UNIVERSITY OF COPENHAGEN FACULTY OF HEALTH AND MEDICAL SCIENCES



PhD Thesis

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Occupational hand eczema in hairdressers

Long-term follow-up and evaluation of a nationwide evidence-based skin protection programme

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> Martin Havmose Copenhagen, August 2022

Abbreviations

- ACD: allergic contact dermatitis
- AD: atopic dermatitis
- ATP: Danish Labour Market Supplementary Pension Scheme (Danish: Arbejdsmarkedets

Tillægspension)

- CI: confidence interval
- HE: hand eczema
- HR: hazard ratio
- IR: incidence rate
- ICD: irritant contact dermatitis
- IRR: incidence rate ratio
- OCD: occupational contact dermatitis
- OHE: occupational hand eczema
- OR: odds ratio
- SIP: secondary individual prevention
- TIP: tertiary individual prevention
- UKWP: United Kingdom Working Party

Table of contents

SUMMARY	4
DANSK RESUMÉ	7
1. INTRODUCTION	9
2. BACKGROUND	11
2.1 Epidemiology of hand eczema in hairdressers	11
2.1.1 Prevalence and incidence	11
2.1.2 Onset	11
2.1.3 Severity	12
2.1.4 Prognosis	13
2.1.5 Risk factors for occupational hand eczema in hairdressers	15
2.1.6 Distribution of ICD and ACD	16
2.2 Diagnosis of ICD and ACD	17
2.3 Career consequences of hand eczema in hairdressers	17
2.4 Prevention of occupational hand eczema in hairdressers	18
3. THESIS OBJECTIVES	20
4. LEGAL PERMITS AND APPROVALS	20
5. MATERIALS AND METHODS	21
5.1 Study design	21
5.1.1 Prospective cohort study	21
5.1.2 Repeated cross-sectional study	22
5.2 Data from registries	23
5.2.1 The Danish National Archives	23
5.2.2. The Danish Hairdressers and Beauticians Union	23
5.2.3 The Danish Labour Market Supplementary Pension Scheme (Danish: Arbejdsmarkedets Tillægspension) (ATP)	23
5.2.4 Statistics Denmark (Danish: Danmarks Statistik)	23

5.3 The questionnaires	. 24
5.3.1 Baseline and follow-up questionnaires	. 24
5.3.2 Definition of outcome variables	. 25
5.3.3 Pilot study	. 26
5.3.4 Distribution of the questionnaires	. 26
6. MAIN RESULTS	27
6.1 Data from registries	. 27
6.1.1 Danish national archives	. 27
6.1.2 Danish Hairdressers and Beauticians Union	. 27
6.1.3 The Danish labour market supplementary pension scheme (ATP)	. 28
6.2 Response to the questionnaires	. 28
6.2.1 Follow-up study of hairdressers graduating from 1985–2007	. 28
6.2.2 Cross-sectional study of hairdressers graduating from 2008–2018	. 29
6.2.3 Data entry of postal questionnaires	. 29
6.3 Baseline characteristics of the study populations	. 30
6.3.1 Follow-up study of hairdressers graduating from 1985–2007	. 30
6.3.2 Cross-sectional study of hairdressers graduating from 2008–2018	. 30
6.4 Analysis of non-respondents	. 31
6.4.1 Follow-up study of hairdressers graduating from 1985–2007	. 31
6.4.2 Cross-sectional study of hairdressers graduating from 2008–2018	. 31
6.5 Manuscript I: Long-term follow-up of hand eczema in hairdressers: a prospective cohort study of hairdressers graduating from 1985–2007	. 32
6.6 Manuscript II: Occupational hand eczema reduces career length in hairdressers: a prospective cohor study of Danish hairdressers graduating from 1985–2007	rt . 33
6.7 Manuscript III: A nationwide skin protection programme introduced in hairdressing vocational scho	ools
was followed by a decreased risk of occupational hand eczema	. 36
7. GENERAL DISCUSSION	.39
7.1 Long-term follow-up of hand eczema in hairdressers: a prospective cohort study of hairdressers graduating from 1985–2007 (manuscript I)	. 39

7.2 Occupational hand eczema reduces career length in hairdressers: a prospective cohort study of Danis	h
hairdressers graduating from 1985–2007 (manuscript II)	41
7.3 A nationwide skin protection programme, implemented in hairdressing vocational schools, was	
followed by a decreased risk of occupational hand eczema (manuscript III)	42
8. CONSIDERATIONS ON METHODOLOGY	45
8.1 Hairdressers lost to follow-up	45
8.2 Exclusion of hairdressing apprentices	46
8.3 Definition of outcome variables	46
8.3.1 Self-reported hand eczema	46
8.3.2 A history of atopic dermatitis	48
9. CONCLUSIONS	49
10. FUTURE PERSPECTIVES	50
11. MANUSCRIPTS	52
Manuscript I	52
Manuscript II	61
Manuscript III	69
12. REFERENCES	91
13. APPENDIX	99

Summary

Background

Occupational exposure to excessive wet work and allergens in cosmetic hair products means that hairdressing is among those occupations with the highest incidence of occupational hand eczema (OHE). This hand eczema (HE) is often severe, and many studies indicate that hairdressers often leave their profession due to HE. To alleviate this problem, an evidence-based skin protection programme was introduced in Danish hairdressing vocational schools in 2011. The programme was evaluated in an initial intervention study that found a decreased incidence of HE and improved compliance with wearing gloves in the intervention group. The nationwide launch of the skin protection programme has yet to be evaluated.

The aims of this thesis were to:

- Investigate the potential for primary prevention of HE after hairdressing apprenticeships
- Examine the long-term prognosis for HE among hairdressers
- Estimate the impact of HE on the career length of hairdressers
- Investigate whether implementation of the nationwide skin protection programme in hairdressing vocational schools has led to a decrease in incident HE

Methods

This thesis is based on three original manuscripts. Manuscripts I and II report prospective cohort studies of all hairdressers graduating from 1985–2007, who were asked to complete a baseline questionnaire sent in 2009 and a follow-up questionnaire sent in 2020. Manuscript III is a repeated cross-sectional study that compares hairdressers trained before and after the implementation of the nationwide evidence-based skin protection programme in Danish hairdressing vocational schools in 2011.

