey of occupational hand eczema in Denmark. *Contact Dermatitis*. 2004;51(4):159-166. https://doi.org/10.1111/j.0105-1873.2004.00423.x
15. Havmose M, Thyssen JP, Zachariae C, Johansen JD. The morbidity of hand eczema and its career consequences in hairdressers – a prospective cohort study from 1985–2018. (Unpublished Manuscript).
16. Bregnhøj A, Menné T, Johansen JD, Søsted H. Prevention of hand eczema among Danish hairdressing apprentices: an intervention study. *Occup Environ Med*. 2012;69(5):310-316. https://doi.org/10.1136/oemed-2011-100294
17. Carøe TK, Ebbehøj N, Agner T. A survey of exposures related to recognized occupational contact dermatitis in Denmark in 2010. *Contact Dermatitis*. 2014;70(1):56-62. https://doi.org/10.1111/cod.12134
18. Bangsgaard N, Thyssen JP, Menné T, et al. Contact allergy to epoxy resin: risk occupations and consequences. *Contact Dermatitis*. 2012;67(2):73-77. https://doi.org/10.1111/j.1600-0536.2012.02072.x
19. Arbejdsmiljørådet. *Arbejdsmiljørådets Anbefalinger Vedrørende Epoxy Og Isocyanater*. 2016.
20. Mose AP, Lundov MD, Zachariae C, et al. Occupational contact dermatitis in painters - an analysis of patch test data from the Danish contact dermatitis group. *Contact Dermatitis*. 2012;67(5):293-297. https://doi.org/10.1111/j.1600-0536.2012.02074.x
21. Boyapati A, Tam M, Tate B, Lee A, Palmer A, Nixon R. Allergic contact dermatitis to methylisothiazolinone: exposure from baby wipes causing hand dermatitis. *Australas J Dermatol*. 2013;54(4):264-267. https://doi.org/10.1111/ajd.12062
22. Havmose M, Thyssen JP, Zachariae C, Menné T, Johansen JD. The epidemic of contact allergy to methylisothiazolinone—an analysis of Danish consecutive patients patch tested between 2005 and 2019. *Contact Dermatitis*. 2020;84(4):1-9. https://doi.org/10.1111/cod.13717

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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10.2 Manuscript II: Occupational contact dermatitis among young people in Denmark – A survey of causes and long-term consequences

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ORIGINAL ARTICLE

CONTACT DERMATITIS WILEY

Occupational contact dermatitis among young people in Denmark – A survey of causes and long-term consequences

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Abstract

Background: Studies on the causes and consequences of occupational contact dermatitis (OCD) among young workers are non-existent.

Objectives: Determine causes and consequences of OCD among workers younger than 35 years of age.

Methods: A questionnaire was sent to 6251 workers younger than 35 years at notification with recognized OCD (response rate 47%).

Results: The most prevalent occupations were health care workers, kitchen workers, nursery teachers, and hairdressers and beauticians. Seventy-six percent still had eczema, and 77% of these had eczema half to all the time over the last 3 months, with 61% evaluating their eczema as moderate to very severe. Fifty-three percent had changed their occupation since notification, and 42.5% had lost their job because of OCD. Allergic OCD increased the odds ratio (OR) for facial or foot eczema, job loss, change in work tasks, difficulties finding work, decrease in income, and sick leave. Age at notification of 25 years of age or younger increased the risk of job loss and feeling restricted in choice of job. Workers in the food industry had a higher OR for job loss, whereas hairdressers and beauticians had a higher risk of job loss and a decrease in income.

Conclusions: The severe, long-term consequences of OCD notification signify the need for further preventive strategies among young workers.

KEYWORDS
occupational allergic contact dermatitis, occupational consequences, occupational contact dermatitis, occupational irritant contact dermatitis

1 | INTRODUCTION

Occupational contact dermatitis (OCD) is a significant societal problem. It is a frequent disease, being the most commonly recognized occupational disease in many countries and it has been shown to have a substantial effect on the lives of the affected individuals, with a decrease in quality of life,[1] increase in job loss and unemployment,[2] and loss of income.[3]

Even though OCD often develops early in life – with the average age at debut being 25 to 36 years,[4,5] studies on the impact of OCD on, specifically, young people's lives are to the best of our knowledge nonexistent. OCD is known to develop even during the first years of training within high risk occupations.[6,7] For this reason, we chose to investigate both the occupational causes of the development of OCD and the long-term consequences of OCD on young peoples' lives. We chose to focus on their eczema status and quality of life 1 to 23 years

after notification of their OCD to the Danish Labour Market Insurance Register (DLMI), and the occupational consequences the OCD has had on their further work life. Detailed knowledge may help to focus the preventive measures directed at OCD.

2 | METHODS

2.1 | Data from the Danish Labour Market Insurance Register

The Danish Labour Market Insurance Register (or DLMI) comprises all recognized cases of occupational diseases in Denmark and is responsible for evaluating OCD cases and paying benefits for afflicted individuals. Before a case is recognized as occupational, the case has been examined by a specialist in dermatology and patch testing has been performed. The DLMI provided data on all persons with recognized occupational contact dermatitis between January 2010 and December 2019, who at the point of notification to the DLMI were younger than 35 years of age. The data included information on gender, birthdate, dates of notification and recognition of the OCD, diagnosis and granted degree of injury, which is the percentage of injury the worker is awarded at recognition. Because occupational irritant contact dermatitis (OICD) is an exclusion diagnosis, where no relevant allergies have been found, workers, who had both an OICD and an occupational allergic contact dermatitis (OACD) recognized were coded as having OACD in all further analysis. A case can be recognized with or without the payment of economic compensation, which is only paid if degree of injury is evaluated to be ≥5%. The degree of injury is dependent on an individual evaluation of the workers' degree of eczema. It is a global assessment of the chronic changes (none, mild, moderate, and severe) and frequency of eruptions (seldom, regularly, frequent), based on a written report from a dermatologists containing an up-to-date clinical description of the eczema and course of disease. The identification of certain occupational allergies, which are perceived as difficult to avoid, will result in the awarding of extra percentage points of injury (5%), for example, nickel, chromium, formaldehyde, and methylisothiazolinone, whereas other factors such as preexisting atopic dermatitis will result in the subtraction of percentage points, in the case of OICD. For this reason, degree of injury represents more than the severity of the OCD. We chose the cutoff of degree of injury of 15% or greater as an outcome measure in the further analysis, as this is the degree of injury a moderate hand eczema with frequent outbreaks will be awarded.

2.2 | Questionnaire

Information was collected using a self-administered questionnaire that was sent electronically on January 21, 2021; two reminders were sent 1 month apart. The questionnaire comprised validated questions from other questionnaires and new questions developed for the purpose of this study. Prior to the study, the questionnaire was evaluated and revised based on interviews with peers and with hand eczema outpatients from Gentofte Hospital, Department of Dermatology. All items were considered relevant and easy to comprehend by the participants. The questionnaire entailed questions on current status and severity of eczema, current occupational status, occupation responsible for the development of their OCD and exposures related to this occupation, and occupational consequences of the OCD. Severity of current hand eczema was evaluated using a self-administered photographic guide based on photographs of hand eczema,[8] along with a visual analogue scale. A history of atopic dermatitis was estimated by a question about doctor-diagnosed atopic dermatitis, and all further analysis were adjusted for the presence of atopic dermatitis. The effect of atopic dermatitis on the long-term consequences of OCD will be the subject of a separate article. Quality of life was estimated using Skindex-29 and EQ-5D-5L.[9-11] We used the categorization of Skindex-29 scores suggested by Nijsten et al.[12] The questionnaire also contained an open statement field; here 49 persons commented qualitatively on the impact of OCD on their life. We categorized the statements into four categories: physical and emotional impact of OCD, impact on career and economy, statements on the health care system, and wishes for the future. Typical examples of the statements were anonymized, and minor changes made, as to not making the statements recognizable.

2.3 | Data analysis and statistics

Study data were collected and managed using REDCap electronic data capture tools hosted at the Capital Region of Denmark.[13,14] The statistical analyses were made in R version 3.6.1. Analysis comprised chi-square test, Wilcoxon test, and binary logistic regression models. All *P*-values are two-sided, and a 5% level of statistical significance was used.

Chi-square and Wilcoxon tests were used to test for differences in the distribution of gender, age at notification, time between notification and questionnaire, degree of injury, and diagnosis among responders and nonresponders.

Binary logistic regression models adjusted for age, sex, atopic dermatitis, and duration of time between notification and the time of the questionnaire were used to calculate odds ratios (OR), including 95% confidence intervals (CIs), for association between the explanatory variables (gender, age at notification, diagnosis, and occupation listed as causal for the development of OCD by the respondents) and the different outcomes (current eczema, placement of OCD, degree of injury </≥ 15%, and the different occupational consequences).

2.4 | Data permissions

The study was approved by the Knowledge Centre on Data Protection Compliance in the Capital Region of Denmark on behalf of the Danish Data Protection Board (P-2020-508).

3 | RESULTS

3.1 | Characterization of the study population

In total, 6251 workers met the inclusion criteria and were sent a questionnaire. A total of 2942 answered the questionnaire (response rate 47%). There were no significant differences between responders and nonresponders with respect to recognized diagnosis or degree of injury, but women had a statistically significant higher likelihood of answering the questionnaire, the responders were slightly older (median age 26 years) compared to the nonresponders (median age 25 years), and a shorter period of time had passed between notification and the time of receipt of the questionnaire among responders (median time 6 years) compared to nonresponders (median time 7 years) (Table 1). Most of the responders were born in Denmark (92%), with the remainder having lived in Denmark on average 19 years at the time of the receipt of the questionnaire. Approximately 42% answered that they had doctor diagnosed atopic dermatitis.

3.2 | Anatomic location of the occupational contact dermatitis at debut

In total, 97% answered that their OCD was located on their hands at debut, whereas 10.9% reported facial OCD, and 6.5% reported OCD involving their feet. The distribution of facial and feet OCD according to gender, age at notification, diagnosis, and occupation listed as casual to the development of OCD by the respondents and the results of adjusted binary logistic regression analysis is listed in Table 2. We found men to have a significantly higher OR of having OCD of the face or feet (OR 1.4 [95%CI: 1.0-1.9] and 2.2 [95%CI: 1.6-3.1],

TABLE 1 Characteristics: The distribution of gender, age at notification, time between notification and questionnaire, diagnosis and degree of injury, place of birth, and doctor-diagnosed atopic dermatitis according to responders and non-responders

	Responders, n = 2942 (47%)	Non-responders, n = 3309 (53%)	*P*-value
Gender, n (%)			
Male	753 (25.6)	1227 (37.1)	**<.001**[a]
Female	2189 (74.4)	2082 (62.9)	**<.001**[a]
Age at notification, y			
Mean ± SD	26 ± 5	25 ± 5	
Median (min-max)	26 (14-34)	25 (11-34)	**<.001**[b]
Time between notification and questionnaire, y			
Mean ± SD	6 ± 3	7 ± 3	
Median (min-max)	6 (1-23)	7 (1-16)	**<.001**[b]
Diagnoses, n (%)			
OICD	2290 (77.8)	2514 (76.0)	.08[a]
OACD	652 (22.2)	795 (24.0)	.08[a]
Degree of injury, n (%)			
Mean ± SD	7 ± 6	7 ± 6	.9[b]
<5%	760 (25.8)	917 (27.7)	
5-14%	1838 (62.5)	1957 (59.1)	
≥15%	344 (11.7)	435 (13.1)	
Country of birth (n = 2886)			
Denmark	2654 (92)		
Country other than Denmark	232 (8)		
Years spent in Denmark, y (n = 228)			
Mean ± SD	19 ± 10		
Median (min-max)	17 (2-43)		
Atopic dermatitis (n = 2393)			
Self-reported doctor-diagnosed atopic dermatitis	1000 (41.8)		

Note: Significant *P*-values are shown in bold face.
Abbreviation: SD, standard deviation.
[a]Chi-square test for difference in the distribution of gender and diagnosis.
[b]Wilcoxon rank-sum test for difference in the median.

TABLE 2 Location of OCD at debut: Distribution of face and foot OCD according to gender, age at notification, diagnosis, and occupation related to the debut of OCD, as well as OR for face and foot OCD

	Total	Face OCD, n (%)	OR (95% CI)	Foot OCD, n (%)	OR (95% CI)
Total	2557	278 (10.9)		166 (6.5)	
Gender					
Male	655	85 (13)	**1.4 (1-1.9)**	74 (11.3)	**2.2 (1.6-3.1)**
Female	1902	193 (10.1)	1	92 (4.8)	1
Age at notification					
≤25 y	1215	136 (11.2)	0.9 (0.7-1.2)	75 (6.2)	0.9 (0.7-1.3)
>25 y	1342	142 (10.6)	1	91 (6.8)	1
Diagnosis					
Occupational allergic contact dermatitis	575	130 (22.6)	**3.6 (2.7-4.6)**	55 (9.6)	**1.9 (1.3-2.7)**
Occupational irritant contact dermatitis	1982	148 (7.5)	1	111 (5.6)	1
Occupation listed as casual to the development of OCD[a]					
Health care workers	702	52 (7.4)	**0.5 (0.4-0.7)**	18 (2.6)	**0.4 (0.2-0.6)**
Kitchen personnel	373	34 (9.1)	0.8 (0.5-1.1)	23 (6.2)	0.9 (0.6-1.5)
Nursery teachers	136	2 (1.5)	**0.1 (0-0.4)**	7 (5.1)	1 (0.5-2.2)
Hairdressers and beauticians	130	18 (13.8)	1.4 (0.8-2.3)	2 (1.5)	0.3 (0.1-1.1)
Craftsmen/builders	127	24 (18.9)	**1.8 (1.1-3)**	18 (14.2)	**1.8 (1-3.3)**
Mechanics/fitters/technicians	122	14 (11.5)	0.9 (0.5-1.6)	7 (5.7)	0.5 (0.2-1.1)
Mixed manual workers	108	20 (18.5)	1.6 (1-2.8)	10 (9.3)	1.3 (0.7-2.6)
Sale assistants	89	13 (14.6)	1.4 (0.8-2.6)	7 (7.9)	1.4 (0.6-3.2)
Bakers and pastry chefs	86	10 (11.6)	1.1 (0.5-2.1)	5 (5.8)	0.9 (0.4-2.3)
Cleaning personnel	72	7 (9.7)	0.9 (0.4-2)	3 (4.2)	0.7 (0.2-2.2)
Agricultural workers/farmers	46	15 (32.6)	**4.1 (2.2-7.8)**	12 (26.1)	**4.6 (2.3-9.2)**
Office workers	46	6 (13)	1.1 (0.5-2.7)	7 (15.2)	**2.8 (1.2-6.5)**
Butchers/slaughterhouse workers	23	5 (21.7)	2.4 (0.9-6.6)	3 (13)	1.9 (0.6-6.7)
Machine operators/metalworkers	23	4 (17.4)	1.5 (0.5-4.5)	3 (13)	1.4 (0.4-4.9)
Gardeners	20	2 (10)	0.9 (0.2-3.9)	1 (5)	0.7 (0.1-5)
Other occupations	135	25 (18.5)	**1.9 (1.2-2.9)**	14 (10.4)	1.7 (0.9-3)

Note: Logistic regression analysis with the outcome odds ratio (OR) of occupational contact dermatitis vs no occupational contact dermatitis of the face and feet, respectively, adjusted by the variables atopic dermatitis, age at notification, and gender. Significant *P*-values are shown in bold face.
Abbreviations: OCD, occupational contact dermatitis, OR, odds ratio, CI, confidence interval.
[a]Each occupation is compared to all the other occupations in the multivariable logistic regression analysis.

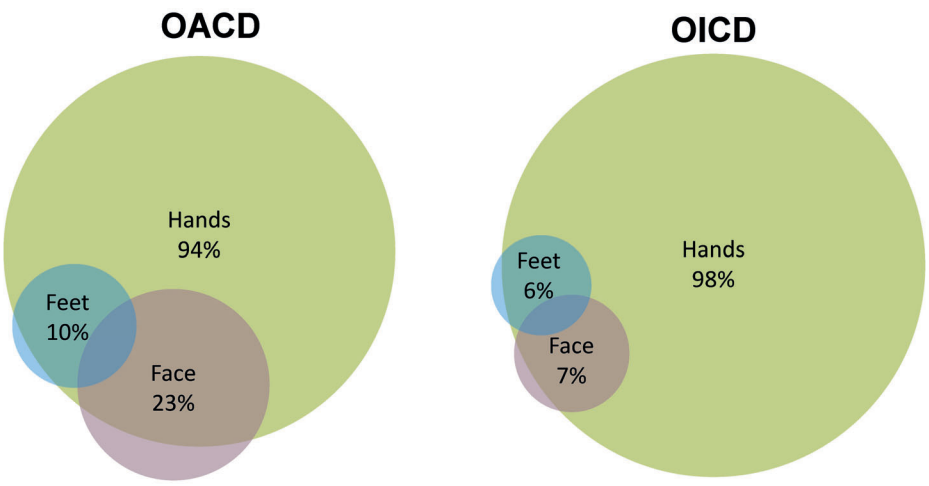

FIGURE 1 Location of occupational contact dermatitis among workers with occupational allergic (OACD) or irritant contact dermatitis (OICD)

respectively). OACD was significantly related to a higher OR for having hand or foot OCD (OR 3.6 [95%CI: 2.7-4.6] and 1.9 [95%CI: 1.3-2.7], respectively), illustrated in Figure 1, where 22.6% of workers with OACD had face OCD, compared to only 7.5% of workers with OICD.

The highest OR for having OCD involving the face or feet was found among agricultural workers/farmers (OR 4.1 [95% CI: 2.2-7.8] and OR 4.6 [95%CI: 2.3-9.2], respectively), where 32.6% had face OCD and 26.1% had foot OCD. Craftsmen/builders also had a significantly higher OR for both face and foot OCD (OR 1.8 [95% CI: 1.1-3] and OR 1.8 [95% CI: 1-3.3], respectively), whereas health care workers had a significantly lower OR for both face and foot OCD (OR 0.5 [95% CI: 0.4-0.7] and OR 0.4 [95% CI: 0.2-0.6], respectively). Surprisingly office workers also had a higher risk of foot OCD compared to the other occupations (OR 2.8, 95% CI: 1.2-6.5). The analyzes were adjusted for atopic dermatitis.

3.3 | Degree of injury

Approximately one-fourth of the respondents were awarded a degree of injury of <5%, which corresponds to no cash payment, whereas 62.5% were awarded between 5% and 14% injury, and 11.7% were awarded ≥15% in degree of injury. As mentioned in the Methods section, we chose to examine the degree of injury using a binary logistic regression with a of degree of injury ≥15% vs < 15% modeled as outcome. The results of the analysis, as well as the distribution of degree of injury ≥15% vs <15% according to gender, age at notification, diagnosis, and occupation listed as casual to the development of OCD by the respondent is presented in Table 3. We found that men had a significantly higher OR of being awarded a degree of injury ≥15% compared to women (OR 1.6, 95% CI: 1.2-2.1). A diagnosis of OACD was also associated with a significantly higher OR of being awarded a degree of injury of ≥15% compared to the diagnosis of OICD alone

TABLE 3 Degree of injury: Distribution of degree of injury ≥15% vs <15% according to gender, age at notification, diagnosis, and occupation related to the debut of OCD, as well as OR for degree of injury ≥15%

	Total	Degree of injury ≥15%, n (%)	Degree of injury <15%, n (%)	OR (95% CI)
Total	6251	779 (12.5)	5472 (87.5)	
Gender				
Male	1980	341 (17.2)	1639 (82.8)	**1.6 (1.2-2.1)**
Female	4271	438 (10.3)	3833 (89.7)	1
Age at notification				
≤25 y	3138	345 (11)	2793 (89)	0.8 (0.6-1)
>25 y	3113	434 (13.9)	2679 (86.1)	1
Diagnosis				
Occupational allergic contact dermatitis	1447	329 (22.7)	1118 (77.3)	**3.4 (2.6-4.5)**
Occupational irritant contact dermatitis	4804	450 (9.4)	4354 (90.6)	1
Occupation listed as causal to the development of OCD[a]				
Healthcare workers	702	70 (10)	632 (90)	0.9 (0.7-1.3)
Kitchen personnel	373	47 (12.6)	326 (87.4)	1.1 (0.8-1.6)
Nursery teachers	136	12 (8.8)	124 (91.2)	0.8 (0.4-1.5)
Hairdressers and beauticians	130	11 (8.5)	119 (91.5)	0.8 (0.4-1.6)
Craftsmen/builders	128	21 (16.4)	107 (83.6)	1.2 (0.7-1.9)
Mechanics/fitters/technicians	122	16 (13.1)	106 (86.9)	0.8 (0.4-1.4)
Mixed manual workers	108	16 (14.8)	92 (85.2)	1.3 (0.7-2.3)
Sale assistants	89	6 (6.7)	83 (93.3)	0.6 (0.3-1.4)
Bakers and pastry chefs	86	12 (14)	74 (86)	1.3 (0.7-2.5)
Cleaning personnel	72	7 (9.7)	65 (90.3)	0.8 (0.4-1.8)
Agricultural workers/farmers	46	7 (15.2)	39 (84.8)	1.2 (0.5-2.7)
Office workers	46	9 (19.6)	37 (80.4)	1.8 (0.8-3.8)
Butchers/slaughterhouse workers	23	7 (30.4)	16 (69.6)	**3.2 (1.3-8)**
Machine operators/metalworkers	23	2 (8.7)	21 (91.3)	0.5 (0.1-2.1)
Gardeners	20	5 (25)	15 (75)	2.3 (0.8-6.4)
Other occupations	135	10 (7.4)	125 (92.6)	0.6 (0.3-1.1)

Note: Logistic regression analysis with the outcome odds ratio (OR) of degree of injury ≥15% vs degree of injury <15%, adjusted by the variables atopic dermatitis, age at notification, and gender. Significant *P*-values are shown in bold face.
Abbreviations: CI, confidence interval; OCD, occupational contact dermatitis; OR, odds ratio.
[a]Each occupation is compared to all the other occupations in the logistic regression analysis.