The Danish Labour Market Supplementary Pension Scheme provides information on payments made within the hairdressing profession and from each individual within the study population. This allowed us to measure the number of years worked in the trade.

Results

<u>Manuscript I</u>: The incidence rate of OHE decreased from 42.8 cases/1,000 person-years (95% confidence interval [CI], 40.8–44.8) at baseline to 3.4 cases/1,000 person-years (95% CI, 2.5–4.6)

at follow-up. The cumulative lifetime prevalence of HE increased from 42.4% at baseline to 45.2% at follow-up.

The time to onset of HE (including the apprenticeship) was a median of 1.2 years, and no statistically significant difference was observed between hairdressers with and without a history of atopic dermatitis (P = 0.18). More than 90% of hairdressers had experienced the onset of HE by their eighth year in the profession (including the apprenticeship).

Among those hairdressers with HE at baseline, 34.6% continued to have persistent, often frequently relapsing, HE at follow-up. Risk factors for persistent HE were previous HE (adjusted odds ratio [aOR], 10.1), a previous positive patch test (aOR, 4.5) and a history of atopic dermatitis (aOR, 1.9).

<u>Manuscript II</u>: Hairdressers with and without OHE had a median career length of 12.0 years and 14.0 years, respectively (P < 0.001). Career length decreased as the frequency of HE increased, and was a median of 7.0 years in hairdressers with OHE 'almost all the time,' 12.0 years in hairdressers with OHE 'several times,' and 20.0 years in hairdressers with OHE 'once' (pairwise comparisons, P < 0.05). Compared to hairdressers without HE, decreased career length was associated with an increased adjusted hazard ratio for having left the trade of 1.9, 1.2 and 0.8 in those who had HE 'almost all the time', 'several times' and 'once', respectively. Risk factors for leaving the trade (partly) because of HE included a history of atopic dermatitis (aOR, 2.2) and a history of contact allergies (aOR, 5.1), particularly if due to hair dyes (aOR, 9.4).

<u>Manuscript III</u>: Decreases in the prevalence of HE (career time prevalence: from 42.8% to 29.0%; 1-year prevalence: from 33.9% to 23.9%; and point prevalence: from 14.1% to 8.1%) and the incidence rate of HE (incidence rate ratio: 0.73; 95% CI, 0.56–0.95) were observed in hairdressers trained after, compared with those trained before, implementation of the skin protection programme. Logistic regression analyses showed that the risk of having OHE had halved in hairdressers trained after implementation of the skin protection programme (aOR, 0.55).

Increases were also observed in the proportion of current hairdressers that used protective gloves regularly when performing shampoos before cutting hair (from 12.6% to 62.9%; odds ratio [OR], 11.8; 95% CI, 6.8–20.3), performing shampoos after dyeing or perming hair (from 57.5% to 90.0%; OR, 6.8; 95% CI, 3.9–12.0), creating permanent waves (from 37.4% to 76.1%; OR, 5.3; 95% CI, 2.6–10.8), colouring eyebrows/lashes (from 0.7% to 13.2%; OR, 21.0; 95% CI, 2.8–157.7), and mixing hair dyes (from 10.9% to 23.2%; OR, 2.5; 95% CI, 1.3–4.7).

5

Conclusions

Incident HE is most likely to occur during a hairdresser's apprenticeship or their first few years of professional work. Therefore, the potential for primary prevention is greatest during the apprenticeship and decreases drastically thereafter.

Because OHE has a poor long-term prognosis and a negative impact on career span, preventive measures are crucial to reduce the burden of the disease and enhance job retention. The evidence-based skin protection programme implemented in Danish vocational schools reduced incident HE and improved compliance with skin protective measures. Therefore, we recommend implementing similar training programmes in hairdressing vocational schools to prevent incident OHE and decrease the long-term impact of the disease.

Dansk resumé

Baggrund

Frisører er igennem deres arbejde hyppigt eksponeret for vådt arbejde og allergener i hårkosmetik. På grund af dette, er frisørfaget blandt de professioner, som oftest rammes af arbejdsbetinget håndeksem. Håndeksemet er ofte svært og flere studier tyder på, at det er medvirkende årsag til at forlade frisørfaget før tid. Som et primært præventivt tiltag til forebyggelse af arbejdsbetinget håndeksem hos frisører, blev der i 2011 indført undervisning i det kemiske arbejdsmiljø på danske frisørskoler. Effekten af denne implementereting har endnu ikke været undersøgt.

Formålet med denne afhandling er at:

- Undersøge potentialet for primær prævention af arbejdsbetinget håndeksem hos frisører efter elevtiden.
- Undersøge prognosen for arbejdsbetinget håndeksem hos frisører
- Estimere arbejdsbetinget håndeksems indflydelse på frisørers karrierelængde
- At evaluere om undervisningen i forebyggelse af håndeksem på danske frisørskoler har ført til at færre frisører udvikler arbejdsbetinget håndeksem.

Metode

Denne afhandling er baseret på tre originale manuskripter. Manuskript I og II er prospektive kohortestudier af alle frisører uddannet fra 1985-2007. Manuskript III er et gentaget tværsnitsstudie der sammenligner frisører uddannet før (2004 til 2007) og efter (2015-2018) indførelsen af undervisning i forebyggelse af håndeksem på danske frisørskoler i 2011. Data blev indsamlet ved hjælp af et spørgeskema som blev sendt i 2009 og 2020. Alle indbetalinger til Arbejdsmarkedets Tillægspension fra frisører inkluderet i studierne blev brugt som estimat for antal år arbejdet i frisørfaget.

Resultater

Manuskript I: Incidensraten af arbejdsbetinget håndeksem faldt fra 42.8 /1000 person-år (95% konfidensinterval (KI) 40.8-44.8) ved baseline (1985-2007 til 2009) til 3.4/1000 person-år (95%KI 2.5-4.6) i opfølgningsperioden (2009 til 2020). Den kumulative livstidsprævalens af håndeksem steg fra 42.4% 2009 til 45.2% i 2020. Mediantiden til debut af arbejdsbetinget håndeksem var 1.2 år efter at være begyndt som frisørelev. Blandt frisører med arbejdsbetinget håndeksem havde

>90% haft debut efter 8 år i faget (inklusive elevtiden). Blandt frisører med håndeksem ved baseline havde 34.6% haft håndeksem i opfølgningsperioden. Risikofaktorer for eksem i opfølgningsperioden var tidligere håndeksem (justeret odds ratio (aOR) 10.1), tidligere kontakt allergi (aOR 4.5) og tidligere atopisk eksem (aOR 1.9).

<u>Manuskript II</u>: Frisører med og uden arbejdsbetinget håndeksem havde en median karrierelængde på henholdsvis 12.0 år og 14.0 år (P<0.001). Karrierelængden forkortes yderligere, hvis håndeksemet var hyppigt, svarende til en median karrierelængde på 7.0 år, 12.0 år og 20.0 år, hos frisører med arbejdsbetinget håndeksem henholdsvis 'næsten hele tiden', 'flere gange' og 'en enkelt gang'. Risikofaktorer for at forlade faget (delvist) på grund af håndeksem var tidligere atopisk eksem (aOR 2.2), kontaktallergi (generelt) (aOR 5.1) og kontaktallergi overfor hårfarve (aOR 9.4).

<u>Manuskript III</u>: Et fald i andelen som havde haft arbejdsbetinget håndeksem i løbet af deres karriere (fra 42.8% til 29.0%), i løbet af det seneste år (fra 33.0% til 23.9%) og i øjeblikket (fra 14.1% til 8.2%) blev observeret når frisører uddannet før og efter indførelsen af undervisningen i det kemiske arbejdsmiljø på danske frisørskoler blev sammenlignet. Dette svarede til omtrent en halvering i risikoen for at få arbejdsbetinget håndeksem.

En samtidig stigning i andelen af nuværende frisører som regelmæssigt brugte handsker når de vaskede kundens hår før klipning (fra 12.6% til 62.9%) (odds ratio (OR) 11.8, 95%KI 6.8-20.3), vaskede kundens hår efter farvning- og permanentbehandling (fra 57.5% til 90.0% (OR 6.8, 95%KI 3.9-12.0), ved permanentbehandling (fra 37.4% til 76.1%) (OR 5.3, 95%KI 2.6-10.8), ved farvning af bryn og vipper (fra 0.7% til 13.2%) (OR 21.0, 95%CI 2.8-157.7), ved blanding af hårfarve (fra 10.9% til 23.2%) (OR 2.5, 95%CI 1.3-4.7) blev set, når frisører uddannet før og efter undervisning i hudbeskyttelse blev indført.

Konklusion

Forekomst af nye tilfælde af arbejdsbetinget håndeksem finder primært sted i elevtiden og i de indledende år efter endt uddannelse. Potentialet for primær prævention af arbejdsbetinget håndeksem er derfor størst i elevtiden og de første år efter endt uddannelse.

Den dårlige prognose af arbejdsbetinget håndeksem og konsekvenserne i form af en nedsat karrierelængde, nødvendiggør primær prævention for at forebygge sygdommen og for at øge fastholdelsen af frisører i faget. Undervisning i forebyggelse af håndeksem hos frisører synes at være effektiv, hvorfor indførelsen af sådanne programmer i frisørskoler anbefales.

1. Introduction

Contact dermatitis is an inflammatory skin disease that results from the exposure of skin to irritants and/or allergens. The disease is subdivided into two main categories, irritant contact dermatitis (ICD) and allergic contact dermatitis (ACD), which differ in their pathogenesis but share the same clinical presentation. ICD is caused by cytotoxic damage to the skin that results in an inflammatory reaction, which is mediated by the innate immune response.¹ ACD is caused by sensitization to allergens and elicitation of a delayed type hypersensitivity reaction upon re-exposure to the culprit allergen.^{1–3} In the acute stage, contact dermatitis may present with itching, erythema, swelling or vesicles, whereas the chronic stage is characterized by dry, scaling skin and sometimes painful fissures.⁴

Contact dermatitis accounted for 32.9% (n = 10,157) of all recognized occupational injuries in Denmark from 2015-2017.⁵ In the same period, compensation for contact dermatitis paid by the Danish Labour Market Insurance totalled 128 million Euros (constituting 7.8% of all compensation paid because of occupational diseases).⁶ In addition, patients with occupational contact dermatitis have an increased risk of losing their jobs and exhibit an overall decrease in quality of life. Therefore, this disease has significant costs at both a societal and personal level.⁷

The incidence rate (IR) of recognized occupational hand eczema (OHE) was approximately 9.8 cases/10,000 workers in Denmark from 2007 to 2018.⁸ Hairdressing was the most commonly affected profession in this investigation with an IR of 42.5/10,000 workers per year. Hairdressing was previously identified as one of the professions that is most frequently affected by OHE, notably in Germany from 1990–2001 (IR, 48.2–97.4/10,000 workers per year), in Denmark from 2001–2002 (IR, 56.1/10,000 workers per year) and in Finland from 2005–2016 (IR, 16.3/10,000 workers per year).^{9–12}

To reduce the level of incident OHE among hairdressers, an evidence-based skin protection programme was implemented nationwide in Danish hairdressing vocational schools in 2011. This was followed by a decrease in the number of recognized cases of OHE among hairdressers from 2013 onwards, suggesting that the programme was effective.⁸ Register-based studies that record recognized cases of OHE provide reliable data in terms of valid diagnoses and job title classification (ISCO: international classification of job titles), but these data may be underreported. For example, 20.7% of Danish hairdressers with hand eczema (HE) reportedly had their HE notified as an occupational injury, and only 29.3% of Australian hairdressers with a confirmed diagnosis of

9

OHE claimed workers compensation.^{13–15} Therefore, in addition to these registries, epidemiological studies are needed to understand the disease and evaluate the effectiveness of preventive measures.