(OR 3.4, 95% CI: 2.6-4.5). Finally, butchers and slaughterhouse workers were found to have a significantly higher OR of having a degree of injury ≥15% (OR 3.2, 95% CI: 1.3-8.0) compared to the other occupations, with 30.4% of butchers and slaughterhouse workers being awarded a degree of injury ≥15%.

Considering the fact, that the presence of some allergies will add to the degree of injury awarded to a worker, we examined if men were more likely than women to get the diagnosis OACD rather than OICD, adjusted for atopic dermatitis and age. We found a significantly higher OR for men to have OACD of 1.4 (95% CI: 1.1-1.7), compared to women.

3.4 | Occupation related to debut of OCD

In the questionnaire, the respondents were asked to answer which occupation was responsible for the development of their OCD. The occupations listed as causal to the development of OCD by the respondents are listed in decreasing order of frequency in Figure 2. The occupations most commonly listed as the reason for OCD by the respondents were "health care worker" and "kitchen personnel" (31% and 17%, respectively).

3.5 | Current eczema status

The current eczema status of the respondents is listed in Table 4. Most respondents had had eczema within the last 3 months (76%), and 77% listed this eczema as being present half of the time to all the time within the last 3 months, and 61% listed their eczema as being

TABLE 4 Current eczema status

	n (%)
Eczema within the last 3 mo (n = 2501)	1901 (76)
Duration of eczema within the last 3 mo (n = 1793)	
All the time	650 (36)
More than half the time	414 (23)
Half the time	320 (18)
Less than half the time	409 (23)
VAS (1-10), mean ± SD (n = 2400)	4.8 ± 2.3
Photoguide (hand eczema only) (n = 1763)	
Almost clear	686 (39)
Moderate	815 (46)
Severe	227 (13)
Very severe	35 (2)
Location of eczema within the last 3 mo (n = 1900)	
Hands	1796 (95)
Face	319 (17)
Foot	144 (8)
Location of hand eczema within the last 3 mo (n = 1794)	
Fingers	1272 (71)
Fingertips	504 (28)
Interdigital	1075 (60)
Dorsum manus	1015 (57)
Palm	641 (36)
Wrist	490 (27)
Lower arm	235 (13)

Abbreviations: SD, standard deviation; VAS, visual analog scale.

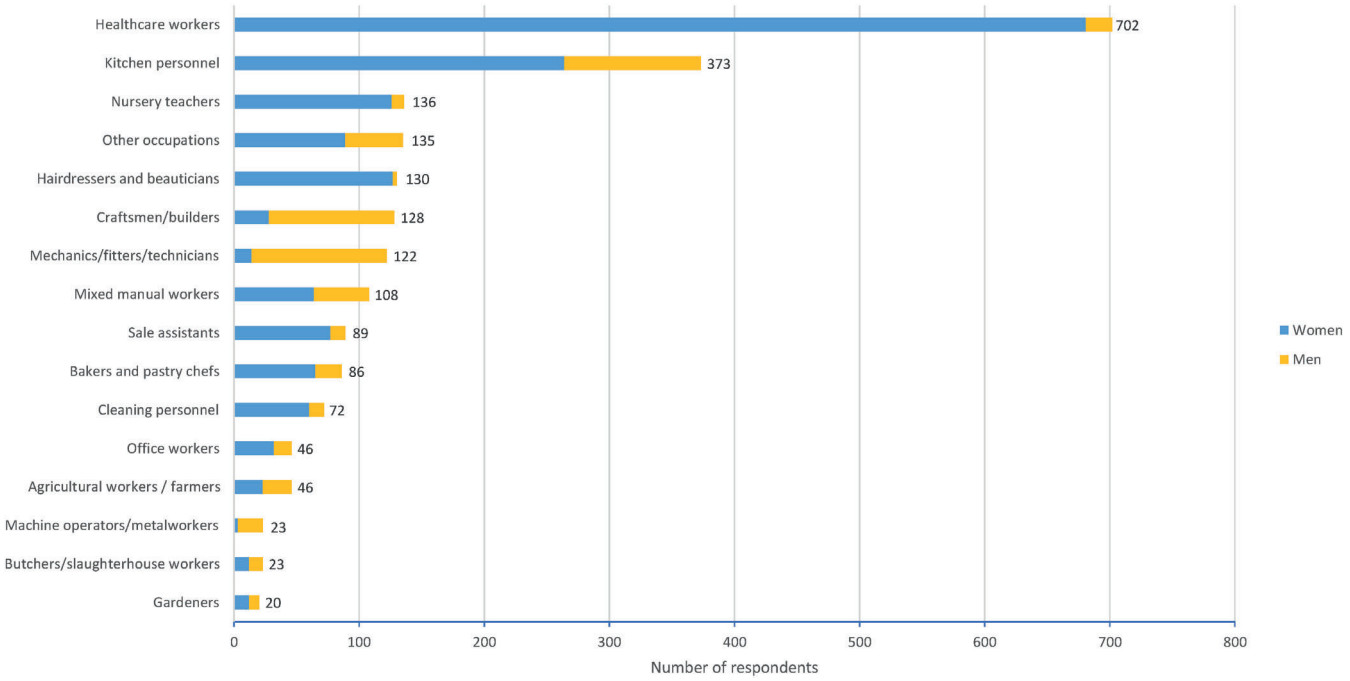

FIGURE 2 Occupations related to the debut of occupational contact dermatitis listed in decreasing order of frequency (n = 2239)

TABLE 5 Current eczema: Distribution of current eczema according to gender, age at notification, diagnosis, and occupation related to debut of OCD

	Total	Current eczema, n (%)	OR (95% CI)
Total	2501	1901 (76)	
Gender			
Male	640	451 (70.5)	**0.7 (0.6-0.9)**
Female	1861	1450 (77.9)	1
Age at notification			
≤25 y	1190	922 (77.5)	1.1 (0.9-1.3)
>25 y	1311	979 (74.7)	1
Diagnosis			
Occupational allergic contact dermatitis	569	412 (72.4)	**0.8 (0.6-1)**
Occupational irritant contact dermatitis	1932	1489 (77.1)	1
Occupation listed as causal to the development of OCD[a]			
Health care workers	702	550 (78.3)	1 (0.8-1.3)
Kitchen personnel	373	304 (81.5)	**1.4 (1.1-1.9)**
Nursery teachers	136	115 (84.6)	1.5 (1-2.5)
Hairdressers and beauticians	130	100 (76.9)	0.9 (0.6-1.4)
Craftsmen/builders	128	94 (73.4)	1 (0.6-1.5)
Mechanics/fitters/technicians	122	78 (63.9)	**0.6 (0.4-0.9)**
Mixed manual workers	108	86 (79.6)	1.3 (0.8-2.1)
Sale assistants	89	65 (73)	0.7 (0.5-1.2)
Bakers and pastry chefs	86	62 (72.1)	0.8 (0.5-1.2)
Cleaning personnel	71	53 (74.6)	1 (0.6-1.7)
Agricultural workers/farmers	46	29 (63)	0.6 (0.3-1.1)
Office workers	46	38 (82.6)	1.5 (0.7-3.3)
Butchers/slaughterhouse workers	23	14 (60.9)	0.6 (0.3-1.5)
Machine operators/metalworkers	23	16 (69.6)	1 (0.4-2.4)
Gardeners	20	15 (75)	1 (0.4-2.9)
Other occupations	135	100 (74.1)	0.9 (0.6-1.3)

Note: Logistic regression analysis with the outcome odds ratio (OR) of current eczema vs no current eczema, adjusted by the variables atopic dermatitis, age at notification, gender, and years since notification. Significant *P*-values are shown in bold face.
Abbreviations: CI, confidence interval; OCD, occupational contact dermatitis; OR, odds ratio.
[a]Each occupation is compared to all the other occupations in the multivariable logistic regression analysis.

moderate to very severe. The most common location of current eczema was the hands, with 95% of respondents listing this as a place of eczema, followed by the face and feet (17% and 8%, respectively). The most common areas for hand eczema were the fingers (71%), interdigital area (60%), and dorsum manus (57%).

In Table 5, the distribution of current eczema according to gender, age at notification, diagnosis, and occupation listed as causal to the development of OCD by the respondents, as well as the results of logistic regression analysis with the outcome OR of current eczema vs no current eczema are listed. Men were found to have a lower OR for having current eczema compared to women, with 70.5% having current eczema compared with 77.9% for women (OR 0.7, 95% CI: 0.6-0.9). The same was true for workers with OACD, where 77.1% had current eczema compared with 72.4% for workers with OICD (OR 0.8, 95% CI: 0.6-1). Having worked as a kitchen personnel at debut was associated with a significantly higher OR of having current eczema (OR 1.4, 95% CI: 1.1-1.9).

3.6 | Occupational consequences

A selection of the occupational consequences found in the present study are listed in Table 6. Job loss because of OCD had been experienced by 42.5%, whereas 35.1 % felt that their choice of jobs and occupations had been affected negatively by their OCD, and 22.8% answered that their work tasks had been changed because of OCD. Sick leave and decrease in income because of OCD were experienced by 14.2% and 11.8%, respectively, whereas 8.2% found it difficult

TABLE 6 Current occupational status and occupational consequences of occupational contact dermatitis

	n (%)
Current occupational status (n = 2355)	
Working	1666 (70.7)
Stay-at-home	46 (2.0)
Unemployed	158 (6.7)
Under education	329 (14.0)
Working part-time while studying (n = 276)	126 (45.7)
Maternity/paternity leave	139 (5.9)
Disability pension	16 (0.7)
Retired	<3[a] (0.0)
Changed occupational field (n = 2015)	1064 (52.8)
Experienced job loss due to OCD (n = 2336)	993 (42.5)
Other consequences of OCD (n = 2333)	
Choice of jobs and occupations is negatively affected	818 (35.1)
Work tasks have been changed	533 (22.8)
Sick leave	332 (14.2)
Decrease in income	276 (11.8)
Difficulties finding work	192 (8.2)
Colleagues and/or employer have a negative attitude	139 (6.0)
Retirement	7 (0.3)

Abbreviations: OCD, occupational contact dermatitis.
[a]Exact numbers cannot be disclosed due to discretion rules.

finding work, and 6.0% answered that their colleagues and/or employer had a negative attitude toward them because of their OCD.

Most of the responders were currently working or under education at the time of the questionnaire (71% and 14%, respectively), and the majority had a higher education of 1 to >4 years duration (69%). More than half of the study population had changed their occupation field since the development of OCD and were currently working in a different occupational field (53%).

In Table 7, the distribution of a selection of the occupational consequences as well as the accompanying ORs according to gender, age at notification, diagnosis, and occupation listed as causal to the development of OCD by the respondents is listed.

Age at notification ≤25 years increased the OR of experiencing job loss because of OCD (OR 1.3, 95% CI: 1.1-1.6) and feeling that your choice of job is negatively affected (OR 1.4, 95% CI: 1.2-1.7).

A diagnosis of OACD was also strongly related to having experienced job loss (OR 1.6, 95%CI: 1.3-1.9), feeling that your choice of job is negatively affected (OR 1.2, 95%CI 1.0-1.5), decrease in income (OR 1.7, 95%CI: 1.3-2.4), and having difficulties finding work (OR 1.8, 95%CI: 1.3-2.5).

The highest OR for having experienced job loss because of OCD was found among butchers and slaughter house workers (OR 3.6, 95%CI: 1.4-9.2), with almost 75% having experienced job loss because of OCD, followed by hairdressers and beauticians (OR 2.8, 95% CI: 1.9-4.1), where 65.4% had experienced job loss because of OCD. Hairdressers and beauticians also had a statistically significantly increased OR of experiencing a decrease in income because of OCD

TABLE 7 Occupational consequences of OCD: Distribution of selected occupational consequences of OCD according to gender, age at notification, diagnosis, and occupation related to debut of OCD

	Total	Job loss because of OCD, n (%)	OR (95%CI)	Choice of jobs is negatively affected, n (%)	OR (95%CI)	Decrease in income because of OCD, n (%)	OR (95%CI)	Difficulty finding work because of OCD, n (%)	OR (95%CI)
Total	2336	993 (42.5)		818 (35.1)		199 (8.5)		192 (8.2)	
Gender									
Male	589	266 (45.2)	1.2 (1-1.4)	199 (34)	1 (0.8-1.2)	59 (10.1)	1.3 (0.9-1.8)	51 (8.7)	1 (0.7-1.4)
Female	1747	727 (41.6)	1	619 (35.4)	1	140 (8)	1	141 (8.1)	1
Age at notification									
≤25 y	1106	512 (46.3)	**1.3 (1.1-1.6)**	437 (39.6)	**1.4 (1.2-1.7)**	85 (7.7)	0.8 (0.6-1.1)	90 (8.2)	1 (0.8-1.4)
>25 y	1230	481 (39.1)	1	381 (31)	1	114 (9.3)	1	102 (8.3)	1
Diagnosis									
Occupational allergic contact dermatitis	538	276 (51.3)	**1.6 (1.3-1.9)**	209 (38.7)	**1.2 (1-1.5)**	66 (12.2)	**1.7 (1.3-2.4)**	64 (11.9)	**1.8 (1.3-2.5)**
Occupational irritant contact dermatitis	1798	717 (39.9)	1	609 (34)	1	133 (7.4)	1	128 (7.1)	1
Occupation listed as causal to the development of OCD[a]									
Health care workers	699	219 (31.3)	**0.5 (0.4-0.7)**	217 (31.1)	**0.8 (0.6-1)**	45 (6.5)	0.7 (0.5-1.1)	37 (5.3)	**0.5 (0.4-0.8)**
Kitchen personnel	372	197 (53)	**1.6 (1.3-2)**	151 (40.8)	**1.3 (1-1.6)**	37 (10)	1.4 (0.9-2)	35 (9.5)	1.3 (0.9-2)

(Continues)

TABLE 7 (Continued)

	Total	Job loss because of OCD, n (%)	OR (95%CI)	Choice of jobs is negatively affected, n (%)	OR (95%CI)	Decrease in income because of OCD, n (%)	OR (95%CI)	Difficulty finding work because of OCD, n (%)	OR (95%CI)
Nursery teachers	135	31 (23)	**0.4 (0.3-0.6)**	42 (31.6)	0.9 (0.6-1.3)	8 (6)	0.7 (0.4-1.5)	10 (7.5)	1 (0.5-1.9)
Hairdressers and beauticians	130	85 (65.4)	**2.8 (1.9-4.1)**	54 (41.9)	1.3 (0.9-1.9)	17 (13.2)	**2 (1.2-3.5)**	15 (11.6)	1.7 (0.9-3)
Craftsmen/builders	126	58 (46)	1.1 (0.8-1.7)	52 (41.6)	1.4 (1-2.1)	16 (12.8)	1.5 (0.9-2.8)	12 (9.6)	1.2 (0.6-2.4)
Mechanics/fitters/technicians	122	53 (43.4)	1 (0.6-1.4)	46 (38)	1.2 (0.8-1.9)	6 (5)	0.5 (0.2-1.1)	9 (7.4)	0.9 (0.4-1.8)
Mixed manual workers	108	50 (46.3)	1.3 (0.9-1.9)	44 (41.1)	1.3 (0.9-2)	7 (6.5)	0.8 (0.4-1.8)	10 (9.3)	1.3 (0.7-2.6)
Sale assistants	87	32 (36.8)	0.8 (0.5-1.3)	20 (22.5)	**0.5 (0.3-0.8)**	3 (3.4)	0.4 (0.1-1.3)	3 (3.4)	0.4 (0.1-1.2)
Bakers and pastry chefs	86	47 (54.7)	**1.6 (1-2.5)**	37 (43)	1.4 (0.9-2.1)	6 (7)	0.9 (0.4-2.1)	12 (14)	**2 (1.1-3.8)**
Cleaning personnel	69	37 (53.6)	**1.7 (1.1-2.8)**	22 (31.4)	0.9 (0.5-1.5)	12 (17.1)	**2.4 (1.3-4.7)**	9 (12.9)	1.6 (0.8-3.3)
Agricultural workers/farmers	46	30 (65.2)	**2.5 (1.3-4.6)**	14 (30.4)	0.8 (0.4-1.6)	4 (8.7)	1 (0.4-2.9)	8 (17.4)	**2.4 (1.1-5.3)**
Office workers	46	7 (15.2)	**0.3 (0.1-0.6)**	12 (26.1)	0.7 (0.4-1.4)	0 (0)	0 (0-0)	0 (0)	0 (0-0)
Butchers/slaughterhouse workers	23	17 (73.9)	**3.6 (1.4-9.2)**	6 (26.1)	0.7 (0.3-1.9)	3 (13)	1.7 (0.5-5.8)	3 (13)	1.7 (0.5-5.9)
Machine operators/metalworkers	23	13 (56.5)	1.8 (0.8-4.2)	8 (34.8)	1.2 (0.5-2.9)	1 (4.3)	0.4 (0.1-3)	1 (4.3)	0.5 (0.1-3.5)
Gardeners	18	4 (22.2)	0.4 (0.1-1.1)	5 (25)	0.7 (0.2-1.8)	1 (5)	0.6 (0.1-4.2)	1 (5)	0.6 (0.1-4.2)
Other occupations	135	51 (37.8)	0.8 (0.6-1.2)	45 (33.8)	0.9 (0.6-1.3)	13 (9.8)	1.2 (0.7-2.3)	10 (7.5)	0.9 (0.5-1.8)

Note: Logistic regression analysis with the outcome odds ratio (OR) of selected occupational consequences of OCD, adjusted by the variables atopic dermatitis, age at notification, gender, and years since notification. Significant *P*-values are shown in bold face.
Abbreviations: CI, confidence interval; OCD, occupational contact dermatitis; OR, odds ratio.
[a]Each occupation is compared to all the other occupations in the multivariable logistic regression analysis.

TABLE 8 Typical examples of open statements from respondents concerning impact of occupational contact dermatitis

Statements on physical and emotional impact of OCD
I am extremely sad that my eczema continues and affects my daily life so much. My fingers hurt, my skin is scaling and leaving open wounds. It is really painful. My hands look terrible. I cancel dates, because I am embarrassed. I am afraid to hold hands, touch people, have sex, cook for other people. I am afraid they will think I am disgusting. I am so ashamed.
My hands are very ugly because of eczema and my self-confidence is very low. I do not like to socialize with people, I do not know, as I feel they stare at my hands. Eg, I do not admit I have baked a cake, I say it is my sister, because who will eat a cake, if it has been baked with my ugly hands?
It has been incredibly humiliating at the workplace to have conditions for being able to work there.
Sometimes I cannot tolerate being touched by my wife or children due to my eczema. It is a terrible feeling for me.
I think the compensation for injury I received at the time was too low considering it is something I have to live with the rest of my life.
Statements on impact of OCD on career and economy
It affects me a lot in my daily life, apart from the pain and the difficulty in doing everyday tasks, the thing is that I cannot choose my jobs in the future. It is very frustrating.
I have had my eczema for many years. It started because of glove use. I have suffered considerable economic losses and have not been able to get a job in the health care sector, as there are certain tasks I cannot do.
My skin disease has been very costly, as I cannot continue my job as chef after my training. I could not be retrained or get a grant to educate me further.
I have really lost a lot of money by having to leave my education/job
My skin problem gets worse all the time. I do not know if I can continue working.
I had to change career due to my eczema. I have not been able to get a job using my new education. I therefore work as a kindergarten assistant, and that affects my hands. I am worried how bad it can get, before I cannot have this job either.
My eczema has destroyed the career-dream I had. I would have like to become baker, pastry chef, or chocolatier.

TABLE 8 (Continued)

I had to change career from being hairdresser—I was one of the best in the country. It was my passion. It hurts that I cannot do this anymore.
Statements on health care system
Hand eczema is a bigger problem than people assume, and all too little information is given about it, and all too little help is offered.
It is terrible to have hand eczema in many ways, and the patients with hand eczema are not taken care of before it goes wrong. I have never got any support.
Not much help from the system, when you get eczema. I just had to move on and find a job and then tolerate my eczema. My eczema is chronic, and they cannot do more for me. This is what the said, anyway.
Statements concerning wishes for the future
My biggest wish is to get rid of my eczema one day.
I hope your investigation will make a difference.
I dream that one day my eczema will go away, and I can live an ordinary life as before the eczema.

(OR 2, 95% CI: 1.2-3.5), as well as cleaning personnel (OR 2.4, 95% CI: 1.3-4.7). Bakers and pastry chefs and agricultural workers and farmers had a higher OR of having difficulty finding work because of OCD (OR 2, 95% CI: 1.1-3.8 and 2.4, 95% CI: 1.1-5.3, respectively). Health care workers generally had a statistically significantly lower OR for several of the occupational consequences: job loss (OR 0.5, 95% CI: 0.4-0.7), choice of jobs negatively affected (OR 0.8, 95% CI: 0.6-1.0), and having difficulty finding work (OR 0.5, 95% CI: 0.4-0.8).

3.7 | Quality of life and emotional impact of OCD

The health-related quality of life of the respondents was evaluated by Skindex-29 and EQ-5D-5L. The results can be found in the Appendix S1. Skindex-29 evaluated the effect as moderate on emotions and functioning and severe with regard to symptoms. The EQ-5D-5L found that 18.1% were in moderate pain/discomfort and 5.1% were in severe pain/discomfort. Sixteen participants even answered that they were in extreme pain/discomfort. Furthermore, 16.9% answered that they were slightly anxious/depressed, and 5.6% and 2.2% answered that they were moderately and severely anxious/depressed, respectively.

In Table 8, some of the typical statements made within each of the four categories described in the Methods section are presented. Respondents described severe emotional strain in connection with their OCD, with sadness over not being able to work in their chosen field, and shame over having eczema. Each statement was presented by a unique person.

4 | DISCUSSION

4.1 | Long-term effects on severity of eczema

On average 6 years after notifying the DLMI of their eczema as being occupational, the vast majority of workers still had symptoms, with 76% having had eczema within the last 3 months (76%), 77% of these listed the eczema as being present half to all the time within the last 3 months, and 61% within the last 3 months as moderate to very severe. The prognosis of OCD has been the subject of several previous studies, but due to differing criteria for healing and measurement of severity the studies are hard to compare. Meding et al[15] found in a 12-year follow-up study that 70% of workers with OCD had had symptoms within the last year, whereas a Danish study from 2006 found that, on average, 25% of workers with recognized OCD had aggravated or persistent severe OCD 1 year after recognition.[16] A Finnish study from 2010 found that OCD had healed in 40% of workers 7-14 years after diagnosis (defined as no eczema during the last year), leaving the remaining 60% as having had eczema within the last year.[17] It is evident, not only from our present study, that OCD has severe long-term effects, and that the healing rates of OCD even many years after recognition are not satisfactory, considering the severe effect having eczema has on overall life.

We found men to have a lower OR than women for having had eczema within the last 3 months. This difference is probably the result of different exposure patterns both at work and at home, with women generally having more wet-work tasks than men,[18] and not the consequence of a genetic difference between the sexes.

4.2 | Occupational consequences of occupational contact dermatitis

We found severe occupational consequences of OCD, as 42.5% had experienced job loss due to OCD, and 35.1% felt that their choice of jobs and occupations was negatively affected; in total 11.8% experienced a decrease in income, which corresponds to the findings in our previous study, showing that workers with OCD on average experienced a drop in income of €1570 per year after notifying the DLMI of an OCD.[3] Especially young people (≤25 years of age at notification) had a higher OR for experiencing job loss and feeling like choice of jobs was negatively affected. This is also encompassed by the open statements, where the respondents expressed frustration over not being able to continue their career, broken dreams, and difficulties in getting a new job/career. These findings are concerning, considering that they are on their way into the job market, and in the beginning of their career.

Men were found to have a higher OR for being awarded a degree of injury ≥15%, and for having OCD located to the face or feet. We also found men to have a statistically significantly higher OR for having OACD. This corresponds to earlier studies, that have found that males have a higher prevalence of OACD compared to females because of exposures related to the metal-working industry and work tools, among others,[4,19] which can explain this gender discrepancy.

4.3 | Quality of life and emotional impact of OCD

Many previous studies have examined the effect of hand eczema and OCD on quality of life, all of them agreeing that OCD has detrimental effects on quality of life.[20-22] We also found that the quality of life was affected in the responders of the study, with Skindex-29 measuring the impact on emotions and functioning as moderate, and symptoms as severe. The open statements illustrated this as well, talking about pain, shame, and humiliation as well as avoiding social situations due to the OCD.

4.4 | Occupational allergic contact dermatitis

OACD was significantly related to a higher OR for many of the consequences of OCD, compared to OICD. Job loss, feeling like choice of jobs was negatively affected, experiencing a decrease in income, and having difficulty finding work were significantly more prevalent among workers with OACD. This may be due to some allergens such as biocides being widespread in the work environment or linked to key procedures of the job, for example, working with epoxy or metal-working fluids. Furthermore, OACD increased the OR of having both hand and foot OCD; this is not surprising as allergic eczema generally causes a more widespread disease than irritant eczema.

OACD was, on the other hand, associated with a significantly lower OR for having had eczema within the last 3 months as compared to OICD. These results are supported by the findings of Cvetkovski et al[23] that patients with OICD have a more severe disease course than those with OACD. A possible explanation for this could be that workers with OACD know which exposure to avoid, whereas workers with OICD have more difficulties avoiding general skin hazardous exposures such as wet work. Adding to this, there has been an increased focus on regulating the use of known allergens in everyday products (ie, the restriction of hexavalent chromium in leather product coming into contact with the skin to no more than 3 mg/kg in the European Union in 2014),[24] making it easier to live with a known allergy. Workers with recognized OICD, on the other hand, may have undiscovered allergies, making it harder to avoid the triggers. A possible culprit could be the use of methylisothiazolinone (MI) as a preservative. MI was approved in 2005 as a stand-alone preservative in cosmetics and household products in the European Union. The use was later substantially restricted in 2017 by regulations in the European Union, but in the intermediate period many people developed allergic contact dermatitis to MI. It is possible that some of the workers with recognized OICD from the same period in reality had an unknown allergy to MI, as it was not included in the testing immediately at approval. Furthermore, a Danish study from 2009 found that patients tested and treated in the hospital sector had a higher prevalence of positive patch-test results compared to patients treated by private dermatologists.[25]

Of workers with OACD, 22.7% were awarded a degree of injury ≥15%, compared to only 9.4% of workers with OICD. An explanation for a big part of this difference may be that many allergies will result in the addition of five extra percentage points of degree of injury, but also that OACD was more widespread involving the face and feet, which means that extra compensation is awarded. Furthermore, workers with OICD often will have a history of atopic dermatitis,[26] resulting in the subtraction of percentage points of degree of injury.

4.5 | Occupations and OCD

Hairdressers and beauticians had a higher OR for job loss because of OCD and experiencing a decrease in income because of OCD, with 65.4% of hairdressers having experienced job loss because of OCD. This corresponds to previous findings, where 44.3% of hairdressers left the hairdressing field after an average of 8.4 years, with 45.5% listing hand eczema as the main reason for changing their occupation.[27]

Agricultural workers/farmers and craftsmen/builders are known to have a high exposure to dust at the workplace, which could explain the significantly higher OR for having facial OCD. Agricultural workers/farmers were also found to have a higher OR for experiencing job loss and having difficulty finding work because of OCD, probably because it is not possible to avoid exposures triggering their disease on the job.

Workers in the food industry are generally exposed to high levels of wet work,[28] and the development of OCD can have severe occupational consequences, as they are unable to work with broken skin on their hands for sanitary reasons. Cvetkovski et al[23] found that workers in the food industry both had a higher proportion of prolonged sick leave and had more often experienced loss of job within the last 12 months because of OCD compared to those in other occupations. This is also supported by the findings in our study, where workers in the food industry (kitchen personnel, bakers and pastry chefs, and butchers/slaughterhouse workers) had significantly higher ORs for having experienced job loss because of their OCD, compared to the other occupations. Butchers/slaughterhouse workers had the highest OR for being awarded a degree of injury ≥15% and for having experienced job loss because of OCD, again signifying the severe consequences of OCD when working in the food industry. Workers in food-related occupations have been shown previously to have a lower clearance rate of their eczema than other occupations. Butcher and kitchen personnel were among the most severely affected subgroups in an earlier Danish study examining severity of OCD 1 year after recognition of OCD,[16] and a follow-up study 7-14 years after diagnosis of OCD among Finnish workers, found that workers in the food industry had the lowest frequency of healing (although not statistically

significant).[17] The present study also found kitchen personnel to have a higher OR than other occupations for having had eczema within the last 3 months. Considering that 52.8% of the respondents had changed to a different occupational field since the debut of their OCD, many of the kitchen personnel will no longer be working as kitchen personnel at the time of the questionnaire, so the explanation for the higher OR for having current eczema could also be related to the nature of the exposure that resulted in developing OCD from working in a kitchen. Kitchen personnel are often exposed to high levels of wet work, resulting in the development of OICD, which we have found to be related to a higher OR for having current eczema than OACD.

Health care workers were found to have a lower OR for having both face and foot OCD. The exposures related to working in health care will more often result in hand eczema than face or foot eczema. In general, health care workers are known to have a high exposure to wet work, with frequent handwashing and the frequent use of occlusive gloves and hand sanitizers.[29]

Health care workers generally had a lower OR for many of the occupational consequences related to OCD (ie, job loss, feeling like choice in jobs is negatively affected, and having difficulties finding work because of OCD), which is thought-provoking, considering that many studies on OCD are done on health care workers,[29-32] presenting the risk of severely underestimating the general consequences of OCD. The lower OR for occupational consequences related to OCD among health care workers could be because health care workers often work in a bigger hospital settings, allowing them to relocate to different more tolerated work functions in comparison to many of the other occupations.

4.6 | Strength and weakness

To the best of our knowledge, the present study is the first epidemiological study of OCD focusing on the young workforce. The strength of this study was the large size of the study population composed of all recognized cases of OCD in Denmark between January 2007 and December 2019, who were younger than 35 years of age at notification. The response rate of 47% is not impressive, but acceptable, and since no major differences between responders and nonresponders were identified, we therefore consider it unlikely that the associations found in the present study are caused by selection bias. A study examining events many years in the past is always vulnerable to recall bias, as is also the case in our study.

4.7 | Conclusion and implications

The severe, long-term consequences of OCD on average 6 years after notification are evident in this study. Given the impact of OCD on the future work life and well-being of the afflicted workers, the authors suggest that it is time to treat the disease with a different state of alertness. There is a need for a national action plan for effective prevention of OCD among young workers, especially in high-risk occupations; for already afflicted workers, we suggest a systematic approach with early and highly specialized testing and treatment in order to reduce the risk of long-term consequences. The open statements of the respondents in this study, which are recognizable for most clinicians treating patients with OCD, makes it evident, that better prevention is also desired by the workers with OCD.

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AUTHOR CONTRIBUTIONS

Torkil Menné: Conceptualization (supporting); methodology (supporting); supervision (equal); writing – review and editing (equal). **Harald William Meyer:** Supervision (equal); writing – review and editing (equal). **Sven Viskum:** Supervision (equal); writing – review and editing (equal). **Mari-Ann Flyvholm:** Conceptualization (supporting); funding acquisition (equal); supervision (equal); writing – review and editing (equal). **Ulrik Ahrensbøll-Friis:** Supervision (supporting); writing – review and editing (equal). **Swen Malte John:** Supervision (equal); writing – review and editing (equal). **Jeanne Duus Johansen:** Conceptualization (lead); formal analysis (supporting); funding acquisition (equal); methodology (equal); project administration (equal); supervision (lead); writing – original draft (supporting); writing – review and editing (equal).

CONFLICTS OF INTERESTS

The authors declare no conflict of interests.

DATA AVAILABILITY STATEMENT

Restrictions apply to the availability of these data, which were used under license for this study.

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REFERENCES

1. Hutchings CV, Shum KW, Gawkrodger DJ. Occupational contact dermatitis has an appreciable impact on quality of life. *Contact Dermatitis*. 2001;45(1):17-20.
2. Carøe TK, Ebbehøj NE, Bonde JP, Agner T. Occupational hand eczema and/or contact urticaria: factors associated with change of profession or not remaining in the workforce. *Contact Dermatitis*. 2018;78(1):55-63. doi:10.1111/cod.12869
3. Dietz JB, Menné T, Meyer HW, et al. Degree of employment, sick leave, and costs following notification of occupational contact dermatitis—a register-based study. *Contact Dermatitis*. 2020;84(4):224-235. doi:10.1111/cod.13719
4. Skoet R, Olsen J, Mathiesen B, Iversen L, Johansen JD, Agner T. A survey of occupational hand eczema in Denmark. *Contact Dermatitis*. 2004;51(4):159-166. doi:10.1111/j.0105-1873.2004.00423.x
5. Dickel H, Kuss O, Blesius CR, Schmidt A, Diepgen TL. Occupational skin diseases in northern Bavaria between 1990 and 1999: a

population-based study. *Br J Dermatol*. 2001;145(3):453-462. doi:10.1046/j.1365-2133.2001.04377.x
6. Uter W, Pfahlberg A, Gefeller O, Schwanitz HJ. Prevalence and incidence of hand dermatitis in hairdressing apprentices: results of the POSH study. Prevention of occupational skin disease in hairdressers. *Int Arch Occup Environ Health*. 1998;71(7):487-492.
7. Bauer A, Bartsch R, Hersmann C, et al. Occupational hand dermatitis in food industry apprentices: results of a 3-year follow-up cohort study. *Int Arch Occup Environ Health*. 2001;74(6):437-442. doi:10.1007/s004200100241
8. Coenraads PJ, Van Der Walle H, Thestrup-Pedersen K, et al. Construction and validation of a photographic guide for assessing severity of chronic hand dermatitis. *Br J Dermatol*. 2005;152(2):296-301. doi:10.1111/j.1365-2133.2004.06270.x
9. Finlay AY, Khan GK. Dermatology life quality index (DLQI)—a simple practical measure for routine clinical use. *Clin Exp Dermatol*. 1994;19(3):210-216. doi:10.1111/j.1365-2230.1994.tb01167.x
10. Chren M, Lasek RJ, Flocke SA, Zyzanski SJ. Improved discriminative and evaluative capability of a refined version of Skindex, a quality-of-life instrument for patients with skin diseases. *Arch Dermatol*. 1997;133(11):1433-1440.
11. Janssen MF, Pickard AS, Golicki D, et al. Measurement properties of the EQ-5D-5L compared to the EQ-5D-3L across eight patient groups: a multi-country study. *Qual Life Res*. 2013;22(7):1717-1727. doi:10.1007/s11136-012-0322-4
12. Nijsten T, Sampogna F, Abeni D. Categorization of Skindex-29 scores using mixture analysis. *Dermatology*. 2009;218(2):151-154. doi:10.1159/000182253
13. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap) – a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377-381.
14. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform*. 2019;95(April):103208. doi:10.1016/j.jbi.2019.103208
15. Meding B, Lantto R, Lindahl G, Wrangsjö K, Bengtsson B. Occupational skin disease in Sweden - a 12-year follow-up. *Contact Dermatitis*. 2005;53(6):308-313. doi:10.1111/j.0105-1873.2005.00731.x
16. Cvetkovski RS, Zachariae R, Jensen H, Olsen J, Johansen JD, Agner T. Prognosis of occupational hand eczema. *Arch Dermatol*. 2006;142(3):305-311.
17. Mälkönen T, Alanko K, Jolanki R, et al. Long-term follow-up study of occupational hand eczema. *Br J Dermatol*. 2010;163(5):999-1006. doi:10.1111/j.1365-2133.2010.09987.x
18. Bryld LE, Hindsberger C, Kyvik KO, Agner T, Menne T. Risk factors influencing the development of hand eczema in a population-based twin sample. *Br J Dermatol*. 2003;149(6):1214-1220. doi:10.1111/j.1365-2133.2003.05678.x
19. Dietz JB, Menné T, Meyer HW, et al. Incidence rates of occupational contact dermatitis in Denmark between 2007 and 2018: a population-based study. *Contact Dermatitis*. 2021;85(4):421-428. doi:10.1111/cod.13910
20. Skoet R, Zachariae R, Agner T. Contact dermatitis and quality of life: a structured review of the literature. *Br J Dermatol*. 2003;149(3):452-456. doi:10.1046/j.1365-2133.2003.05601.x
21. Moberg C, Alderling M, Meding B. Hand eczema and quality of life: a population-based study. *Br J Dermatol*. 2009;161(2):397-403. doi:10.1111/j.1365-2133.2009.09099.x
22. Agner T, Andersen KE, Brandao FM, et al. Hand eczema severity and quality of life: a cross-sectional, multicentre study of hand eczema patients. *Contact Dermatitis*. 2008;59(1):43-47. doi:10.1111/j.1600-0536.2008.01362.x
23. Cvetkovski RS, Rothman KJ, Olsen J, et al. Relation between diagnoses on severity, sick leave and loss of job among patients with occupational hand eczema. *Br J Dermatol*. 2005;152(1):93-98. doi:10.1111/j.1365-2133.2005.06415.x
24. European Union Commission regulation (EU) No. 301/2014 of 25 March2014 amending Annex XVII to regulation (EC) No. 1907/2006 of the European Parliament and of the Council on the Registration. Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards chromium VI compounds Text with EEA relevance.
25. Hald M, Agner T, Blands J, et al. Clinical severity and prognosis of hand eczema. *Br J Dermatol*. 2009;160(6):1229-1236. doi:10.1111/j.1365-2133.2009.09139.x
26. Nicholson PJ. Occupational contact dermatitis: known knowns and known unknowns. *Clin Dermatol*. 2011;29(3):325-330. doi:10.1016/j.clindermatol.2010.11.012
27. Lysdal SH, Søsted H, Andersen KE, Johansen JD. Hand eczema in hairdressers: a Danish register-based study of the prevalence of hand eczema and its career consequences. *Contact Dermatitis*. 2011;65(3):151-158. doi:10.1111/j.1600-0536.2011.01935.x
28. Carøe TK, Ebbehøj NE, Bonde JPE, Flachs EM, Agner T. Hand eczema and wet work: dose – response relationship and effect of leaving the profession. *Contact Dermatitis*. 2018;6(5):341-347. doi:10.1111/cod.12934
29. Ibler KS, Jemec GBE, Agner T. Exposures related to hand eczema: a study of healthcare workers. *Contact Dermatitis*. 2012;66(5):247-253. doi:10.1111/j.1600-0536.2011.02027.x
30. Ibler KS, Jemec GBE, Flyvholm MA, Diepgen TL, Jensen A, Agner T. Hand eczema: prevalence and risk factors of hand eczema in a population of 2274 healthcare workers. *Contact Dermatitis*. 2012;67(4):200-207. doi:10.1111/j.1600-0536.2012.02105.x
31. Wilke A, Gediga K, Weinhöppel U, John SM, Wulfhorst B. Long-term effectiveness of secondary prevention in geriatric nurses with occupational hand eczema: the challenge of a controlled study design. *Contact Dermatitis*. 2012;66(2):79-86. doi:10.1111/j.1600-0536.2011.01976.x
32. Held E, Wolff C, Gyntelberg F, Agner T. Prevention of work-related skin problems in student auxiliary nurses: an intervention study. *Contact Dermatitis*. 2001;44(5):297-303. doi:10.1034/j.1600-0536.2001.440509.x

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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10.3 Manuscript III: Degree of employment, sick leave, and costs following notification of occupational contact dermatitis – A register-based study

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ORIGINAL ARTICLE

CONTACT DERMATITIS WILEY

Degree of employment, sick leave, and costs following notification of occupational contact dermatitis—A register-based study

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Abstract

Background: Occupational contact dermatitis (OCD) is the most commonly recognized occupational disease in Denmark.