2. Background

2.1 Epidemiology of hand eczema in hairdressers

2.1.1 Prevalence and incidence

A recent systematic review and meta-analysis on the epidemiology of HE in hairdressers found a pooled IR of 51.8/1,000 person-years, a pooled lifetime prevalence of 38.2%, a pooled 1-year prevalence of 20.3% and a pooled point prevalence of 7.7%.¹⁶ In comparison, similar estimates for the general population included a pooled IR of 7.3/1,000 person-years (females: 8.7/1,000 person-years; males: 4.7/1,000 person-years), a pooled lifetime prevalence of 14.7% (females: 19.4%; males: 12.4%), a pooled 1-year prevalence of 8.1% (females: 14.0%: males: data not available) and a pooled point prevalence of 2.8% (females: 3.0%; males: 2.0%).¹⁷ Thus, HE apparently occurs much more frequently among hairdressers than among the general population, before taking confounders such as age and atopic dermatitis (AD) into consideration.

Furthermore, a Swedish study that compared female hairdressers (n = 3,665) with females from the general population (n = 5,034) found an age-adjusted incidence rate ratio (IRR) of 2.5 for HE among the hairdressers, compared with the controls.¹⁸ Interestingly, the IRR increased to 3.1 if the hairdressers were less than 25 years of age, indicating that career stage may be an important factor in the onset HE among hairdressers.

Similarly, a systematic review on the epidemiology of HE in hairdressers found a pooled IR of 150.9/1,000 person-years among hairdressing apprentices and 23.9/1,000 person-years among fully qualified hairdressers.¹⁶ The POSH study (not included in the systematic review), which is the largest prospective cohort study of hairdressing apprentices to date (n = 1,134), reported a similar IR of 152/1,000 person-years.¹⁹ Compared to the IRs for HE reported among the general population, these IRs are staggering and illustrate the consequences of occupational exposure for hairdressers.

2.1.2 Onset

The proportion of hairdressers with HE who experienced disease onset during their apprenticeships has been investigated in cross-sectional questionnaire studies and was approximately 68.7% among Danish hairdressers graduating from 1985–2007 (n = 5,324; surveyed up to 24 years after

graduation) and approximately 40% among Swedish hairdressers graduating from 1975–1995 (n = 3,665; surveyed up to 26 years after graduation).^{18,20} Swedish hairdressers with HE who experienced disease onset after their apprenticeships included 19%, 12%, and 19% who experienced onset within 1–2 years, 3–5 years, and after 5 years, respectively.¹⁸

Older studies that reported on HE onset among hairdressers were all performed on patients who had attended tertiary dermatology clinics; consequently, these studies had much smaller and more selective study populations. Regardless, the same pattern of early onset was documented. Already in the 1950s, 60.7% of English hairdressers with HE had experienced onset within the first year in the trade, and this had increased to 70.5% after three years in the trade.²¹ Similarly, in the 1970s, 67% of German hairdressers with HE had reportedly been affected during their apprenticeships.²² Furthermore, 72% of hairdressers with HE in Sweden and 56.1% of hairdressers with HE in North America were less than 25 years of age when they were examined in dermatology clinics.^{23,24} In the 1980s, hairdressers in Canada had worked for a mean duration of approximately 6.5 years (range: 4 months to 40 years) before the onset of HE.²⁴ This estimate might reflect a delay in diagnosis, given the findings of previous studies. For England in the 1990s, hairdressers had worked a mean duration of 1.2 years (range: 1 month to 6 years) before the onset of HE; and at the turn of the millennium, approximately 82% of hairdressers in Spain with HE had experienced onset within 3 years of starting work.^{25,26}

Thus, hairdressers who develop HE often experience early disease onset. However, cross-sectional surveys found that 31.3–60% of hairdressers who develop HE exhibit disease onset after their graduation; therefore, the proportion of hairdressers who exhibit disease onset after their apprenticeship is unclear.^{18,20} The potential for primary prevention of HE among fully qualified hairdressers needs to be investigated further.

2.1.3 Severity

A substantial proportion of hairdressers with HE develop moderate to severe lesions during the apprenticeship. Among hairdressing apprentices followed during the POSH study from 1992–1994 (n = 1,134), 24.1% had moderate to severe HE upon clinical examination.¹⁹ Similar results were found in a smaller prospective study of German hairdressing apprentices (n = 66) who were followed from 1992–1995, with 62.7% (n = 32) having minimal skin changes, 21.6% (n = 11) having moderate eczema and 15.7% (n = 8) having severe eczema when clinically examined.²⁷

12

Furthermore, clinical examinations of hairdressing apprentices in a department store in the 1970s found that 43.3% (n = 13) had mild, 43.3% (n = 13) had moderate, and 13.3% (n = 4) had severe skin changes.²⁸

More recent studies have reported less severe HE in hairdressing apprentices. A Danish study in 2008–2009, that assessed trainees 18 months after starting their apprenticeships (n = 284), reported a mean HE Severity Index (HECSI) score of 8.4 (median, 6.0; range, 2–21), corresponding to mild eczema.²⁹ Similarly, a study of Croatian hairdressing apprentices (n = 101) from 2016 reported Osnabruck HE Severity Indexes ranging from 1–6, again corresponding to mild HE.³⁰ This is potentially good news, but these results should be interpreted with caution because HE fluctuates in severity, as reported by the POSH study, and clinical examinations produce a wide range of estimates for the point prevalence of HE among hairdressers (range, 4.2% to 25.7%).^{16,19}

In addition, clinical examination of HE in hairdressers is susceptible to selection bias because hairdressers with HE may have left the trade and not been included in the study population. A study of hairdressers (including apprentices) with HE working in salons in Taiwan in 1994 (n = 82) found that 35.4% (n = 18) had mild, 62.2% (n = 51) had moderate, and 2.4% (n = 2) had severe HE.³¹ HE was more often moderate or severe among the hairdressing apprentices. The authors offered two explanations for this observation: either occupational exposure differed between the apprentices and qualified hairdressers, or hairdressers who were particularly susceptible to irritants and allergens had left the trade by the time of the study. Interestingly, an Australian study found that fully qualified hairdressers had moderate or severe dermatitis more often than apprentices. The authors suggested that this was due to a cumulative effect, because apprentices and fully qualified hairdressers had worked a mean of 2.0 and 14.4 years in the trade, respectively.³²

In summary, hairdressing apprentices with HE often have moderate or severe lesions. There have been few reliable studies on the severity of HE among fully qualified hairdressers, and the long-term effects of occupational exposure remain uncertain.

2.1.4 Prognosis

Studies examining the prognosis for HE in hairdressers generally have highly selective study populations that include hairdressers with recognized OHE or hairdressers with HE who have attended dermatology clinics. The factors that potentially affect prognoses include a history of AD

or contact allergies and continuous affiliation with the hairdressing trade. In the following section, the available evidence is summarized.

Studies on hairdressers with recognized occupational dermatosis have follow-up periods that ranged from 12 to 15 months.^{33,34} Among hairdressers with recognized OHE in Denmark from 2001–2002 (n = 30), 36.7% had aggravated or persistently severe symptoms, whereas 30.0% showed improvements in their condition, at 12-month follow-up.³⁴ Among hairdressers with occupational dermatosis in Austria from 1981–1982 (n = 247), 68% of those with ACD and 42% of those with ICD continued to have skin problems at 15-month follow-up, and hairdressers with a history of AD were more likely to have a poor prognosis.³³ Thus, approximately one-third of hairdressers with recognized OHE have persistent symptoms after 1 year, and a history of AD or contact allergies indicates a poorer prognosis.

The negative impact of contact allergies was also documented in hairdressers who had attended dermatology clinics in Ireland from 1987–2004 (n = 51). A questionnaire was sent out after the visit (mean follow-up time, 8.8 years; range, 0.5–17 years) and 21.4% of hairdressers with ACD reported having persistent HE despite changing career (the corresponding figure for hairdressers with ICD was not reported).³⁵ Furthermore, hairdressers with ACD had a higher risk than hairdressers with ICD of persistent HE.

Leaving the hairdressing profession is generally beneficial for the prognosis of HE. A study on hairdressers with occupational dermatitis who had attended a tertiary clinic from 1991–1994 (n = 23) and were followed up 1–4 years after the visit found that all were symptomatic at follow-up. However, hairdressers who left the trade were more likely to experience improvement in their HE condition than those who continued working as hairdressers.²⁵ Similarly, among hairdressers who attended a dermatology clinic from 1971–1978 (n = 18), 87.5% of those who left the hairdressing trade experienced improvement in their HE condition, compared to only 37.5% of those who remained (follow-up time not specified).²⁸ Overall, 38.9% of these hairdressers had uncontrolled HE, and all of these cases were atopic.²⁸ Similarly, among hairdressers with ICD who attended a dermatology clinic from 1953–1958 (n = 77), all who left the trade experienced complete remission of their symptoms at follow-up in 1958, with the exception of one hairdresser who had AD.²¹ Only a single study, performed on hairdressers who were patch tested from 1974–1976 (n = 20), did not find that AD influenced HE prognosis. However, 30.0% of these hairdressers had uncontrolled eczema at follow-up (3–5 years after patch testing), which is consistent with previous reports.²¹

In summary, 21.4–38.9% of hairdressers with HE exhibits persistent HE within a follow-up period ranging from 1–8.8 years. Leaving the trade and the absence of a history of AD or contact allergies has a positive effect on prognosis. However, many of the relevant studies have been performed on highly selective and often small study populations (range, 18–77 hairdressers). Thus, the prognosis of HE needs to be evaluated over longer timescales and in study populations that are more representative of the average hairdresser.

2.1.5 Risk factors for occupational hand eczema in hairdressers

2.1.5.1 Atopic dermatitis

AD is a chronic relapsing inflammatory skin disease. Most patients with AD experience disease onset by the age of 5 years and remission of symptoms by early adolescence.⁴¹ The prevalence of AD varies in different countries, but approximately 20% of people living in Scandinavia experience symptoms of AD in any given year.⁴² Patients with AD exhibit decreased epidermal barrier function, often caused by loss of function of the filaggrin gene.⁴³ A history of AD in childhood is associated with an increased risk of HE, particularly if affected individuals have occupations that involve wet work, such as hairdressing.^{44,45}

Therefore, those with a history of AD are generally advised to avoid hairdressing. Consequently, Danish hairdressing apprentices training in 2008 were less likely to have AD than individuals from the general population.^{46,47} Nevertheless, a systematic review of studies published from 2000 to 2021 found that 18.1% of hairdressers had a history of AD, suggesting that this may still be a relevant risk factor for many hairdressers.¹⁶

2.1.5.2 Occupational exposures

Irritants

Wet work is an umbrella term that encompasses exposure to water, soaps, and detergents. Wet work for more than 2 hours per day is generally considered a risk factor for HE (adjusted odds ratio [aOR], 1.7).⁴⁵ Hairdressers perform wet work when shampooing, handling damp hair and cleaning the salon. Hairdressing is among those occupations with the greatest exposure to wet work, and up to 86.6% of hairdressers report performing more than 2 hours of wet work per day (with most performing more than 4 hours per day).^{48,49}

Exposure to wet work begins during the hairdressing apprenticeship, with 63.7% of hairdressing apprentices performing more than 2 hours of wet work per day. This estimate includes exhairdressers in the denominator; therefore, the actual occupational exposure may be higher.³⁷ Furthermore, protective gloves occlude the skin and inhibit perspiration and is generally considered to contribute to wet work. Regardless, wearing gloves is preferable to unprotected wet work.⁴⁵ Finally, chemicals in cosmetic hair products, such as preservatives, fragrances and surfactants in shampoos, may irritate the skin.⁵⁰