Objectives: To examine the impact of recognized OCD on degree of employment, sick leave, unemployment, and job change.

Methods: Data on all recognized individuals with OCD notified in Denmark between 2010 and 2015 (n = 8940) were linked to information on social transfer payments in the years before and after notification. The number of weeks on unemployment benefits or sick leave and the degree of employment during the 2 years prior to notification was compared with the 2 years following notification.

Results: The degree of employment decreased on average 8.9 work-hours/month, corresponding to an average annual loss of income per worker of approximately €1570. The average number of weeks that workers were receiving unemployment benefits and paid long-term sick leave rose by 2.5 and 3.4 weeks, respectively, corresponding to an average additional annual cost per worker of approximately €420 and €770, respectively. Longer case-processing time was significantly associated with lower degree of employment and higher levels of unemployment and sick leave.

Conclusions: OCD has a significant negative impact on employment and economics, thus highlighting the need for a national, strategic action plan for effective prevention of OCD.

KEYWORDS

allergic contact dermatitis, degree of employment, irritant contact dermatitis, job loss, labor market affiliation, occupational, prognosis, sick leave

1 | INTRODUCTION

Occupational contact dermatitis (OCD) is the most commonly recognized occupational disease in Denmark, comprising around one-third of all recognized occupational diseases.[1] More than 90% of all OCD cases have eczema on the hands.[2,3] The 1-year prevalence of hand eczema in the general population is approximately 10% and twice as high in high-risk occupations such as health care and hairdressing.[4-6]

OCD often has an early onset in life, the average age at debut being 25 to 36 years.[2,7] Furthermore, OCD often debuts during

training or within the first few months of working in high-risk occupations.[2] OCD is often a chronic relapsing condition with a poor prognosis, and considerable impact on the quality of life and the work-life of the individual.[4,8-10] In Germany, the socioeconomic costs of OCD have been estimated to exceed €1.5 billion.[11] In Denmark, the socioeconomic costs have been suggested to be close to €100 million a year, but this estimate is based on assumptions made more than 20 years ago.[12]

In several countries, different kinds of prevention programs aimed at reducing the burden of OCD have been tested.[11,13-16] Considering the impact of OCD, surprisingly few investigations into the potentially derived inequality in health, and societal and personal costs exist. The aim of this study was to investigate the occupational and socioeconomic consequences of having OCD and to examine the indicators of potential inequality due to OCD using Danish official registers of OCD, sick leave, and social benefits in order to estimate societal costs.

2 | METHODS

Study definitions can be found in Table 1.

2.1 | Study population

The study population consisted of all workers with OCD, who were notified to the Danish Labour Market Insurance (DLMI) from January 1, 2010 to December 31, 2015. Only cases later recognized as being occupational diseases were included in the study population (latest recognition date was December 31, 2018) resulting in 8940 cases.

2.2 | Data from the Danish Labour Market Insurance (DLMI) register

The DLMI register comprises all notified and recognized cases of occupational diseases in Denmark. In Denmark, anyone can notify the DLMI of an occupational disease, whereas doctors and dentists are obliged by law to notify all suspected cases without delay. Almost all notifications are made by doctors. Individuals with suspected OCD are patch tested and examined by a dermatologist. In most cases, the DLMI will ask for a dermatologist's statement as the basis for their case handling. A lawyer, supported by medical specialists, is responsible for the final decision regarding recognition. The main criteria for recognition of OCD are that the disease should present itself with typical symptoms documented in the patient's files by a doctor, and that a relationship in time is established between the OCD and the documented exposures at the workplace, and that these exposures are known to cause contact dermatitis. The contact dermatitis can be recognized as occupational if the above-mentioned criteria are met, and this can result in compensation to the worker. It is possible also to have a worsening of a pre-existing skin disease recognized as a partly occupational disease. The data used in this study were obtained from the DLMI register, and included demographic information such as sex and age at onset, diagnosis, and information on industry of employment. The classification of the industry of employment was based on the Danish Industry Code year 2007 (DB07). The 726 different industries of employment in DB07 were for analysis purposes

TABLE 1 Study definitions

Degree of employment	Number of hours the worker has been working in a given month (work-hours/month).
Case-processing time	The time between notification and recognition. As all doctors are required by law to notify the DLMI at the first suspicion of occupational contact dermatitis (OCD), we use the time between notification and recognition as a proxy for the time between the first visit to a doctor with symptoms of OCD and the final diagnosis. A long case-processing time is therefore indicative of a complex disease and/or that the worker has had a longer way through the medical system. The case-processing time was dichotomized to ≤1 year (short case-processing time) or >1 year (long case-processing time).
Employer sick leave period	The period that a worker is required to be on sick leave before being eligible for paid long-term sick leave. During the employer sick leave period, the worker's sick leave is covered by the employer. Changing legal reforms have resulted in differing employer sick leave periods during the period being evaluated in this study.
Decrease in degree of employment of ≥21 work-hours/month	The 25% of the workers in our study population who experienced the greatest decrease in degree of employment during the 2 years after notification decreased with ≥21 work-hours/month. For this reason, we chose a decrease in degree of employment of ≥21 work-hours/month as the cut-off point when evaluating which occupational groups were most affected by their OCD.
Exceedingly high-risk occupations	Occupations with incidence rates of OCD ≥7 cases per 10 000 workers per year.
High-risk occupations	Occupations with incidence rates of OCD 3–7 cases per 10 000 workers per year.
Self-supporting	Periods of time during which the worker is not given any form of government subsidy.
Unemployment benefits	All forms of governmental subsidies given during periods during which the worker is not employed.
Paid long-term sick leave	Governmental subsidy given during sick leave stretching beyond the initial employer sick leave period.

categorized into 24 main occupational groups with inspiration from the literature.[7,17] Some workers occurred several times in the register, and to avoid duplicates, workers with both a recognized occupational irritant contact dermatitis (OICD) and a recognized occupational allergic contact dermatitis (OACD) were coded as having an OACD.

2.3 | Data from the Danish Register for Evaluation of Marginalization

Data from the DLMI register was transferred to Statistics Denmark, and Statistics Denmark linked the data from the DLMI register to the information from the Danish Register for Evaluation of Marginalization (DREAM) on an individual level. DREAM comprises information on the weekly social transfer payments for all inhabitants in Denmark (such as paid long-term sick leave, disability pension, education grant, unemployment benefits, and maternity pay), and the degree of employment for each month (work-hours/month). Only paid long-term sick leave is registered in the DREAM register. Before being eligible for paid long-term sick leave, the worker must receive sick leave for a set period of time covered by their employer, called the employer sick leave period. Changing legal reforms have resulted in different employer sick leave periods between January 2008 and December 2017. The employer sick leave period was 15 days between April 2007 and June 2008, 21 days between June 2008 and January 2012, and 30 days between January 2012 and ongoing.[18] The length of the employer sick leave period and the reasons for paid long-term sick leave are not registered in the DREAM register. Moreover, the DREAM data included demographic information about sex, origin, citizenship, place of residency (municipality), place of work (municipality), and industry of employment for each month (DB07).

2.4 | Data analysis and statistics

The statistical analyses were made in SPSS version 24. Analyses comprised prevalence proportions (PPs), paired sample *t* test, independent samples *t* test, two-way analysis of variance (ANOVA), and binary logistic regression models. All *P*-values are two-sided, and a 5% level of statistical significance was used. The estimated incidence rates of OCD (cases per 10 000 person-years) according to the occupational groups were calculated based on the average yearly numbers of full-time employees in the various occupational groups between 2010 and 2015. These data were provided by estatistik.dk in March 2020.

In this study, we used the workers with OCD as their own controls, as we compared the degree of employment and the number of weeks self-supporting or on unemployment benefits or paid long-term sick leave in the 2 years after notification with the 2 years before notification of OCD. To avoid misleading results, the following exclusion criteria were applied: death, emigration, maternity leave, or retirement on age pension (public) within 2 years before or after notification of the OCD, or age <18 years 2 years before notification (Appendix S1), leaving 6685 workers for analysis.

Paired sample *t* test was used to compare the degree of employment (work-hours/month) and the average number of weeks that workers were self-supporting, obtaining unemployment benefits, or paid long-term sick leave during the 2 years before and after notification. The changing length of the employer sick leave period during the period of evaluation in this study represented a problem. A worker being on sick leave for 30 days would be registered in the DREAM registry with three different durations depending on when he was sick (15 days if he was sick between January 2008 and June 2008, 9 days if he was sick between June 2008 and January 2012, and 0 days if he was sick between January 2012 and December 2017). In addition, the problem could not be solved by adding the known length of the employer sick leave period to the registered data, as the earlier described worker would figure in the data with 30 days if he was sick between January 2008 and January 2012, and 0 days if he was sick between January 2012 and December 2017. For this reason we decided to compare only the amount of paid long-term sick leave before and after notification of OCD on workers, who had the same employer sick leave period during the 2 years before and after notification—that is, workers with OCD notified between January 2014 and December 2015 (n = 2172).

Two-way ANOVA was used to examine the effect of long vs short case-processing time (duration of time between notification and recognition) on the monthly degree of employment and the number of weeks that workers were self-supporting, obtaining unemployment benefits or paid long-term sick leave during the 2 years after notification adjusted for age and sex. To avoid misleading results because of the changing duration of the employer sick leave period, we compared only the amount of paid long-term sick leave after notification of OCD on workers, with the same employer sick leave period in the 2 years after notification—that is, workers with OCD that was reported between January 2012 and December 2015 (n = 4503).

We found that the 25% of workers with OCD in our data set who had experienced the greatest drop in degree of employment in the 2 years after notification were working on average 21 hours a month less compared to before the notification of OCD. To examine which of the 24 occupational groups experience the greatest drop in degree of employment after notification, a log-binomial regression analysis was performed for each of the occupational groups adjusted for sex and dichotomized age (≤ vs. >35 years) and with all other workers in the data set as the reference group. A decrease in degree of employment during the 2 years after notification of ≥21 or <21 hours was modeled as outcome. The log-binomial regression analysis yielded (adjusted) prevalence ratios (PRs) as risk estimates with accompanying confidence intervals (CIs).

Information on the average number of inhabitants and the average yearly income before taxes in each municipality in Denmark between 2010 and 2015 was provided by Statistics Denmark in February 2020. A linear regression analysis was performed to investigate the relation between the average yearly income before taxes and

the number of OCD cases per 10 000 persons per year in the municipalities of Denmark. The study was approved by the Danish Data Protection Board (no. HGH-2017-093, I-suite no. 05911).

3 | RESULTS

3.1 | Study population

The characteristics of the study population are shown in Table 2. The study population consisted of 67.3% (6020) women and 32.7% (2920) men (female/male ratio approximately 2:1). The mean age at notification was 37.4 years (median 36, quartiles 26–48): 37.2 years for women (median 36, quartiles 26–48) and 37.9 years for men (median 37, quartiles 26–49). Occupational irritant contact dermatitis (OICD) was recognized in 72.6%, whereas occupational allergic contact dermatitis (OACD) was recognized in 27.4%. The majority of workers were Danish (89.6%) and had a Danish citizenship (94.5%).

3.2 | Incidence rates

The prevalence proportion (or PP) of OICD in the study population was 75.0% among women and 67.7% among men, whereas the PP of OACD was higher among men compared to women (32.3% and 25.0%, respectively). The distribution of men and women and the estimated incidence rates of OCD per 10 000 workers per year for the 24 different occupational groups are listed in Table 3. We found 16 occupational groups to be exceedingly high-risk and 4 occupational groups to be high-risk occupations. We found especially high incidence rates among hairdressers (136 per 10 000 workers per year), leather tanning and processing workers (99 per 10 000 workers per year), beauticians (76 per 10 000 workers per year), bakers (59 per 10 000 workers per year), florists (57 per 10 000 workers per year), and glue manufacture workers (52 per 10 000 workers per year).

There was a marked difference in the distribution of men and women in the different occupational groups; for example, 1915 women and 139 men were working in health care, whereas 497 men and 82 women were working as metalworkers. There were more than six times as many men than women working as mechanics, fitters and technicians, craftsmen and builders, and metalworkers, whereas more than 10 times as many women than men were working as hairdressers, beauticians, florists, and healthcare workers. The five most common occupational groups in the data set for men were metalworkers, craftsmen and builders, factory workers, restaurant workers, and sales assistants, whereas the five most common occupational groups for women were healthcare workers, hairdressers, restaurant workers, daycare and nursery workers, and sales assistants.

TABLE 2 Characteristics of the study population: Workers with recognized occupational contact dermatitis and notification date between January 1, 2010 and December 31, 2015 (N = 8940)

Characteristics	Total
Male, % (n)	32.7 (2920)
Female, % (n)	67.3 (6020)
Age ± SD (years)	37.4 ± 12.9
Age ≤35 years, % (n)	48.7 (4357)
Diagnoses	
OICD, % (n)	72.6 (6492)
OACD, % (n)	27.4 (2448)
Case-processing time ± SD (months)	10.6 ± 7.0
Origin	
Danish, % (n)	89.6 (8009)
Immigrant from non-Western country, % (n)	1.1 (98)
Immigrant from Western country, % (n)	0.2 (16)
Descendant from non-Western country, % (n)	6.1 (541)
Descendant from Western country other than Denmark, % (n)	3.1 (276)
Citizenship	
Denmark, % (n)	94.5 (8445)
Non-Western country, % (n)	2.8 (248)
Western country other than Denmark, % (n)	2.8 (247)

Abbreviations: OACD, occupational allergic contact dermatitis; OICD, occupational irritant contact dermatitis; SD, standard deviation.

3.3 | Degree of employment

The average degree of employment during the 2 years prior compared to the 2 years following notification fell from 122.7 to 113.7 work-hours/month (mean difference of 8.9 work-hours/month, 95% CI: 7.8–10.0; $P < .001$; n = 6685). Results are shown in Table 4. In Denmark, the minimum wage was €14.72 per hour in 2015. If the workers in the study population were working at minimum wage, the average annual loss of income per worker was €1570, corresponding to a total loss of income for the whole group (n = 6685) in the 2 years after notification of at least €21 000 000. Estimates of the economic costs of OCD for the individual worker and society are shown in Table 5.

Workers with case-processing time >1 year were on average working 5.5 fewer hours per month (95% CI 2.6–8.3, $P < .001$) adjusted for sex and age in the 2 years after notification than workers with case-processing time ≤1 year (Table 6). This corresponds to workers with case-processing time >1 year earning approximately €970 less per year than workers with case-processing time ≤1 year during the 2 years after notification.

The following occupational groups had a significantly higher risk of working at least 21 hours less per month after notification of an OCD: florists (PR 2.3, 95% CI: 1.02–5.03; $P = .045$), cleaning personnel (PR 2.2, 95% CI: 1.63–2.86; $P < .001$), hairdressers (PR 2.19, 95% CI: 1.64–9.91; $P < .001$), bakers (PR 2.03, 95% CI: 1.39–2.97; $P < .001$), butchers and slaughterhouse workers (PR 1.94, 95% CI:

TABLE 3 The distribution of occupational contact dermatitis according to occupational group, sex, and estimated incidence rates (n = 8940)

Occupation	No. of males with OCD (%)	No. of females with OCD (%)	No. of workers with OCD (%)	Number of full-time employees in Denmark[a]	Estimated rates (cases per 10 000 workers per year)
Hairdressers	<3[b]	>370[b]	374 (4.2)	4590	135
Leather tanning and processing	4 (0.1)	-	4 (<0.1)	67	99
Beauticians	-	21 (0.3)	21 (0.2)	462	76
Bakers	58 (2.0)	110 (1.8)	168 (1.9)	4758	59
Florists	-	45 (0.7)	45 (0.5)	1315	57
Glue manufacture	5 (0.2)	-	5 (0.1)	161	52
Dentists and dental assistants	9 (0.3)	164 (2.7)	173 (1.9)	11 782	24
Restaurant workers	206 (7.1)	354 (5.9)	560 (6.3)	38 939	24
Hotel workers	37 (1.3)	81 (1.3)	118 (1.3)	12 742	15
Butchers/ slaughterhouse workers	71 (2.4)	47 (0.8)	118 (1.3)	14 865	13
Cleaning personnel	65 (2.2)	208 (3.5)	273 (3.1)	38 765	12
Healthcare workers	139 (4.8)	1915 (31.8)	2054 (23.0)	293 636	12
Metalworkers	497 (17.0)	82 (1.4)	579 (6.5)	89 308	11
Mechanics/fitters/ technicians	149 (5.1)	10 (0.2)	159 (1.8)	25 785	10
Food production workers (factory workers)	80 (2.7)	69 (1.1)	149 (1.7)	27 204	9
Agricultural workers/ farmers/gardeners	82 (2.8)	79 (1.3)	161 (1.8)	31 597	8
Daycare/nursery workers	15 (0.5)	316 (5.2)	331 (3.7)	83 704	6
Craftsmen and builders	386 (13.2)	53 (0.9)	439 (4.9)	122 208	6
Sale assistants	205 (7.0)	277 (4.6)	482 (5.4)	137 897	6
Factory workers	235 (8.0)	168 (2.8)	403 (4.5)	117 192	6
Other occupations	488 (16.7)	1254 (20.8)	1742 (19.5)	581 194	5
Postal workers	25 (0.9)	26 (0.4)	51 (0.6)	18 691	4
Teachers	69 (2.4)	241 (4.0)	310 (3.5)	205 095	2
Office workers	93 (3.2)	128 (2.1)	221 (2.5)	275 718	1

Abbreviations: OCD, occupational contact dermatitis.
[a]Information obtained from estatistik.dk, the average number of full-time employees during 2010–2015.
[b]Exact numbers cannot be disclosed due to discretion rules.

1.24–3.01; P = .003), and craftsmen and builders (PR 1.48, 95% CI: 1.15–1.89; P = .002), while healthcare workers had a significantly lower risk (PR 0.62, 95% CI: 0.53–0.72, P < .001) (Table 7).

3.4 | Unemployment benefits

The number of weeks the workers were self-supporting during the 2 years prior compared to the 2 years following notification fell from 81.4 to 73.9 weeks (mean difference of 7.4 weeks, 95% CI: 6.6–8.2; P < .001). In turn, the number of weeks the workers were obtaining unemployment benefits rose significantly from 9.7 to 12.2 weeks (mean difference of 2.5 weeks, 95% CI: 1.9–3.0; P < .001) (Table 4).

There are different degrees of unemployment benefits depending, among other factors, on the age of the worker and if they are the sole provider of their family. A worker over the age of 30 years without children was in 2015 given approximately €1451 a month in unemployment benefits. If, hypothetically, the workers in the study population were all given this standard rate when on unemployment benefits, the average additional annual costs per worker would be €420 during the 2 years after notification compared to the 2 years before notification, corresponding to a total additional societal cost for the whole group (n = 6685) during the 2 years after notification compared to the 2 years prior to notification of at least €5 600 000 (Table 5).

Workers with case-processing time >1 year were self-supporting on average 3.0 weeks less during the 2 years after notification (95% CI: 0.9–

TABLE 4 Paired-samples *t* test examining the average monthly degree of employment, the average number of weeks self-supporting, on unemployment benefits and paid long-term sick leave during the 2 years prior to notification compared to the 2 years after notification of an occupational contact dermatitis (n = 6685)

Variable	Two years prior to notification	Two years after notification	Mean difference (95% CI)
Average monthly degree of employment (work-hours/month)	122.7	113.7	**− 8.9 (−10.0 to − 7.8]**
Average number of weeks self-supporting (weeks)	81.4	73.9	**−7.4 (−8.2 to − 6.6)**
Average number of weeks on unemployment benefits (weeks)	9.7	12.2	**2.5 (1.9 to 3.0)**
Average number of weeks on paid long-term sick leave (weeks)[a]	4.2	7.0	**2.8 (2.1 to 3.5)**

Note: Result in bold were statistically significant ($P < .05$).
[a]Based on the subgroup of workers, who were under the same employer sick leave period reform during the 2 years before and after notification—that is, workers with OCD that was notified between January 2014 and December 2015 (n = 2172).

TABLE 5 Estimates of the economic costs of OCD to the individual worker and society (n = 6685)

Variable	Average per worker per year	Total for the whole group during the 2-year follow-up period after notification (n = 6685 and n = 2171, respectively)
Loss of income, €[a]	1570	21 000 000
Unemployment benefits, €[b]	420	5 600 000
Paid long-term sick leave, €[c]	770	3 300 000

[a]Based on the minimum wage in Denmark in 2015 (€14.72/hour).
[b]Based on the standard rate of unemployment benefits in Denmark in 2015 for a worker without children who is over the age of 30 years (€1451/month).
[c]Based on the standard rate of paid long-term sick leave in Denmark in 2015 (€553/week) and on the subgroup of workers, who were under the same employer sick leave period reform during the 2 years before and after notification—that is, workers with OCD that was notified between January 2014 and December 2015 (n = 2172).

5.1, $P = .004$) adjusted for sex and age compared to workers with case=processing time ≤1 year. Furthermore, workers with case-processing >1 year were on unemployment benefits for on average of 2.7 weeks (95% CI: 1.3–4.1) more during the 2 years after notification than workers with case-processing time ≤1 year. This corresponds to workers with case-processing time >1 year, costing society €450 more per year after notification than workers with case-processing time ≤1 year (Table 6).

TABLE 6 Two-way ANOVA examining the effect of case processing time >1 year on monthly degree of employment, number of weeks self-supporting, on unemployment benefits and long-term paid sick leave during the 2 years after notification (n = 6685)

Variable	Effect of case processing time >1 year on the variable during the 2 years after notification of OCD (95% CI)[a]	Additional cost per worker per year, €
Monthly degree of employment (work-hours/month)[b]	**−5.5 (−8.3 to − 2.6)**	970
Weeks self-supporting (weeks)	**−3.0 (−5.1 to − 0.9)**	-
Weeks on unemployment benefits (weeks)[c]	**2.7 (1.3 to 4.1)**	450
Weeks on long-term paid sick leave (weeks)[d]	**1.4 (0.4 to 2.4)**	390

Note: Result in bold were statistically significant ($P < .05$).
Abbreviations: CI, confidence interval; OCD, occupational contact dermatitis.
[a]Adjusted for sex and dichotomized age.
[b]Based on the minimum wage in Denmark in 2015 (€14.72/hour).
[c]Based on the standard rate of unemployment benefits in Denmark in 2015 for a worker without children over the age of 30 years (€1451/month).
[d]Based on the standard rate of paid long-term sick leave in Denmark in 2015 (€553/week) and on the subgroup of workers, who were under the same employer sick leave period reform during the 2 years after notification—that is, workers with OCD that was notified between January 2012 and December 2015 (n = 4503).

3.5 | Paid long-term sick leave

Paid long-term sick leave was registered for 31.9% of the study population (n = 2133) at some point during the 2 years before notification compared to 35.8% of the study population (n = 2396) during the 2 years after notification. The number of weeks the workers were on paid long-term sick leave during the 2 years prior compared to after notification rose from 4.2 to 7.0 weeks (mean difference of 2.8 weeks, 95% CI: 2.1–3.5; $P < .001$; n = 2172) (Table 4).

The standard amount a person on paid long-term sick leave was granted in 2014 and 2015 was €553 a week. If, hypothetically, the

TABLE 7 Average decrease in work-hours/month and the risk of experiencing a drop of ≥21 work-hours/month in the 2 years after notification of occupational contact dermatitis for the 24 occupational groups (n = 6685)

Occupation	Average decrease in work-hours/month per worker in the 2 years after notification, work-hours/month	No. of workers, with employment decrease ≥21 work-hours/month (%)	Prevalence ratio (95% CI)[a]
Agricultural workers, farmers, and gardeners	14.9	34 (33)	1.3 (0.8–1.9)
Bakers	19.7	49 (43.8)	**2.0 (1.4–2.9)**
Beauticians	9.5	6 (37.5)	1.5 (0.5–4.2)
Butchers and slaughterhouse workers	23.6	33 (38.4)	**1.9 (1.2–3.0)**
Cleaning personnel	18.3	87 (40.8)	**2.2 (1.6–2.9)**
Craftsmen and builders	12.4	110 (33.4)	**1.5 (1.1–1.9)**
Daycare and nursery workers	8.2	54 (22.0)	0.9 (0.6–1.2)
Dentists and dental assistants	14.1	39 (29.1)	1.2 (0.8–1.8)
Factory workers	10.1	77 (22.6)	0.9 (0.7–1.2)
Florists	9.3	11 (44)	**2.3 (1.0–5.0)**
Food production workers (factory)	7.3	26 (21)	0.8 (0.5–1.3)
Glue manufacture workers	2.9	< 5[b]	-
Hairdressers	29.4	93 (44.7)	**2.2 (1.6–2.9)**
Healthcare workers	3.5	276 (18.5)	**0.6 (0.5–0.7)**
Hotel workers	10.5	27 (32.9)	1.3 (0.8–2.1)
Leather tanning and processing workers	0.9	< 5[b]	-
Mechanics, fitters, and technicians	9.0	24 (20.9)	0.7 (0.5–1.1)
Metalworkers	10.7	119 (25.0)	1.0 (0.8–1.3)
Office workers	5.6	35 (19.1)	0.7 (0.5–1.0)
Teachers	4.3	47 (21.4)	0.8 (0.6–1.1)
Postal workers	22.3	12 (27.9)	1.2 (0.6–2.4)
Restaurant workers	6.1	125 (31.2)	1.2 (0.9–1.4)
Sale assistants	4.8	82 (24.3)	0.8 (0.6–1.1)
Other occupations	8.5	319 (22.8)	0.9 (0.8–1.0)

Note: Result in bold were statistically significant ($P < .05$). CI, confidence interval.

[a]Log-binomial regression analysis performed for each of the occupational groups with decrease in employment of ≥ or <21 work-hours/month modelled as outcome. The reference group for the analysis was all other workers. Results have been adjusted for sex and dichotomized age.

[b]Exact numbers cannot be disclosed due to discretion rules.

workers in the study population on paid long-term sick leave were all given this standard rate, this would result in an average annual additional cost per worker of €770 during the 2 years after notification compared to the 2 years before notification, corresponding to a total additional societal cost for the whole group (n = 2172) during the 2 years after notification compared to the 2 years prior to notification of at least €3 300 000 (Table 5).

Workers with case-processing time >1 year were on long-term paid sick leave for on average of 1.4 weeks more during the 2 years after notification (95% CI: 0.4–2.4; $P = .007$) adjusted for sex and age compared to workers with case-processing time ≤1 year (Table 6). This corresponds to workers with case-processing time >1 year costing society €390 more per year after notification than workers with case-processing time ≤1 year. This analysis was based only on the workers who were under the same employer sick leave period reform during the 2 years after notification—that is, workers with OCD who were notified between January 2012 and December 2015 (n = 4503).

3.6 | Job change

The industry of employment (DB07) at the time of notification was known for all the workers in the study population (n = 8940). Two years after notification, the industry of employment (DB07) was known for 4704 of the workers. Of these 4704 workers, 47.9%

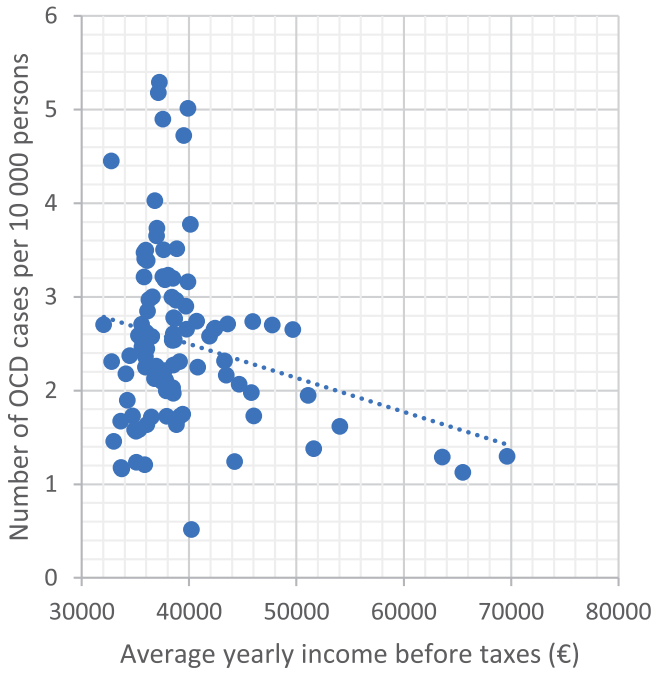

FIGURE 1 Number of OCD cases per year per 10 000 persons in relation to the average income in the municipality (€)

(n = 2255) were employed in the same industry of employment 2 years after notification, whereas 52.1% (n = 2449) were employed in a different or unknown industry. The reason for job change is not known.

3.7 | Inequality in health in relation to OCD

The average yearly income before taxes was compared with the number of OCD cases per 10 000 persons per year in the different municipalities in Denmark using a linear regression analysis. We found that the rates of OCD cases fell, with 0.362 (95% CI 0.074–0.651) cases per 10 000 persons when the average yearly income before taxes rose with €10 000 (P = .014), thus indicating a tendency toward lower rates of OCD in high-income municipalities (Figure 1.).

4 | DISCUSSION

4.1 | Incidence rates

The highest incidence rate in our study was found among hairdressers (135 per 10 000 workers), which was higher than the incidence rate in Northern Bavaria between 1990 and 1999 (97.4 per 10 000 workers),[7] and more than twice as high as the incidence rate among hairdressers found in a Danish study examining the incidence rates in different occupations in 2001–2002 (56.1 per 10 000 workers).[2] This is of major interest, as a prevention program was launched in 2011 in all hairdressing schools in Denmark, based on positive results from an intervention study.[16] However, no actions have been taken to educate employers in the hairdressing trade, which may impair the impact of educating apprentices. Another reason for the higher incidence rate of OCD among hairdressers in Denmark in 2010–2015 compared to 2001–2002 could be that a higher level of attention on work-related skin disease in the hairdressing field has resulted in more cases being notified, or the reason could be different definitions of the number of hairdressers in Denmark in the two studies.

The second highest incidence rate in our study was found among leather tanning and processing workers (99 per 10 000 workers), which was substantially higher than the incidence rate found in Northern Bavaria between 1990 and 1999 (5 per 10 000 workers).[7] Because of the small size of the group of leather workers in this study (4/67), the difference may be due to random variation; however, tanning is an occupation with potentially high risk exposures, for example, to chromium VI, and it is of concern that several cases are seen from such as small trade, indicating lack of proper protection.

Also top-ranking were bakers, florists, and dentists and dental assistants; incidence rates in our study (59, 57, and 24 cases per 10 000 workers, respectively) were twice as high as those in Northern Bavaria between 1990 and 1999 (33.2, 23.9, and 10.8 cases per 10 000 workers, respectively),[7] but were approximately half of the incidence rates in Denmark in 2001–2002 (83.7 cases per 10 000 workers for bakers and 41.8 cases per 10 000 workers for dental technicians; no incidence rates for florists exists).[2] Previously, acrylates were a major source of allergic contact dermatitis in dentist and dental technicians,[19] however, becoming much less after no-touch techniques were introduced. By contrast, no specific prevention programs have been launched in bakers.

The incidence rates among healthcare workers and metalworkers (12 and 11 cases per 10 000 workers, respectively) were comparable with the incidence rates in Northern Bavaria 1990–1999 (7.3 and 9 cases per 10 000 workers, respectively) and in Denmark 2001–2002 (6.8 cases per 10 000 workers for healthcare workers).[2,7]Trends in OCD during the observation period will be the subject of a separate paper.

4.2 | Loss of income

The monthly degree of employment of all the workers fell on average 8.9 work-hours in the 2 years after notification compared to the 2 years prior to notification, corresponding to a yearly loss of income of approximately €1570 per worker. €1570 is a considerable amount for the average worker, and as not all workers are affected, the sum may be even higher. Some of this loss might have been mitigated by either paid long-term sick leave or unemployment benefits, but the subsidies given during paid long-term sick leave and unemployment will always be significantly lower than a worker's previous income. It has earlier been reported that the average delay from onset of OCD to notification to the DLMI is around 4.5 years (median 2 years),[2] so it is reasonable to assume that the degree of employment has been affected by OCD not only in the 2 years after notification, but also in

the 2 years prior to notification. For this reason, the loss of income found in this study is more likely to be an underestimation than an overestimation. In this study, we do not know the reason for the drop in monthly degree of employment, or if OCD was the main driving factor. Meding et al[3] found that the personal economic situation worsened for 32% of workers because of their OCD, and 45% of the workers with worsened personal economy reported a loss of income of 25% or more. Mälkönen et al[20] found similar results, with a worsened economic situation for 23% of OCD patients. It could be considered that the average monthly degree of employment would drop naturally with age, but we confer that this should not be of significance when looking at a 4-year period.

The risk of a decreased degree of employment of ≥21 hours/month after notification differs between the various occupational groups. We found that florists, hairdressers, cleaning personnel, bakers, butcher and slaughterhouse workers, and craftsmen and builders had a significantly higher risk, whereas healthcare workers had a significantly lower risk of experiencing a decrease in degree of employment of ≥21 hours/month. Florists, hairdressers, bakers, and butchers often work in smaller enterprises, where it can be difficult to relocate the worker with OCD to another function, and in particular it can be difficult to find a position with less skin exposures to relocate to. This may also apply to larger enterprises, as exposure to allergens and irritants is tightly linked to core tasks of the trade. Healthcare workers on the other hand often work in a bigger hospital setting where it can be easier to relocate the worker to a different function. Moreover, some healthcare workers may also have a higher level of education making it easier for them to find different work tasks.

4.3 | Sick leave

Workers with OCD were on paid long-term sick leave significantly more weeks (2.8 weeks) during the 2 years after notification compared to the 2 years prior to notification. Only the amount of paid long-term sick leave extending past the employer sick leave period is registered in the DREAM register. A Danish report on the sickness absence of workers in Denmark showed that long-term sickness absence (over 30 days) represents 39% of the total sickness absence in Denmark.[21] Considering this, the amount of sick leave in our study is grossly underestimated. A German study examining the degree of sickness absence during the last 12 months among patients with OCD, showed that 62.9% of the patients had at least one absence day because of OCD during the previous 12 months—the average amount of sickness absence being 76.4 days, whereas 11.5% had extremely long sickness absence of 6 months or longer.[10] Meding et al[3] found in a 12-year follow-up study of patients with occupational skin disease that 48% had been on sick leave for at least one period of 7 days due to their occupational skin disease during the follow-up period. A questionnaire study examining Danish workers with OCD that had been recognized by the DLMI found that 19.9% reported prolonged sick leave of >5 weeks per year due to OCD.[22] The employers are only compensated for long-term sick leave, which means that OCD is a significant cause of production loss, which is a serious negative effect.

4.4 | Job change and unemployment

The number of weeks that workers were obtaining unemployment benefits rose significantly by 2.5 weeks in the 2 years following notification. Furthermore, we found that 52.6% of workers with OCD were employed in a different or unknown industry of employment 2 years after notification. These results are similar to the results found in a Danish study from 2017 where 48.7% of workers with recognized OCD were still in the same profession 5 years after recognition, whereas 32.6% had changed their profession and 18.8% were outside the labor market.[23] We do not know the reason for the change in industry of employment, but it is not unlikely that OCD was a contributing or driving factor. A number of studies have found that ~23–25% of workers with OCD lose their job because of OCD, with 15% ending up unemployed or on disability pension, and 34–82% of workers make occupational changes (most commonly change of job) because of their OCD.[20,22] Among high-risk occupations, the numbers are even worse. In a study from 2011, 44.3% of hairdressers left the hairdressing field after an average of 8.4 years, 45.5% because of hand eczema.[6]

Across studies and countries it is shown that OCD is a cause of unemployment; this affects the worker and their families, as unemployment is linked to impaired mental health.[24] In our study many workers had changed their industry of employment 2 years after notification of OCD. It has been shown that change of work improves OCD; however, it is also associated with a negative impact on the workers' quality of life.[23]

4.5 | Case-processing time

Case-processing time was shown to be significantly related to the monthly degree of employment and the number of weeks on unemployment benefits and paid long-term sick leave. Workers with long case-processing time (>1 year) worked on average 5.5 hours less a month and were on unemployment benefits and paid long-term sick leave for 2.7 and 1.4 weeks more, respectively, than workers with short case-processing time (≤1 year). These results support earlier studies that have found that the time between debut and diagnosis has an influence on the prognosis of the contact dermatitis,[25] and underscore the need for reducing the case-processing time in the future.

4.6 | Inequality in health in relation to OCD

We found that the incidence of OCD correlated negatively with yearly income before taxes, with higher rates in low-income municipalities and lower rates in high-income municipalities, suggesting a social

[Correction added on 24 November 2020, after first online publication: Data in Sections 4.3 and 4.5 have been corrected in this current version.]

inequality in the incidence of OCD. These results can be explained by the fact that compared to high-income work, low-income work more often involves wet work and chemical exposures. Furthermore, Noiesen et al[26] showed that individuals with lower socioeconomic status had more difficulty reading cosmetic ingredient labels and, for this reason, had more difficulty complying with the medical instructions. The prognosis has also been described to be poorer among workers with lower socioeconomic status in terms of severity, quality of life, and sick leave.[27-29]

4.7 | Socioeconomic costs

We found that the socioeconomic costs connected with OCD are substantial. The additional costs to society during the 2-year period after notification compared to the 2-year period before notification of unemployment benefits for the whole group of workers (n = 6685) were €5 600 000, whereas it was only possible to calculate the total cost of paid long-term sick leave for a subgroup of the workers because of the changing duration of the employer sick leave period. The total cost for the 2172 workers with OCD notified between January 2014 and December 2015 was approximately €3 300 000. The annual costs per worker with OCD were estimated to be approximately €1200 in socioeconomic costs (€420/year unemployment benefits and €770/year paid long-term sick leave), and approximately €1570 in lost income. These results are not comparable to cost-of-illness studies, as they do not take into account the direct costs of OCD (costs associated with medical care), or the indirect costs (costs associated with loss of productivity due to sick leave). The cost-of-illness of OCD in Denmark has earlier been estimated to €724 in direct costs for the 4 years prior to patch testing and the year after patch testing, with productivity costs for the same period of €10 722.[30] In comparison, the cost-of-illness in Germany has been calculated to be €5358.4 per patient in the year leading up to a 3-week interdisciplinary inpatient rehabilitation (with 80% attributable to indirect costs).[31] This suggests that the total cost of OCD in Denmark is significantly higher than the initial calculations made in this study. Further studies into the cost-of-illness of OCD focusing on the productivity loss due to sick leave and the cost of medical care in Denmark are necessary to completely illuminate the socioeconomic costs of OCD in Denmark.

4.8 | Strength and weaknesses

The strengths of this study are the large size of the study population, comprising all patients with recognized OCD in Denmark between 2010 and 2015, and the use of reliable register data of high quality. Because the DREAM register provides objective measures on social transfer payments, there was no recall bias regarding the degree of employment or the number of weeks on unemployment benefits or paid long-term sick leave.

Although the Danish registers are generally of a high standard, there are well-known limitations in a register-based study. In this study design it is not possible to evaluate the potential causal relationship between OCD and the social benefits, as the reasons for paid long-term sick leave or disability pension are not registered and could be due to a different independent disease. Moreover, not all data relevant for a complete economic analysis was available in the registers. For example, only sick leave extending past the employer sick leave period is registered in the DREAM register, making it impossible to make assumptions about the productivity loss costs, which have earlier been shown to be substantial in OCD cases.[10,30,32] Some costs were estimated using assumptions, as explained above. These assumptions have in general been conservative, making an underestimation of costs more likely than an overestimation.

We did not include a separate control group, but instead the person served as their own control before and after recognition of OCD over a reasonably short period. Having a separate control group could have supported the results further, but would entail a risk that cases would also be present in the control group because all data were handled anonymized. Another problem would be the presence of workers with not-yet recognized OCD in the control group. We believe that the current analysis represents the best possible and conservative estimate of some of the costs of OCD to society and the individual.