Allergens

Hairdressing involves exposure to occupational allergens when dyeing or bleaching hair and creating permanent waves. Oxidative hair dyes may contain the allergens paraphenylenediamine or toluene-2,5-diamine and are used in combination with allergenic couplers such as resorcinol.^{51,52} Bleaching agents may contain ammonium persulfate and permanent wave solutions may contain thioglycolates (coupled with glyceryl or ammonium) or cysteamine hydrochloride.^{53,54} Fragrances and preservatives may be found in shampoos, conditioners and hair styling products such as gels, mousses and sprays.⁵⁵ Additionally, protective rubber gloves may contain rubber accelerators such as thiurams and carbamates.⁵⁶ Finally, acrylates are emerging as occupational allergens in hairdressing, due to the recent trend for acrylic nail cosmetics.^{53,57} Release of nickel from hairdressing tools is not considered problematic for hairdressing in Denmark, but may be an issue in other countries.^{58–60}

Hairdressers who were patch tested in Denmark from 2002–2011 and in Italy from 1999–2016 exhibited a high prevalence of contact allergies to hair dyes (particularly those containing paraphenylenediamine) and bleaching products, as well as an increased risk of sensitivity to paraphenylenediamine (odds ratio [OR], 7.4–9.9) and thiuram mix (OR, 2.0–2.1) compared to other patch tested patients.^{59,61}

2.1.6 Distribution of ICD and ACD

A study based on registries of occupational skin diseases in Germany from 1990 to 1999 found that the IRs of ICD and ACD among hairdressers (and barbers) (n = 856) were 46.9 and 67.2 per 10,000 workers per year, respectively.⁶³ The proportions of Danish hairdressers with ICD and ACD were more similar: among Danish hairdressers with recognized OHE from 2006–2011, 48.3% (n = 184)

were categorized as having ICD and 46.7% (n = 178) were categorized as having ACD.⁶⁴ Thus, approximately half of hairdressers with recognized occupational contact dermatitis had ACD.

The distribution of ICD and ACD reported by studies involving patch tests on hairdressers who attended dermatology clinics was similar. Among hairdressers who were patch tested in Greece from 1985–1994 (n = 106), 47% had an occupationally relevant positive patch test.⁶⁵ Furthermore, among hairdressers who were patch tested in Austria, Germany, and Switzerland from 1995–2002 (n = 884), 52% were diagnosed with ACD and 36.8% with ICD.⁶⁶ Among Danish hairdressers with severe HE from 2003–2010 (n = 99), 55.6% were diagnosed with ACD and 44.4% with ICD.⁶⁷ Among hairdressers patch tested in North America from 1994–2010 (n = 432), 72.7% had ACD.⁶⁸

2.2 Diagnosis of ICD and ACD

To determine whether contact dermatitis is caused by irritants or allergens, a patient's exposure history must be evaluated and potential allergies investigated. A contact allergy is diagnosed by an is *in vivo* elicitation of a type IV hypersensitivity reaction. The most widely used method for identifying contact allergies is patch testing, which involves applying allergen solutions directly onto the skin. The allergens are loaded into occlusive chambers and are often chosen because they are relevant for the patient (e.g., a baseline series or a hairdressing series). The European Society of Contact Dermatitis recommends occlusion for 2 days, with subsequent reading of the patch test on days 2, 3 or 4 and 7.⁶² The patch test allergens are graded as follows: no reaction (–), doubtful reaction (?+), weak positive reaction (+), strong positive reaction (++), extremely positive reaction (+++), or irritant reaction.⁶² The relevance of a positive patch test is determined by the patient's history, the clinical manifestations, and thorough qualitative and quantitative exposure assessments. A relevant positive patch test means that ACD can be diagnosed. If current relevance is lacking but the patient has a relevant history of exposure to irritants, a diagnosis of ICD can be made.

2.3 Career consequences of hand eczema in hairdressers

Large questionnaire studies suggest that hairdressers frequently leave the hairdressing trade prematurely. Among Danish hairdressers graduating from 1985–2007 (n = 5,324), 44.3% had left the trade by 2009; and the mean duration spent in the profession among hairdressers that left the trade was 8.4 years.²⁰ Additionally, a Norwegian study (n = 124) found that 37% of hairdressers had

left the trade 5 years after graduation.³⁶ High drop-out rates during the hairdressing apprenticeship have also been reported, ranging from 21.8% in Denmark to 31.4% in Germany.^{19,37}

Approximately 17.4% to 23.1% of fully qualified hairdressers who left the trade^{20,36} and 11.0% to 47.4% of hairdressing apprentices who discontinued training^{19,37,38} were reportedly influenced to change their careers by HE. Furthermore, 18.0% to 60.0% of hairdressers who attended dermatology clinics had reportedly left the trade at follow-up (follow-up time ranged from 1.0 to 8.8 years after the visit).^{21,25,28,35,39} Additionally, most of these patients were less than 25 years of age, suggesting that hairdressers often change their careers early.^{25,35,40}

Thus, hairdressers often leave the trade early and HE may influence the decision to change career. However, the extent to which HE shortens the careers of hairdressers remains unclear.

2.4 Prevention of occupational hand eczema in hairdressers

Prevention of a disease can be subdivided into primary, secondary, and tertiary categories, depending on the disease stage targeted.⁶⁹ Primary prevention focuses on preventing a disease from ever occurring in healthy individuals, whereas secondary prevention focuses on limiting disease progression and preventing the onset of illness in patients at the subclinical disease stage. Tertiary prevention focuses on alleviating symptoms and preventing sequelae in patients who already have disease manifestations.

Evidence-based skin protection programmes have been developed as primary prevention measures for high-risk groups, notably student auxiliary nurses and cleaners in pig slaughterhouses and cheese dairies.^{70–73} Interventional studies have shown that these programmes can result in less frequent aggravation of skin problems, decreased transepidermal water loss, better understanding of skin protection, and improved compliance in the wearing of protective gloves. The programmes were evaluated at follow-up intervals that ranged from 2.5 to 12 months.