4.9 | Conclusion

Occupational contact dermatitis (or OCD) has a significant negative impact on the occupational and economic situation of the afflicted workers and cause substantial costs for society. We found that while the degree of employment falls, the unemployment and sick leave rises after notification of OCD, especially for workers with long case-processing time. Some occupations were high risk and more affected than others. We also found that the duration of the case-processing time is associated with worsened outcome for the worker, indicating a need to lower the case processing time. The case cannot be concluded before a final diagnosis has been made; this is why a speedier diagnosis and treatment may be of benefit. The results of the study highlight the need for a national action plan for effective prevention of OCD, preventing new cases as well as reducing the consequences in those who have acquired the disease.

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AUTHOR CONTRIBUTIONS

Jojo Biel-NielsenDietz: Conceptualization; Data Curation; Formal Analysis; Methodology; Project Administration; Writing-original draf; Writing-review & editing. **Torkil Menné:** Conceptualization; methodology; writing-review and editing. **Harald Meyer:** Writing-review and editing. **Sven Viskum:** Writing-review and editing. **Mari-Ann Flyvholm:** Conceptualization; funding acquisition; writing-review and editing. **Ulrik Ahrensbøll-Friis:** Writing-review and editing. **Swen**

Malte John: Writing-review and editing. **Jeanne Duus Johansen:** Conceptualization; formal analysis; funding acquisition; methodology; project administration; writing-original draft; writing-review and editing.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Danish Labour Market Insurance Register and Statistics Denmark (DREAM). Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the Danish Labour Market Insurance and Statistics Denmark with the permission of the Danish Data Protection Board.

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REFERENCES

1. The Danish Labour Market Insurance. Arbejdsskadestatistik 2020. https://www.aes.dk/da/Statistik/Arbejdsskader/Arbejdsskadestatistik.aspx. Published 2018. Accessed March 17, 2020.
2. Skoet R, Olsen J, Mathiesen B, Iversen L, Johansen JD, Agner T. A survey of occupational hand eczema in Denmark. *Contact Dermatitis*. 2004;51(4):159-166.
3. Meding B, Lantto R, Lindahl G, Wrangsjö K, Bengtsson B. Occupational skin disease in Sweden - a 12-year follow-up. *Contact Dermatitis*. 2005;53(6):308-313.
4. Thyssen JP, Johansen JD, Linneberg A, Menné T. The epidemiology of hand eczema in the general population - prevalence and main findings. *Contact Dermatitis*. 2010;62(2):75-87.
5. Ibler KS, Jemec GBE, Flyvholm M, Diepgen TL, Jensen A, Agner T. Hand eczema: prevalence and risk factors of hand eczema in a population of 2274 healthcare workers. *Contact Dermatitis*. 2012;67(4):200-207.
6. Lysdal SH, Søsted H, Andersen KE, Johansen JD. Hand eczema in hairdressers: a Danish register-based study of the prevalence of hand eczema and its career consequences. *Contact Dermatitis*. 2011;65(3):151-158.
7. Diepgen TL, Kuss O, Blesius CR, Schmidt A, Diepgen TL. Occupational skin diseases in northern Bavaria between 1990 and 1999: a population-based study. *Br J Dermatol*. 2001;145(3):453-462.
8. Skoet R, Zachariae R, Agner T. Contact dermatitis and quality of life: a structured review of the literature. *Br J Dermatol*. 2003;149(3):452-456.
9. Moberg C, Alderling M, Meding B. Hand eczema and quality of life: a population-based study. *Br J Dermatol*. 2009;161(2):397-403.
10. Diepgen TL, Scheidt R, Weisshaar E, John SM, Hieke K. Cost of illness from occupational hand eczema in Germany. *Contact Dermatitis*. 2013;69(2):99-106.
11. Brans R, Skudlik C, Weisshaar E, et al. Multicentre cohort study 'rehabilitation of occupational skin diseases – optimization and quality Assurance of Inpatient Management (ROQ)': results from a 3-year follow-up. *Contact Dermatitis*. 2016;75(4):205-212.
12. Sundhedsstyrelsen. *Forebyggelse Af Kontakteksemer*. 1st ed.; 1998.
13. Fisker MH, Ebbehøj NE, Vejlstrup SG, et al. Prevention of hand eczema: effect of an educational program versus treatment as usual – results of the randomized clinical prevex trial. *Scand J Work Environ Health*. 2018;44(2):212-218.
14. Soltanipoor M, Kezic S, Sluiter JK, et al. Effectiveness of a skin care programme for the prevention of contact dermatitis in healthcare workers (the healthy hands project): a single-Centre, cluster randomized controlled trial. *Contact Dermatitis*. 2019;80(6):365-373.
15. Graversgaard C, Agner T, Jemec GBE, Thomsen SF, Ibler KS. A long-term follow-up study of the hand eczema trial (HET): a randomized clinical trial of a secondary preventive programme introduced to Danish healthcare workers. *Contact Dermatitis*. 2018;78(5):329-334.
16. Bregnhøj A, Menné T, Johansen JD, Søsted H. Prevention of hand eczema among Danish hairdressing apprentices: an intervention study. *Occup Environ Med*. 2012;69(5):310-316.
17. Carøe TK, Ebbehøj N, Agner T. A survey of exposures related to recognized occupational contact dermatitis in Denmark in 2010. *Contact Dermatitis*. 2014;70(1):56-62.
18. Statistics Denmark. Statistikdokumentation for Dagpenge Ved Sygdom Eller Fødsel Mv. 2019; 2019. https://www.dst.dk/da/Statistik/dokumentation/statistikdokumentation/dagpenge-ved-sygdom-eller-foedsel-mv-/sammenlignelighed.
19. Aalto-Korte K, Alanko K, Kuuliala O, Jolanki R. Methacrylate and acrylate allergy in dental personnel. *Contact Dermatitis*. 2007;57(5):324-330.
20. Mälkönen T, Alanko K, Jolanki R, et al. Long-term follow-up study of occupational hand eczema. *Br J Dermatol*. 2010;163(5):999-1006.
21. Flyvholm M, Thorsen SV, Bültmann U. Sickness Absence Report 2019. Descriptive Analysis on Wage Earners' Sickness Absence in Denmark - Based on Register and Questionnaire Data. Copenhagen; 2019.
22. Cvetkovski RS, Rothman KJ, Olsen J, et al. Relation between diagnoses on severity, sick leave and loss of job among patients with occupational hand eczema. *Br J Dermatol*. 2005;152(1):93-98.
23. Carøe TK, Ebbehøj NE, Bonde JPE, Vejlstrup SG, Agner T. Job change facilitates healing in a cohort of patients with occupational hand eczema. *Br J Dermatol*. 2018;179(1):80-87.
24. Paul KI, Moser K. Unemployment impairs mental health: meta-analyses. *J Vocat Behav*. 2009;74(3):264-282.
25. Hald M, Agner T, Blands J, Johansen JD. Delay in medical attention to hand eczema: a follow-up study. *Br J Dermatol*. 2009;161(6):1294-1300.
26. Noiesen E, Larsen K, Agner T. Compliance in contact allergy with focus on cosmetic labelling: a qualitative research project. *Contact Dermatitis*. 2004;51(4):189-195.
27. Cvetkovski RS, Zachariae R, Jensen H, Olsen J, Johansen JD, Agner T. Quality of life and depression in a population of occupational hand eczema patients. *Contact Dermatitis*. 2006;54(2):106-111. https://doi.org/10.1111/j.0105-1873.2006.00783.x
28. Lerbaek A, Kyvik KO, Ravn H, Menné T, Agner T. Clinical characteristics and consequences of hand eczema - an 8-year follow-up study of a population-based twin cohort. *Contact Dermatitis*. 2008;58(4):210-216. https://doi.org/10.1111/j.1600-0536.2007.01305.x
29. Hald M, Agner T, Blands J, et al. Clinical severity and prognosis of hand eczema. *Br J Dermatol*. 2009;160(6):1229-1236. https://doi.org/10.1111/j.1365-2133.2009.09139.x
30. Sætterstrøm B, Olsen J, Johansen JD. Cost-of-illness of patients with contact dermatitis in Denmark. *Contact Dermatitis*. 2014;71(3):154-161. https://doi.org/10.1111/cod.12231
31. Andrees V, John SM, Nienhaus A, et al. Economic evaluation of a tertiary prevention program for occupational skin diseases in Germany. *Contact Dermatitis*. 2020;82(6):361-369. https://doi.org/10.1111/cod.13506
32. Diepgen TL, Purwins S, Posthumus J, Kuessner D, John SM, Augustin M. Cost-of-illness analysis of patients with chronic hand

eczema in routine care in Germany: focus on the impact of occupational disease. *Acta Derm Venereol*. 2013;93(5):538-543. https://doi.org/10.2340/00015555-1565

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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10.4 Manuscript IV: Assessing the Efficacy of a German-Inspired Intervention on Occupational Contact Dermatitis in Denmark: A Randomized Controlled Trial with 3-months Follow-up

Dietz JB, Simonsen ABN, Menné T, Ahlström MG, Flyvholm MA, Blomberg MH, Erichsen CY, Meyer HW, Viskum S, Ahrensbøll-Friis U, John SM, Johansen JD. *(Manuscript)*

Title

Assessing the Efficacy of a German-Inspired Intervention on Occupational Contact Dermatitis in Denmark: A Randomized Controlled Trial with 3-months Follow-up

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Conflicts of Interests

The authors declare no conflict of interests.

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Ethics statement

The study was approved by the Danish Patient Safety Authority (31-1521-161) and the Knowledge Centre on Data Protection Compliance in the Capital Region of Denmark on behalf of the Danish Data Protection Board (P-2019-650). The study was conducted according to the Declaration of Helsinki, and participation required signed consent forms.

Keywords

Atopic dermatitis, Occupational contact dermatitis, Occupational consequences

Abstract

Background: Occupational contact dermatitis (OCD) is a prevalent, often chronic disease that poses a risk for job loss and decreased quality of life. In Germany, a multi-step prevention program emphasizing early detection and highly specialized multidisciplinary treatment has been implemented with great success.

Objectives: To examine the effectiveness of a Danish-adapted version of the German prevention effort on OCD severity, quality of life, and occupational consequences at 3-months follow-up.

Methods: Randomized, controlled trial. Participants were recruited after first referral from General Practitioner to Dermatologist with suspected OCD. The intervention group (IG) received a Danish-adapted, multidisciplinary intervention, while the control group (CG) received standard treatment. OCD severity, occupational consequences, and quality of life were assessed at 3-months follow-up.

Results: A statistically significant decrease in severity of eczema was found at 3-months follow-up in the IG compared to the CG. The IG were statistically significantly more likely to have seen a dermatologist at 3-months follow-up. Higher treatment level in the IG was indicated by the results but was not statistically significant. No significant difference was found in quality of life or occupational consequences.

Conclusions: These initial findings suggest that early and specialized treatment of OCD improves OCD prognosis.

1 Introduction

Occupational contact dermatitis (OCD) is a debilitating disease that often evolves into a chronic condition, characterized by severe symptoms,[1] decline in quality of life,[2,3] job loss,[1,4] and diminished income.[5] OCD is the most recognized occupational disease in many western countries, notably in Denmark and Germany, where escalating case numbers have prompted several prevention initiatives.[6–11]

In 2005, the German Statutory Accident Insurance (DGUV) implemented a comprehensive multi-step prevention program.[12] Upon receiving a notification about a worker with OCD, the DGUV considers the severity and chronicity risk of the worker's symptoms and the associated risk of job loss when determining the most appropriate step for each patient.[13] This prevention concept has since been adopted and implemented in Austria.[14]

The multi-step prevention program involves three steps of individual prevention, with the Tertiary Individual Prevention (TIP) being offered to workers with severe OCD and/or if the workers face an elevated risk of abandoning their profession due to their condition's severity. TIP is specifically designed to reduce disease severity, improve quality of life, and, crucially, enable affected workers to remain in their profession. This program involves a three-week interdisciplinary inpatient rehabilitation, a subsequent three-week off-work period, and continuous dermatological follow-up.

There are several structural differences between the Danish and German healthcare and occupational accident insurance systems,[15] necessitating an adapted approach in the Danish setting. Our research group has therefore developed a prevention intervention suitable for a Danish hospital setting focusing on fast medical diagnostics and treatment, education on skin-protective behavior and highly specialized diagnostics and treatment performed by a multidisciplinary team inspired by the German TIP effort.

The present study aims to examine the effectiveness of this Danish-adapted intervention on OCD severity, quality of life, and occupational consequences.

2 Methods

2.1 Study design

The study was unblinded, controlled and randomized, with an allocation ratio of 1:1. The study was conducted and reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines to ensure a methodological approach and transparent reporting of findings.[16 17] For the primary analysis, only participants who adhered to the study protocol in either the intervention group (IG) or control group (CG) were included, as per a per-protocol analysis. This allowed for an evaluation of participants based on their group assignment and compliance with the protocol. The study was registered at ClinicalTrials.gov (identifier: NCT04790799).

2.2 Recruitment and study population

The participants were recruited from the Danish National Referral Database, which holds information on all active referrals from one doctor to another in Denmark. Inclusion criteria were as follows: age between 15 and 65 years, referral to a dermatologist with hand eczema, hand eczema presence within the past three months, suspected occupational cause (by participant or doctor), and ability to provide informed consent. Exclusion criteria were as follows: current pregnancy, breastfeeding, or severe psychiatric condition that might overshadow hand eczema issue. Participants were recruited following their first referral from a general practitioner to a dermatologist with suspected occupational hand eczema (OHE). The participants were contacted via secure email (eBoks) and via phone with written and oral information about the study.

The enrollment period was from June 2020 to December 2022, with a break in recruitment from January 2021 until December 2021 due to technical difficulties in the National Referral Database system. Participants gave informed consent complying with the Helsinki Declaration before entering the study.

2.2.1 Power calculation and sample size

The power calculation for this study was conducted based on the estimation that 75% of the IG participants and 50% of the CG participants would experience an improvement in their hand eczema during the follow-up period. The power calculation was conducted with a desired power of 80% and a 95% confidence interval.[17] The result of this calculation suggested a total sample size of 116 participants for the study. However, due to constraints in recruitment, the study was unable to reach this suggested sample size.

2.2.2 Randomization

The randomization of study participants was performed using a block randomization approach with a block size of six, stratified by sex and age. The randomization list was computer-generated using a tool developed by Sealed Envelope Ltd.[18] The randomization process was carried out using the RedCAP randomization module to ensure secure and unbiased allocation. Participants were enrolled and assigned to either the IG or CG by a project nurse affiliated with the study.

2.2.3 Participant flow and follow-up

A total of 284 individuals were assessed for eligibility. Of these, 228 were excluded due to not meeting the inclusion criteria, declining to participate, or because their general practitioner did not allow contact (see Supplementary Material for details).

Fifty-six participants were randomized into the study, with 30 allocated to the intervention group and 26 to the control group. Out of the intervention group, four participants did not receive the intervention due to non-attendance, resulting in 26 participants receiving the intervention.

There was a minor attrition during the follow-up phase, with three participants lost to follow-up in the intervention group and four in the control group. Therefore, at 3-months follow-up, 23 participants from the IG and 22 participants from the CG were analyzed for the primary outcomes.

2.2.4 Attrition analysis

Given the attrition observed during the follow-up phase, an attrition analysis was performed to identify any potential bias resulting from participant drop-out. This analysis involved a comparison of baseline characteristics between participants who completed the study and those who did not, with the aim of identifying any systematic differences between them.

2.2.5 Blinding

Given the nature of the interventions, the study was conducted in an unblinded manner. Both the participants and the healthcare providers were aware of the group assignments. Similarly, the data collectors and analysts were not blinded to the group assignments.

2.3 Intervention

The intervention consisted of several components. Participants in the IG were invited to a consultation with a dermatologist at the Department of Dermatology at Gentofte Hospital within 2-3 weeks of study inclusion. Prior to this consultation, a chemical engineer examined the ingredient information of all the products the participant had been in contact with, both at work and at home. In collaboration with the treating dermatologist, the chemical engineer then compiled a list of potential allergens for subsequent testing. The initial treatment plan was established during the first doctor consultation based on a pre-

defined standardized treatment strategy. Subsequently, IG participants underwent extended allergen testing using patch and prick test. In relation to the doctor consultation, the IG participants received education on skin protective behavior and glove counselling. IG participants were also shown a video, specifically produced for this research project, covering essential aspects of hand eczema, its prevention, treatment strategies, and the importance of skin-protective behavior. In relevant cases, referrals were made to the Department of Social Medicine and/or the Department of Occupational and Environmental Medicine.

The CG navigated the Danish healthcare system independently, without any intervention from the research team, and received the standard treatment for OHE.

2.4 Questionnaire

The study participants were asked to fill out a questionnaire at inclusion and at 3-months follow-up. The questionnaire was evaluated and revised prior to the study based on interviews with peers and hand eczema outpatients. The questionnaire included questions about severity of eczema, occupational status, occupational consequences, overall health, use of medicine and the medical system and quality of life. The questions were mainly drawn from the Nordic Occupational Skin Questionnaire (NOSQ-2002) and the Health 2006 survey.[19,20] Severity of current hand eczema was assessed by a question about degree of eczema within the last three months, self-administered photographic guide[21] and a visual analogue scale (VAS). History of atopic dermatitis was based on confirmatory answer to a question about doctor-diagnosed atopic dermatitis.[22] Wet work was defined as having wet hands > 2 hours per shift, wearing occlusive gloves > 2 hours per shift and/or washing their hands > 20 times per shift. Quality of life was assessed using Dermatology Life Quality Index (DLQI), Skindex-29 and EQ-5D-5L.[23–25]

2.5 Assessment of treatment

The treatment of both the IG and CG participants was assessed by accessing their online Shared Medication Record. The Shared Medication Record is a system used in Denmark where all information about a patient's current and past prescribed medications are centrally stored and can be assessed by authorized healthcare professionals. The treatment within the last year was assessed at baseline, and within the last three months at 3-month follow-up.

2.5 Outcome Measures

The primary outcomes, assessed at both baseline and 3-months follow-up, included several parameters. Hand eczema severity was self-assessed using three different measures: the degree of eczema experienced within the last three months on an ordinal scale, the severity of current eczema using a visual analogue scale from 0-10, and a photographic guide assessing hand eczema severity. Occupational consequences were self-assessed based on whether the participant experienced job loss or sick leave within the last three months. Quality of life was also self-assessed using: DLQI, Skindex-29 and EQ-5D-5L.

Medication use was assessed based on self-reported use of topical corticosteroids within the last three months, and review of the online Shared Medication Record by a research physician.

2.6 Statistical Analysis

Study data were collected and managed using REDCap Electronic Data Capture tools hosted at the Capital Region of Denmark.[26,27] Statistical analyses were conducted using R version 4.2.2.

Differences in the distribution of baseline characteristics between the IG and CG were tested using Fishers exact test and Wilcoxon rank sum test. For ordinal and binary outcome variables, ordinal or binary logistic

regression models were used to calculate odds ratios and 95% confidence intervals, adjusting for age, sex, atopic dermatitis, and baseline values of the variable comparing the IG and CG group. Linear regression models were used to examine the difference between the IG and CG for the continuous outcome variables, adjusted for sex, age, atopic dermatitis, and baseline values of the variable. All p-values were 2-sided, and a 5% level of statistical significance was used.

2.6.1 Missing Data

In the present study, not all participants completed every question in the questionnaire. Therefore, the analysis of primary and secondary outcomes was based on available case analysis, meaning that each analysis included only participants who had provided responses to the specific variables being analyzed. The exact sample size for each outcome variable is provided in the result tables.

2.7 Ethics statement

The study was approved by the Danish Patient Safety Authority (31-1521-161) and the Knowledge Centre on Data Protection Compliance in the Capital Region of Denmark on behalf of the Danish Data Protection Board (P-2019-650). The study was conducted according to the Declaration of Helsinki, and participation required signed consent forms.

3 Results

3.1 Study population

3.1.1 Baseline characteristics

The baseline characteristics of the study population can be found in Table 1. The sex distribution was approximately equal across the groups, with males accounting for 39.1% (n=9) of the IG and 50% (n=11) of the CG (p=0.6). The mean age of the participants was slightly higher in the IG (40.5 ± 14.5 years) compared to the CG (35.1 ± 14.6 years), but the difference was not statistically significant (p=0.3). Almost all of the participants were born in Denmark (95.2% in the IG, and 100% in the CG). In terms of occupations, both groups demonstrated a diverse distribution, with healthcare workers and mechanics, fitters and technicians being the most common groups in the IG, and healthcare workers and kitchen personnel being the most common groups in the CG.

Characteristics relating to disease duration at baseline and severity of all-time worst eczema can be seen in Table 2. The distribution of disease duration was similar in the IG and CG, with the majority of participants in both groups having a disease duration of less than one year. Similarly, the groups were comparable in terms of the severity of all-time worst eczema both assessed by VAS-score and photographic guide. The IG had a higher share of participants with atopic dermatitis (26.1% compared to 9.1% in the CG), but this difference was not statistically significant (p = 0.2).

3.1.2 Attrition analysis

In the analysis of attrition, there were 45 participants who were retained in the study and 11 who dropped out. The groups were balanced in terms of intervention assignment, sex, age, country of birth, VAS score of worst eczema, and self-reported doctor-diagnosed atopic dermatitis. A notable difference was observed in disease duration since onset, where 90.9% of drop-outs had a disease duration of less than 1 year, compared to 48.9% of the retained participants (P<.05). Further details of the attrition analysis are presented in the Supplementary material.

3.1.2 Description of the intervention group and HECSI score

IG participants had their first consultation with a dermatologist at the Department of Dermatology, on average, 34.7 days after referral (IQR 16.5-48 days). This delay was solely due to patients choosing to postpone their consultation due to conflicts with work schedules, exams, or travel plans. IG participants had, on average, 2.2 doctor consultations within the first three months of inclusion in the study.

A project nurse scored IG participants' Hand Eczema Severity Index (HECSI) at their initial consultation and again at the 3-months follow-up. During this period, there was an observed decrease in average HECSI score, from 32.4 at baseline to 19.1 at the 3-months follow-up.

Irritant contact dermatitis was the most common final diagnosis (78.3%), followed by allergic contact dermatitis (17.4%), with atopic dermatitis being the most common supplementary diagnosis (27.8%). All the IG participants were diagnosed with OCD (table 3).

An overview of the patch-testing and the patch-test results for the IG participants can be found in the supplementary material.

3.2 Wet work and skin protective behavior

The IG's and CG's exposure to wet work at baseline is illustrated in Table 4 and is found to be similar in the IG and CG. Table 5 demonstrates the daily use of hand moisturizers in both the IG and CG. From baseline to the 3-months follow-up, the IG showed a remarkable shift towards more frequent use. Specifically, the proportion of workers using moisturizers several times daily increased from 40.9% to 71.4%. Conversely, in the CG, the proportion of workers never using moisturizers increased from 22.2% to 29.4%, and the proportion using it several times daily only saw a small increase from 38.9% to 52.9%. But this difference was not statistically significant.

3.3 Doctor visits and treatment of hand eczema

3.3.1 Doctor visits

Table 6 presents the proportion of workers in the IG and CG who have had a consultation with a dermatologist at the 3-months follow-up. All participants in the IG (100%, n=23) had seen a dermatologist within the first three months of the study, compared with 68.2% (n=15) in the CG. This difference was found to be statistically significant.

3.3.2 Topical treatment

In both groups, potent topical corticosteroids were the most commonly prescribed treatments. Within the IG 87% (n=20) were prescribed potent corticosteroids, in contrast to the CG where 50% (n=11) of the participants were prescribed potent corticosteroids (table 7). Topical treatment with mild, moderate or very potent corticosteroids, as well as tacrolimus, was less prescribed in both groups, with more participants in the IG being prescribed tacrolimus (21.7% compared to 9.1% in the CG) and more participants in the CG being prescribed very potent corticosteroids (13.6% compared to 4.3% in the IG).

Participants were also asked about their use of topical corticosteroids in the last three months (table 8). We found a tendency for the IG participants to have used topical corticosteroid treatment for a longer period of time within the last three months compared to the CG, but this difference was not statistically significant (table 8).

3.3.3 Systemic treatment

The use of systemic treatment within the last three months, showed a different pattern. No participants from the IG were prescribed systemic treatment including antibiotics for their OHE. In the CG, acitretin was prescribed to 4.5% (n=1) and antibiotics were prescribed to 9.1% (n=2).

3.4 Severity of hand eczema

The self-assessed severity of hand eczema in both the IG and CG was evaluated at baseline and 3-months follow-up (table 9). Measurements of severity considered the degree of eczema within the last three months, severity as per the VAS scale and self-assessment using the photographic guide.

In the context of the degree of eczema within the past three months, the IG demonstrated an improvement in their condition at the 3-months follow-up compared to baseline. Specifically, the proportion of participants who reported having eczema “all the time” decreased from 56.5% at baseline to 30.4% at 3-months follow-up. In contrast, the CG saw an increase in the same parameter, with 50% reporting constant eczema at baseline, rising slightly to 59.1% at the 3-months follow-up. The difference in changes between the two groups was statistically significant, with an adjusted odds ratio (OR) of 4.6 (95% CI 1.3-18, $P < .05$) for the CG to have a higher degree of eczema compared to the IG (adjusted for sex, age, atopic dermatitis, and degree of eczema at baseline).

Self-reported severity of eczema over the last three months on the VAS scale displayed a decrease in both groups. However, the mean severity score was lower in the IG (4.1 ± 2.3) than the CG (4.8 ± 2.7) at the 3-months follow-up, but this difference did not reach statistical significance.

In the analysis of self-assessed severity of hand eczema within the last three months using the photographic guide, it was observed that the IG experienced notable improvement at the 3-months follow-up. The proportion of IG participants reporting “No eczema” or “Almost clear” eczema increased, whereas those reporting “Moderate”, “Severe”, or “Very severe” eczema decreased from baseline to 3-months follow-up. In comparison, changes in the CG were less pronounced. Notably, the adjusted OR for having a higher severity of hand eczema for the CG was found to be 7 (95% CI 1.9-29.2, $P < .01$).

3.5 Occupational consequences

Occupational consequences of OCD were examined at the 3-months follow-up, focusing on events within the last three months directly caused by their OCD (table 10). In the IG, 4.5% reported sick leave compared to none in the CG. A similar proportion of participants reported changes to their work assignments in the IG (4.3%) and CG (9.1%). Notably, no one in the IG reported changing their workplace within the same field, contrasting with 9.1% in the CG.

Job loss due to OCD was similar across groups (4.3% in the IG and 4.5% in the CG), with a majority reporting no consequences (60.9% in IG, 59.1% in CG).

3.6 Quality of life

The IG and CG displayed comparable scores across the examined quality of life instruments at baseline and at follow-up (Supplementary material). For both groups, the mean DLQI score indicated a small impact on life at baseline and follow-up, and similarly, Skindex-29 scores remained moderate for emotions and functioning, while symptoms moved from “extremely severe” to “severe”. Overall, no statistically significant differences were observed between the IG and CG, demonstrating similar quality of life in both groups at baseline and 3-months follow-up.

4 Discussion

4.1 Severity of OCD

Our findings demonstrated a statistically significant reduction in the severity of OCD in the IG compared to the CG based on the degree of eczema within the last three months and self-assessed severity of hand eczema using the photographic guide. Additionally, we found a decreasing trend in the VAS score in the IG compared to the CG, but this did not reach statistical significance. VAS has in several studies been shown to correlate poorly to other severity assessment tools, such as photographic guide and dermatologist-rated severity.[28–30]

Studies conducted in Germany have examined the effect of TIP on the severity of OCD after intervention, although these studies lacked a control group. OCD severity was found to decrease statistically significantly 1 month, 1 year and 3 years after intervention compared to baseline.[11,31,32]

The findings suggest potential benefits of the intervention, possibly due to the immediate initiation of highly specialized diagnostics and treatment provided in the intervention setting. This interpretation is consistent with previous research by Hald et al,[33] which demonstrated that delays in medical attention for hand eczema correlated with poorer prognosis.

4.2 Treatment and skin protective behavior

We found that all the IG participants and 68.2% of the CG had seen a dermatologist at 3-months follow-up. The waiting list for the first consultation at a local dermatologist is on average 5 months in Denmark.[34] Furthermore, there will often be a subsequent waiting period for patch testing of unknown duration. Concurrently, we noted a tendency for the IG participants to report more treatment in terms of both prescribed topical treatment and self-reported use of topical corticosteroid treatment at the 3-months follow-up, although this was not statistically significant. While the use of hand moisturizers at 3-months follow-up did not reach statistical significance, we found a tendency for the IG group to use hand moisturizers more frequently than the CG. This would be in alignment with our expectations, as part of the intervention was education in skin-protective behavior. These findings could be part of the explanation for the lower severity of OCD observed at 3-months follow-up in the IG.

4.3 Occupational consequences and quality of life

We found no significant differences in occupational consequences or quality of life between the IG and CG. Given that previous studies have reported severe impact of OCD on both aspects,[1,2] it is plausible that our follow-up was too early in the disease course to capture the potential impact of the intervention. Although the DLQI and Skindex-29 instruments are skin-specific quality-of-life tools, they lack precision in capturing the specific impact of eczema symptoms on quality of life. Since this study's commencement, the quality of life in hand eczema questionnaire (QOLHEQ) has been developed and validated in Danish,[35] presenting a better option for evaluating quality of life in hand eczema patients.

4.4 Strengths and limitations

This study's strengths include its randomized, controlled design and adherence to the CONSORT guidelines, which enhance the validity and transparency of the findings.

We applied a per-protocol analysis, focusing on participants who completed the study and adhered to the protocol, because of the study's size and challenges encountered in participant adherence and data completion. However, this approach inherently carries the risk of bias, as it excludes drop-outs, who might

systematically differ from those adhering to the protocol, potentially introducing attrition bias and limiting the generalizability of the results.

An attrition analysis was conducted to identify any systematic differences between retained participants and drop-outs. The only significant difference was in disease duration, which was shorter among drop-outs. This could potentially lead to an underestimation of the intervention's effect, given that OCD with a shorter disease duration generally has a better prognosis.[33]

Several obstacles were encountered during the study. Disruptions caused by the COVID-19 pandemic and subsequent lockdown, a nationwide nurse strike, and technical difficulties within the Danish National Referral Database system hindered participant recruitment and workflow. Furthermore, a legislative requirement to obtain permission from the referring physician before contacting patients further slowed recruitment and reduced the number of potential participants. As a result, the study was unable to reach its desired sample size, impacting statistical power.

Conclusion

A statistically significant improvement was found in the severity of OCD at the 3-months follow-up in the intervention group compared to the control group, indicating a favorable effect of early intervention and treatment as implemented in the tested Danish-adapted intervention. Analysis of further follow-up data is planned.

References

1. Dietz JB, Menné T, Meyer HW, et al. Occupational contact dermatitis among young people in Denmark – A survey of causes and long-term consequences. *Contact Dermatitis*. 2022;86(5):404-416. doi:10.1111/cod.14050

2. Hutchings C V, Shum KW, Gawkrodger DJ. Occupational contact dermatitis has an appreciable impact on quality of life. *Contact Dermatitis*. 2001;45(1):17-20.

3. Quaade AS, Alinaghi F, Dietz JB, Erichsen CY, Johansen JD. Chronic hand eczema: a prevalent disease in the general population related to reduced quality of life and poor overall health measures. *(Unpublished Manuscript)*.

4. Carøe TK, Ebbehøj NE, Bonde JP, Agner T. Occupational hand eczema and/or contact urticaria: factors associated with change of profession or not remaining in the workforce. *Contact Dermatitis*. 2018;78(1):55-63. doi:10.1111/cod.12869

5. Dietz JB, Menné T, Meyer HW, et al. Degree of employment, sick leave, and costs following notification of occupational contact dermatitis—A register-based study. *Contact Dermatitis*. 2021;84(4):224-235. doi:10.1111/cod.13719

6. Bregnhøj A, Menné T, Johansen JD, Søsted H. Prevention of hand eczema among Danish hairdressing apprentices: An intervention study. *Occup Environ Med*. 2012;69(5):310-316. doi:10.1136/oemed-2011-100294

7. Ibler KS, Jemec GBE, Diepgen TL, et al. Skin care education and individual counselling versus treatment as usual in healthcare workers with hand eczema: Randomised clinical trial. *BMJ (Online)*. 2012;345(7887). doi:10.1136/bmj.e7822

8. Flyvholm MA, Mygind K, Sell L, Jensen A, Jepsen KF. A randomised controlled intervention study on prevention of work related skin problems among gut cleaners in swine slaughterhouses. *Occup Environ Med*. 2005;62(9):642-649. doi:10.1136/oem.2004.016576

9. Held E, Mygind K, Wolff C, Gyntelberg F, Agner T. Prevention of work related skin problems: An intervention study in wet work employees. *Occup Environ Med*. 2002;59(8):556-561. doi:10.1136/oem.59.8.556

10. Sell L, Flyvholm MA, Lindhard G, Mygind K. Implementation of an occupational skin disease prevention programme in Danish cheese dairies. *Contact Dermatitis*. 2005;53(3):155-161. doi:10.1111/j.0105-1873.2005.00674.x

11. Skudlik C, Weisshaar E, Scheidt R, et al. First results from the multicentre study Rehabilitation of Occupational Skin Diseases - Optimization and Quality Assurance of Inpatient Management (ROQ). *Contact Dermatitis*. 2011;66:140-147.

12. Brans R, Skudlik C, Weisshaar E, et al. Multicentre cohort study 'Rehabilitation of Occupational Skin Diseases – Optimization and Quality Assurance of Inpatient Management (ROQ)': results from a 3-year follow-up. *Contact Dermatitis*. 2016;75(4):205-212. doi:10.1111/cod.12614

13. Ahlström MG, Dietz JB, Wilke A, Johansen JD, John SM, Brans R. Evaluation of the secondary and tertiary prevention strategies against occupational contact dermatitis in Germany: A systematic review. *Contact Dermatitis*. 2022;87(2):142-153. doi:10.1111/cod.14099

14. Wilfinger D, Kummer M, Aberer W, Takacs S, Galli-Novak E. BK-19 new - establishment of a successful prevention model in Austria for occupational skin diseases. *Dermatologie in Beruf und Umwelt*. 2018;66(3):135-139. doi:10.5414/DBX00326

15. Dietz JB, Flyvholm M, Menné T, et al. *En Sammenligning Mellem Dansk Og Tysk Arbejdsskadesystem Med Fokus På Håndeksem*.; 2018. https://www.videncenterforallergi.dk/wp-content/uploads/files/rapporter/Rapport-finalfeb2018-En_sammenligning_mellem_dansk_og_tysk_arbejdsskadesystem_med_fokus_på_håndeksem.pdf

16. Schulz KF, Altman DG, Moher D. CONSORT 2010 Statement: Updated guidelines for reporting parallel group randomised trials. *J Clin Epidemiol*. 2010;63(8):834-840. doi:10.1016/j.jclinepi.2010.02.005

17. SP K. Sample Size Calculator. Accessed August 14, 2019. https://clincalc.com/stats/samplesize.aspx

18. Sealed Envelopte LTd. Accessed June 8, 2020. https://www.sealedenvelope.com/simple-randomiser/v1/lists

19. Susitaival P, Flyvholm MA, Meding B, et al. Nordic Occupational Skin Questionnaire (NOSQ-2002): A new tool for surveying occupational skin diseases and exposure. *Contact Dermatitis*. 2003;49(2):70-76. doi:10.1111/j.0105-1873.2003.00159.x

20. Hald M, Berg ND, Elberling J, Johansen JD. Medical consultations in relation to severity of hand eczema in the general population. *British Journal of Dermatology*. 2008;158(4):773-777. doi:10.1111/j.1365-2133.2007.08431.x

21. Coenraads PJ, Van Der Walle H, Thestrup-Pedersen K, et al. Construction and validation of a photographic guide for assessing severity of chronic hand dermatitis. *British Journal of Dermatology*. 2005;152(2):296-301. doi:10.1111/j.1365-2133.2004.06270.x

22. Silverberg JI, Patel N, Immaneni S, et al. Assessment of atopic dermatitis using self-report and caregiver report: a multicentre validation study. *British Journal of Dermatology*. 2015;173(6):1400-1404. doi:10.1111/bjd.14031

23. Finlay AY, Khan GK. Dermatology Life Quality Index (DLQI)—a simple practical measure for routine clinical use. *Clin Exp Dermatol*. 1994;19(3):210-216. doi:10.1111/j.1365-2230.1994.tb01167.x

24. Chren M, Lasek RJ, Flocke SA, Zyzanski SJ. Improved Discriminative and Evaluative Capability of a Refined Version of Skindex, a Quality-of-Life Instrument for Patients With Skin Diseases. *Arch Dermatol*. 1997;133(11):1433-1440.

25. Janssen MF, Pickard AS, Golicki D, et al. Measurement properties of the EQ-5D-5L compared to the EQ-5D-3L across eight patient groups: A multi-country study. *Quality of Life Research*. 2013;22(7):1717-1727. doi:10.1007/s11136-012-0322-4

26. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap) – A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377-381.

27. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform*. 2019;95(April):103208. doi:10.1016/j.jbi.2019.103208

28. Hald M, Veien NK, Laurberg G, Johansen JD. Severity of hand eczema assessed by patients and dermatologist using a photographic guide. *British Journal of Dermatology*. 2007;156(1):77-80. doi:10.1111/j.1365-2133.2006.07565.x

29. Cvetkovski RS, Jensen H, Olsen J, Johansen JD, Agner T. Relation between patients' and physicians' severity assessment of occupational hand eczema. *British Journal of Dermatology*. 2005;153(3):596-600. doi:10.1111/j.1365-2133.2005.06768.x

30. Mollerup A, Johansen JD. Response shift in severity assessment of hand eczema with visual analogue scales. *Contact Dermatitis*. 2015;72(3):178-183. doi:10.1111/cod.12335

31. Weisshaar E, Skudlik C, Scheidt R, et al. Multicentre study 'rehabilitation of occupational skin diseases -optimization and quality assurance of inpatient management (ROQ)'-results from 12-month follow-up. *Contact Dermatitis*. 2013;68(3):169-174. doi:10.1111/j.1600-0536.2012.02170.x

32. Brans R, Skudlik C, Weisshaar E, et al. Multicentre cohort study 'Rehabilitation of Occupational Skin Diseases – Optimization and Quality Assurance of Inpatient Management (ROQ)': results from a 3-year follow-up. *Contact Dermatitis*. 2016;75(4):205-212. doi:10.1111/cod.12614

33. Hald M, Agner T, Blands J, Johansen JD. Delay in medical attention to hand eczema: A follow-up study. *British Journal of Dermatology*. 2009;161(6):1294-1300. doi:10.1111/j.1365-2133.2009.09402.x

34. www.sundhed.dk. *Accessed 21 July 2023*.