An evidence-based skin protection programme was also designed for hairdressers, in line with these earlier programmes. This programme consisted of 11 guidelines. Six of the guidelines focused on personal protective equipment: 1. Use gloves when you wash, dye bleach or perm; 2. Disposable gloves must be clean, new and dry; 3. Never reuse disposable gloves; 4. Use cotton gloves underneath protective gloves; 5. Use gloves for as long as necessary but as short as shortly possible; and 6. Use gloves when doing wet work in your spare time. Five of the guidelines focused on safe

practice in the workplace: 1. Cut the hair before you dye; 2. Mix in a separate ventilate cabinet; 3. Use an unscented lipid-rich moisturizer; 4. Do not wear rings at work; and 5. Use warm gloves when it is cold outside. The programme reduced the incidence of HE and increased compliance with wearing protective gloves among hairdressing apprentices at 18-month follow-up.⁷⁴ It was implemented nationwide in Danish hairdressing vocational schools in 2011. In addition, teaching material was provided by the Danish Research Centre for Hairdressers and Beauticians and delivered by specially trained vocational teachers. There are no requirements to the time used to teaching the material, but usually 1-2 days are spent. Since 2015, hairdressing apprentices have been required to pass a written exam on the content of the skin protection programme to continue with their apprenticeships. They must also show that they can use gloves correctly at the final apprenticeship exam to qualify as a hairdressers.⁷⁵

Secondary and tertiary prevention of occupational skin disease, and contact dermatitis in particular, has been implemented in Germany, where patients with an occupational skin disease are invited to participate in a secondary individual prevention (SIP) programme. The SIP programme consists of a health education seminar and training on prevention methods, such as the correct use of gloves.⁷⁶ If outpatient therapy and enrolment in the SIP programme is insufficient to achieve disease control, the patient is invited to participate in a tertiary individual prevention (TIP) programme. The TIP programme consists of 3 weeks of inpatient rehabilitation at a specialized dermatology unit, followed by 3 weeks off work with continued treatment and outpatient support.⁷⁷ A recent systematic review concluded that the SIP and TIP programmes decreased disease severity, increased quality of life and enabled most patients to continue in their profession.⁷⁸ The SIP programme enhanced job retention in a cohort of hairdressers (n = 300), with 58.5% of the hairdressers who enrolled in the SIP programme remaining in their profession at 5-year follow-up, compared to 29.1% in a control group.⁷⁹ A follow-up study of patients enrolled in the TIP programme found that 41.3% of hairdressers continued to work in the trade at 3-year follow-up, and 62.0% of patients continued to work in their chosen profession overall.⁸⁰

Effective primary prevention would decrease the burden on secondary and tertiary prevention programmes as well as the personal and societal costs of OHE. The skin protection programme implemented in Danish hairdressing vocational schools in 2011 should be evaluated to determine whether it has been successful and whether changes need to be made.

3. Thesis objectives

The overall objectives were to investigate the long-term prognosis for HE, the potential for primary prevention after completion of hairdressing apprenticeship, assess the impact of HE on the career length of hairdressers, as well as to evaluate the effect of a nationwide skin protection programme implemented in Danish hairdressing vocational schools

Manuscript I

- To examine the potential for primary prevention after completion of the hairdressing apprenticeship
- To investigate the long-term prognosis for HE in hairdressers and identify the risk factors associated with poor prognosis

Manuscript II

- To examine the impact of HE on career length in hairdressers
- To identify the risk factors associated with decreased career length in hairdressers with HE

Manuscript III

• To evaluate whether an evidence-based skin protection programme, implemented nationwide in Danish hairdressing vocational schools, was followed by a decrease in incident HE and an improvement in compliance with skin protective measures

4. Legal permits and approvals

This study was approved by the Danish Data protection Agency (P-2019-346).

5. Materials and methods

5.1 Study design

This thesis is based on three observational studies. Two studies are prospective cohort studies (manuscripts I and II), and one study is a repeated cross-sectional study (manuscript III).

In May 2009, a questionnaire study was performed on all hairdressers graduating from Danish hairdressing vocational schools from 1985–2007.²⁰ This study serves as baseline in all three manuscripts (I–III).

5.1.1 Prospective cohort study

To answer the research questions posed in manuscripts I and II, a prospective cohort study of all hairdressers graduating from 1985–2007 was performed (Figure 1). A follow-up questionnaire was sent to all respondents of the 2009 questionnaire study in 2020. Payments to the Danish Labour Market Supplementary Pension Scheme (Danish: Arbejdsmarkedets Tillægspension) (ATP) from all cohort members were used to estimate the number years worked as a hairdresser and the corresponding time at risk within the profession.



Figure 1. Study design of the prospective cohort study (manuscripts I and II). In May 2009, a questionnaire was sent to all hairdressers graduating from Danish hairdressing vocational schools from 1985–2007. In May 2020 a follow-up questionnaire was sent to all respondents of the 2009 survey. The longitudinal lines illustrate the hypothetical follow-up time for each graduation year.

5.1.2 Repeated cross-sectional study

To answer the research questions posed in manuscript III, two cross-sections of hairdressers trained before and after implementation of the nationwide skin protection programme were compared.

The skin protection programme was implemented nationwide in 2011. Because hairdressing vocational training in Denmark takes 4 years, the first hairdressers who enrolled in the programme graduated in 2015.⁸¹ A comparison was made between hairdressers who graduated from 2015–2018 and received a questionnaire in May 2020 (i.e., enrolled in the skin protection programme) and hairdressers who graduated from 2004–2007 and received a questionnaire in May 2009 (i.e., not enrolled in the skin protection programme). Therefore, both cross-sections spanned four consecutive graduation years and each hairdresser received a questionnaire 2 years after the last graduate in their cross-section had completed their training (Figure 2).