35. Yüksel YT, Ibler K, Agner T, Ofenloch R. Validation of the Danish version of the Quality of Life in Hand Eczema Questionnaire (QOLHEQ). *British Journal of Dermatology*. 2022;187(2):256-258. doi:10.1111/bjd.21041

Tables

Table 1. *Baseline characteristics of the intervention and control group*

	Intervention, n(%)	Control, n(%)	P value
Sex (n=45)†			
Male	9 (39.1%)	11 (50%)	0.6
Female	14 (60.9%)	11 (50%)	
Age, years (n=45)‡			
Mean ± SD	40.5 ± 14.5	35.1 ± 14.6	0.3
Median [interquartile range]	43 [29-52.5]	30.5 [26-50]	
Country of birth (n=38)†			
Denmark	20 (95.2%)	17 (100%)	1
Other country	1 (4.8%)	0 (0%)	
Occupation (n=45)			
Healthcare workers	6 (26.1%)	4 (18.2%)	
Kitchen personel	2 (8.7%)	4 (18.2%)	
Mechanics, fitters and technicians	4 (17.4%)	1 (4.5%)	
Office workers	2 (8.7%)	3 (13.6%)	
Machine operators and metalworkers	1 (4.3%)	2 (9.1%)	
Cleaning personnel	1 (4.3%)	2 (9.1%)	
Hairdressers and beauticians	2 (8.7%)	1 (4.5%)	
Sale assistants	1 (4.3%)	1 (4.5%)	
Nursery teachers	2 (8.7%)	2 (9.1%)	
Bakers and pastry chefs	1 (4.3%)	0 (0%)	
Butchers, slaughterhouse workers	0 (0%)	1 (4.5%)	
Mixed manual workers	1 (4.3%)	1 (4.5%)	

†Fisher's exact test

‡Wilcoxon rand sum test

Table 2. *Characteristics related to disease duration and severity of all time worst eczema in the intervention and control group.*

	Intervention, n(%)	Control, n(%)	P value
Disease duration since onset (n=45)‡			
< 1 year	13 (56.5%)	9 (40.9%)	0.4
1-5 years	6 (26.1%)	8 (36.4%)	
6-10 years	2 (8.7%)	4 (18.2%)	
> 10 years	2 (8.7%)	1 (4.5%)	
VAS-score (0-10) of all time worst eczema (n=43)‡			
Mean ± SD	7.3 ± 1.8	7.2 ± 2.1	0.6
Median [interquartile range]	7.7 [7.1-8.6]	7.3 [7-8.1]	
Photographic guide - all time worst eczema (n=45)‡			
Almost clear (group 1)	2 (8.7%)	1 (4.5%)	0.3
Moderate (group 2)	8 (34.8%)	7 (31.8%)	
Severe (group 3)	12 (52.2%)	9 (40.9%)	
Very severe (group 4)	1 (4.3%)	5 (22.7%)	
Atopic dermatitis (self-reported) (n=45)†			
Atopic dermatitis	6 (26.1%)	2 (9.1%)	0.2
No atopic dermatitis	17 (73.9%)	20 (90.9%)	

†Fisher's exact test

‡Wilcoxon rand sum test

Table 3. *Characteristics of the intervention group and their diagnosis and treatment course at Department of Dermatology at Gentofte Hospital, Denmark, (n=23)*

	Intervention group
Number of Doctor Consultations within the first 3 months (n=23)	
Mean ± SD	2.2 ± 0.4
Median [interquartile range]	2 [2-2]
Days between referal from GP until first doctor consultation at the Department of Dermatology (n=23)	
Mean ± SD	34.7 ± 16.7
Median [interquartile range]	40 [16.5-48]
Hand Eczema Severity Index (HECSI) score, mean ± SD	
Baseline (n=23)	32.4 ± 21.6
3-months follow-up (n=20)	19.1 ± 21.6
Primary diagnosis (n=23), n(%)	
Irritant contact dermatitis	18 (78.3%)
Allergic contact dermatitis	4 (17.4%)
Atopic dermatitis	0 (0%)
Other diagnosis	1 (4.3%)
Secondary diagnosis (n=18), n(%)	
Irritant contact dermatitis	2 (11.1%)
Allergic contact dermatitis	0 (0%)
Atopic dermatitis	5 (27.8%)
Other diagnosis	1 (5.6%)
End diagnosis - Occupational contact dermatitis (n=23), n(%)	
Yes	23 (100%)
No	0 (0%)

Table 4. *Proportion of workers in the intervention and control group meeting the different criteria for the definition of wet work at baseline and 3-months follow-up.*

Wet work	**Intervention group n(%)**	**Control group n(%)**
Wet hands > 2 hours per shift (n=39)		
Yes	5 (23.8%)	4 (22.2%)
No	16 (76.2%)	14 (77.8%)
Wearing occlusive gloves > 2 hours per shift (n=26)		
Yes	9 (69.2%)	6 (46.2%)
No	4 (30.8%)	7 (53.8%)
Washing their hands > 20 times per shift (n=39)		
Yes	7 (33.3%)	6 (33.3%)
No	14 (66.7%)	12 (66.7%)

Table 5. *Daily use of hand moisturizers in the intervention and control group at baseline and 3-months follow-up.*

Daily use of hand moisturizers ($n^{baseline}$=40, $n^{3\text{-months}}$=38)	Intervention group n(%)		Control group, n(%)	
	Baseline	3-months	Baseline	3-months
Never	4 (18.2%)	3 (14.3%)	4 (22.2%)	5 (29.4%)
A couple of times a week	3 (13.6%)	0 (0%)	2 (11.1%)	2 (11.8%)
Once daily	6 (27.3%)	3 (14.3%)	5 (27.8%)	1 (5.9%)
Several times daily	9 (40.9%)	15 (71.4%)	7 (38.9%)	9 (52.9%)

Table 6. *Proportion of workers in the intervention and control group who have had a doctor-consultation with a dermatologist at 3-months follow-up (n=45).*

Doctor consultation with a dermatologist within the last three months?	Intervention group n(%)	Control group n(%)	P-value†
Yes	23 (100%)	15 (68.2%)	< 0.01
No	0 (0%)	7 (31.8%)	

† Fisher's exact test

Table 7. *Medical treatment during the last three months of the intervention and control group at 3-months follow-up (n=45)*

	Intervention group, n(%)	Control group, n(%)
Topical treatment		
Mild corticosteroids	1 (4.3%)	1 (4.5%)
Moderate corticosteroids	1 (4.3%)	1 (4.5%)
Potent corticosteroids	20 (87%)	11 (50%)
Very potent corticosteroids	1 (4.3%)	3 (13.6%)
Tacrolimus	5 (21.7%)	2 (9.1%)
Systemic treatment		
Acitretin	0 (0%)	1 (4.5%)
Antibiotics	0 (0%)	2 (9.1%)

Table 8. *Use of topical corticosteroid treatment within the last three months at 3-months follow-up (n=44).*

	Intervention group, n(%)	**Control group, n(%)**
No topical corticosteroid use	2 (8.3%)	3 (15%)
< 2 months all together	9 (37.5%)	10 (50%)
> 2 months all together	13 (54.2%)	7 (35%)

Table 9. *Severity of hand eczema at baseline and at 3-months follow-up for the intervention and control group assessed by degree of eczema within the last three months, self-assessed severity by VAS-scale and self-assessed severity using the photographic guide (n=45)*

	Intervention group n(%)		**Control group n(%)**	
	Baseline	**3-months**	**Baseline**	**3-months**
Degree of eczema within the last three months				
No eczema	0 (0%)	1 (4.3%)	1 (4.5%)	0 (0%)
Less than half the time	3 (13%)	4 (17.4%)	0 (0%)	2 (9.1%)
Half the time	3 (13%)	4 (17.4%)	1 (4.5%)	3 (13.6%)
More than half the time	4 (17.4%)	7 (30.4%)	9 (40.9%)	4 (18.2%)
All the time	13 (56.5%)	7 (30.4%)	11 (50%)	13 (59.1%)
Crude OR for having larger amount of hand eczema (control group), OR (95% CI)				2.9 (1-9.1)
Adjusted OR for having larger amount of hand eczema (control group), OR (95% CI)†				**4.6 (1.3-18)***
Severity of eczema within the last three months on the VAS scale ($n^{baseline}$=44)				
Mean ± SD	5.9 ± 2	4.1 ± 2.3	6.8 ± 2	4.8 ± 2.7
Crude mean difference (95% CI)				0.3 (-1.2;1.8)
Adjusted mean difference (95% CI)†				0.6 (-1;2.1)
Severity of hand eczema within the last three months self-assessed by the photographic guide				
No eczema	0 (0%)	1 (4.3%)	0 (0%)	0 (0%)
Almost clear (group 1)	5 (21.7%)	9 (39.1%)	2 (9.1%)	5 (22.7%)
Moderate eczema (group 2)	9 (39.1%)	3 (13%)	12 (54.5%)	11 (50%)
Severe eczema (group 3)	9 (39.1%)	3 (13%)	5 (22.7%)	3 (13.6%)
Very severe eczema (group 4)	1 (4.3%)	0 (0%)	3 (13.6%)	3 (13.6%)
Crude OR for having higher severity of hand eczema (control group), OR (95% CI)				2.8 (0.9-9)
Adjusted OR for having higher severity of hand eczema (control group), OR (95% CI)†				**7 (1.9-29.2)****

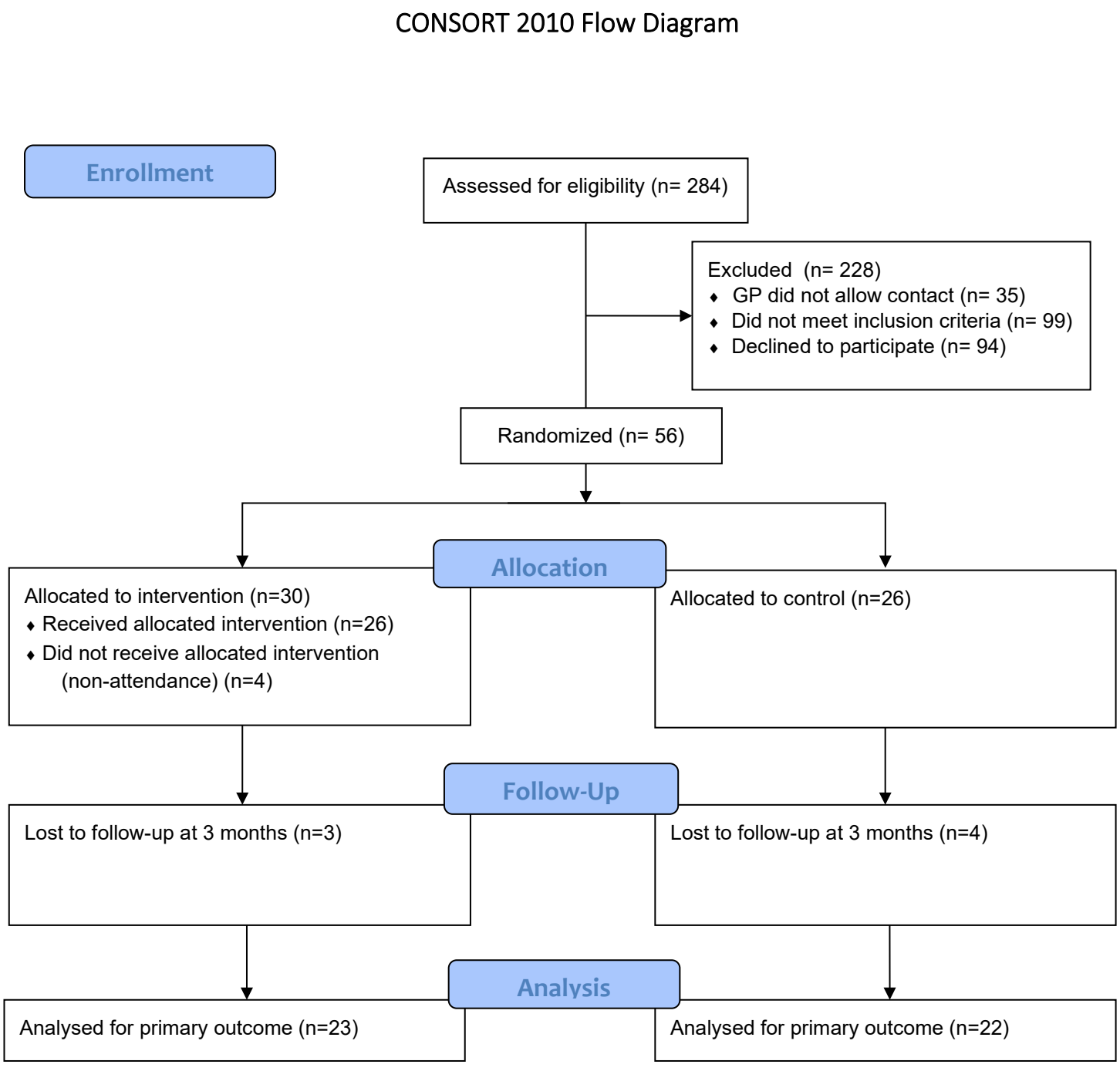
†Adjusted for age, sex and atopic dermatitis

* P < .05, ** P < .01, *** P < .001

Table 10. *Consequences experienced by the intervention and control group within the last three months at 3-months follow-up (n=45)*

	Intervention group, n(%)	**Control group, n(%)**
Sickleave	1 (4.5%)	0 (0%)
Changed workassignments (in the same workplace)	1 (4.3%)	2 (9.1%)
Changed workplace (in the samme occupational field)	0 (0%)	2 (9.1%)
Changed occupational field	2 (8.7%)	2 (9.1%)
Jobloss	1 (4.3%)	1 (4.5%)
Retired	0 (0%)	0 (0%)
No consequences	14 (60.9%)	13 (59.1%)

Supplementary Figure 1. *Flow diagram for the study*



Supplementary Table 1. *Attrition-analysis*

	Retained participants, n=45	Dropouts, n=11	P value
Group, n(%)†			
Intervention	23 (51.1)	7 (63.6)	0.5
Kontrol	22 (48.9)	4 (36.4)	
Sex, n(%)†			
Male	20 (44.4)	4 (36.4)	0.7
Female	25 (55.6)	7 (63.6)	
Age, years‡			
Mean ± SD	37.9 ± 14.6	34.3 ± 12.8	0.4
Median [interquartile range]	32 [26-52]	40 [23-44]	
Country of birth, n(%)†	*n=38*		
Denmark	37 (97.4)	9 (81.8)	0.1
Other country	1 (2.6)	2 (18.2)	
Disease duration since onset, n(%)‡			
< 1 year	22 (48.9)	10 (90.9)	<0.05
1-5 years	14 (31.1)	1 (9.1)	
6-10 years	6 (13.3)	0 (0.0)	
> 10 years	3 (6.7)	0 (0.0)	
VAS-score (0-10) of all time worst eczema‡	*n=43*		
Mean ± SD	7.3 ± 1.9	7.8 ± 1.4	0.7
Median [interquartile range]	7.5 [7.0-8.4]	7.5 [6.7-9.0]	
Photoguide - all time worst eczema, n(%)‡			
Almost clear (group 1)	3 (6.7)	2 (18.2)	0.7
Moderate (group 2)	15 (33.3)	4 (36.4)	
Severe (group 3)	21 (46.7)	2 (18.2)	
Very severe (group 4)	6 (13.3)	3 (27.3)	
Atopic dermatitis (self-reported), n(%)†		*n=10*	
Atopic dermatitis	8 (17.8)	3 (30.0)	0.4
No atopic dermatitis	37 (82.2)	7 (70.0)	

† Fisher's exat test for count data

‡ Wilcoxon rank sum test

Supplementary Table 2. *Patch-testing of the intervention group (n=23)*

Allergen	Participants tested, n(%)
European Baseline Series	23 (100%)
Supplementary Standard Series	23 (100%)
Fragrance Allergens	23 (100%)
Extended Rubber Chemicals	17 (73.9%)
Metalworking Fluid Components (current)	4 (17.4%)
Metalworking Fluid Components (Historical)	1 (4.3%)
Shampoo Components	1 (4.3%)
Hairdresser/customer Series	1 (4.3%)
Supplementary Hair Dye Allergens	1 (4.3%)
Bakers' Allergens	1 (4.3%)
Food Allergens	1 (4.3%)
Acrylate Mini Series	1 (4.3%)
Nail Acrylates	2 (8.7%)
Surface Coating and Adhesive Acrylates	1 (4.3%)
Essential oils	1 (4.3%)
Black Henna Tattoo allergens (low concentrations9	1 (4.3%)
Patient's own products	19 (82.6%)

Supplementary Table 3. *Patch-testing results for the intervention group (n=23)*

Allergen	Positive patch test, n(%)	Occupational allergy, n(%)
Nickel	2 (8.7%)	0 (0%)
Cobalt	2 (8.7%)	0 (0%)
Chromium	1 (4.3%)	0 (0%)
Formaldehyde	1 (4.3%)	0 (0%)
Methylchloroisothazolinone/Methylisothazolinone (MCI/MI)	1 (4.3%)	0 (0%)
Fragrance Mix II	1 (4.3%)	0 (0%)
Linalool	2 (8.7%)	1 (4.3%)
Methyl Glutaronitrile (MDBGN)	1 (4.3%)	0 (0%)
Benzisothiazolinone (BIT)	1 (4.3%)	1 (4.3%)
Sodium Metabisulfite	1 (4.3%)	1 (4.3%)
Hydroxyethyl Methacrylate (HEMA)	1 (4.3%)	1 (4.3%)
Hydroxyethyl Acrylate (HEA)	1 (4.3%)	1 (4.3%)
Ethyl Acrylate	1 (4.3%)	1 (4.3%)
Hydroxypropyl Mehacrylate (HPMA)	1 (4.3%)	1 (4.3%)
Ethylene Glycol Dimethacrylate (EGDMA)	1 (4.3%)	1 (4.3%)
Thiruam Mix	1 (4.3%)	1 (4.3%)

Supplementary Table 4. *Quality of life at baseline and 3-months follow-up for the intervention and control group assessed by DLQI, Skindex-29 and EQ-5D-5L.*

	Intervention group n(%)		Control group n(%)	
	Baseline	3-month	Baseline	3-month
Dermatology Life Quality Index (DLQI) ($n^{baseline}$=38, $n^{3\text{-}month}$=39)				
Mean ± SD	5.9 ± 3.7	4.6 ± 3.6	5.6 ± 3.6	4.9 ± 4
Interpretation (effect on patient's life)	small	small	small	small
Crude mean difference (95% CI)				0.1 (-2;2.2)
Adjusted mean difference (95% CI)†				0.9 (-1.4;3.2)
Skindex-29				
Emotions (n=43)				
Mean ± SD	33.6 ± 16.9	28.6 ± 20.4	38.5 ± 25	31.3 ± 25.6
Interpretation (effect on patient's life)	Moderate	Moderate	Moderate	Moderate
Crude mean difference (95% CI)				-2.4 (-13;8.2)
Adjusted mean difference (95% CI)†				-0.5 (-11.6;10.7)
Symptoms ($n^{baseline}$=43, $n^{3\text{-}month}$=44)				
Mean ± SD	55.3 ± 19.5	42.9 ± 20.1	57.5 ± 20.2	49.8 ± 22.5
Interpretation (effect on patient's life)	Extremely severe	Severe	Extremely severe	Severe
Crude mean difference (95% CI)				5.5 (-5.5;16.5)
Adjusted mean difference (95% CI)†				7.6 (-4.1;19.2)
Functioning ($n^{baseline}$=43, $n^{3\text{-}month}$=42)				
Mean ± SD	17.2 ± 15.5	12.4 ± 11.1	15.5 ± 18	12.7 ± 18.7
Interpretation (effect on patient's life)	Moderate	Moderate	Moderate	Moderate
Crude mean difference (95% CI)				0.4 (-6.6;7.4)
Adjusted mean difference (95% CI)†				1.9 (-5.4;9.3)
EQ-5D-5L				
Mobility (n=45)				
No problems	18 (78.3%)	22 (95.7%)	19 (86.4%)	21 (95.5%)
Slight problems	4 (17.4%)	1 (4.3%)	3 (13.6%)	0 (0%)
Moderate problems	1 (4.3%)	0 (0%)	0 (0%)	0 (0%)
Severe problems	0 (0%)	0 (0%)	0 (0%)	1 (4.5%)
Unable to walk about	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Self-care (n=45)				
No problems	22 (95.7%)	22 (95.7%)	19 (86.4%)	17 (77.3%)
Slight problems	1 (4.3%)	1 (4.3%)	2 (9.1%)	4 (18.2%)
Moderare problems	0 (0%)	0 (0%)	1 (4.5%)	0 (0%)
Severe problems	0 (0%)	0 (0%)	0 (0%)	1 (4.5%)
Unable to wash or dress	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Usual activities (n=45)				
No problems	14 (60.9%)	12 (52.2%)	11 (50%)	14 (63.6%)

Slight problems	6 (26.1%)	10 (43.5%)	7 (31.8%)	6 (27.3%)
Moderare problems	3 (13%)	1 (4.3%)	3 (13.6%)	1 (4.5%)
Severe problems	0 (0%)	0 (0%)	1 (4.5%)	1 (4.5%)
Unable to do usual activities	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Pain / discomfort				
No pain/discomfort	3 (13%)	6 (26.1%)	3 (13.6%)	6 (27.3%)
Slight pain/discomfort	12 (52.2%)	14 (60.9%)	9 (40.9%)	11 (50%)
Moderate pain/discomfort	6 (26.1%)	3 (13%)	8 (36.4%)	1 (4.5%)
Severe pain/discomfort	2 (8.7%)	0 (0%)	2 (9.1%)	3 (13.6%)
Extreme pain/discomfort	0 (0%)	0 (0%)	0 (0%)	1 (4.5%)
Anxiety / depression				
Not anxious/depressed	18 (78.3%)	19 (82.6%)	17 (77.3%)	17 (77.3%)
Slightly anxious/depressed	3 (13%)	3 (13%)	4 (18.2%)	3 (13.6%)
Moderately anxious/depressed	2 (8.7%)	1 (4.3%)	1 (4.5%)	1 (4.5%)
Severely anxious/depressed	0 (0%)	0 (0%)	0 (0%)	1 (4.5%)
Extremely anxious/depressed	0 (0%)	0 (0%)	0 (0%)	0 (0%)

†Adjusted for age, sex and atopic dermatitis

* P < .05, ** P < .01, *** P < .001