Figure 2. Study design of the repeated cross-sectional study. Hairdressers graduating from 2004–2007 received a questionnaire in May 2009, and hairdressers graduating from 2015–2018 received a questionnaire in May 2020. The evidence-based skin protection programme was implemented nationwide in 2011. Longitudinal lines illustrate potential follow-up times.

5.2 Data from registries

5.2.1 The Danish National Archives

Data from the 2009 study of all hairdressers graduating from Danish hairdressing vocational schools from 1985–2007 were retrieved.²⁰ These data included the Central Person Register (CPR) social security number (Danish: Det Centrale Personregister number) of all members of the study population, the original questionnaire used, and all questionnaire data from respondents. The CPR numbers for all cohort members were originally provided by the Danish Hairdressers and Beauticians Union in 2007.

5.2.2. The Danish Hairdressers and Beauticians Union

The CPR numbers of all hairdressers graduating from 2008–2018 were obtained. We requested a list of graduation years for all hairdressers graduating from 1985–2018, but these data were only available from 1997–2018.

5.2.3 The Danish Labour Market Supplementary Pension Scheme (Danish: Arbejdsmarkedets Tillægspension) (ATP)

All payments made from the hairdressing trade to the ATP from each member of the 1985–2007 cohort and the 2008–2018 cross-section were recorded.

The ATP is a mandatory pension scheme in Denmark. Employers are obliged to contribute to the ATP on behalf of their employees if the employee works at least 10 hours per week. This includes employees on maternity leave. Payments to the ATP are tagged with the occupation (i.e., SE number) of the employee; hairdressers have the SE numbers 960210 and 930210. Independent hairdressers can choose to contribute to the ATP, but this is not mandatory.

5.2.4 Statistics Denmark (Danish: Danmarks Statistik)

Statistics Denmark provided information on whether participants' CPR numbers were still valid, i.e., whether the participants still resided in Denmark, had not emigrated, and were not deceased. CPR numbers are coded in the following format: ddmmyy-xxxx; the first six digits are the date of

birth and the last four digits are a unique personal identifier that is an even number for females and an odd number for males.

5.3 The questionnaires

5.3.1 Baseline and follow-up questionnaires

Two questionnaires were used in this thesis. The baseline questionnaire was the original questionnaire used in the 2009 study and the follow-up questionnaire was an updated version of the baseline questionnaire, changed to assess the follow-up period from 2009–2020 (see 'definition of outcome variables' for the relevant changes).

- The baseline questionnaire was used for a new cross-sectional survey of hairdressers graduating from 2008–2018. This cross-section was examined in a similar way to the cross-section of hairdressers graduating from 1985–2007 in the 2009 study.
- The follow-up questionnaire was used in the prospective study of hairdressers graduating from 1985–2007 and was sent to all respondents of the 2009 study.²⁰

The baseline questionnaire contained 171 items across the following categories. All respondents: occupational status (2 items), HE (27 items), asthma (6 items), allergies (4 items), other health issues (9 items), hair dye (self-use) (8 items), henna tattoos and piercings (6 items), nail cosmetics (32 items), smoking (8 items), alcohol (2 items), social status including domestic exposures (9 items) and coronavirus disease 2019 (11 items). For current hairdressers only: occupational exposures (15 items), gloves/emollients/ventilation (17 items), and whether they were thinking of leaving the hairdressing trade (3 items). For ex-hairdressers only: occupational exposures including current use of gloves (7 items) and reasons for leaving the hairdressing trade (5 items). The follow-up questionnaire contained the same items as the baseline questionnaire, except for 4 questions used to diagnose a history of AD using the United Kingdom Working Party (UKWP) criteria (these data were already available from the 2009 study).⁸²

The following questions about compliance with the nationwide skin protection programme were added to the baseline questionnaire: "Do you cut the hair before hair dyeing/permanent waving?"; "Do you use disposable gloves if necessary, but for the shortest time possible?"; "Do you use cotton gloves underneath disposable gloves?"; "Do you wear finger rings while working?"; "Do you use

warm gloves when outside in cold weather?"; "Do you use gloves when doing wet work in your spare time?".⁷⁴

5.3.2 Definition of outcome variables

See appendix for definition of outcome variables used in the questionnaires.

The Nordic Occupational Skin Questionnaire (NOSQ-2002)

The NOSQ-2002 is a standardized questionnaire designed to collect epidemiological data on occupational skin diseases.⁸³ The questions on self-reported HE used in our baseline questionnaire were taken from the NOSQ-2002: item D1, "Have you ever had hand eczema?" (yes/no); item D4, "How often have you had hand eczema?" (only once and for less than 2 weeks/only once for more than 2 weeks/more than once/nearly all the time); and D5, "When did you last have eczema on your hands?" (just now/not now but within the last 3 months/between 3–12 months ago/more than 12 months ago). In the follow-up questionnaire, items D1 and D4 were adapted to *"have you had hand eczema since 2009"* and *"how often have you had hand eczema since 2009?"*. No changes were made to the response options. The following question on domestic wet work exposure was also used: item E6 *"how many hours per day do you spend on the following activities outside your work: preparing food, cleaning and washing, care of children less than 4 years of age?"* (response options for each: 0/less than 0.5/0.5–2/more than 2 hours per day).

UK Working Party criteria

The UKWP criteria are used to diagnose a history of AD.⁸² The criteria used are: a) a history of an itchy skin condition; b) a history of flexural involvement; c) a history of dry skin; d) onset before the age of 2 years; e) a personal history of asthma or hay fever; and f) visible flexural dermatitis. Criterion (f) was excluded from the questionnaire. In manuscript I, a history of AD was defined as having the major criterion (a) plus two or more of the four minor criteria (b–e), because this definition was used in the initial questionnaire in 2009.²⁰ A decision was made to change the diagnostic criteria for manuscripts II and III to require three or more minor criteria. This was done to increase specificity when assessing the history of AD within an adult population.⁸⁴

Years worked in the trade

Years worked in the trade was defined as the cumulative number of years a hairdresser had contributed to the ATP. Thus, potential career gaps were taken into account. Maternity leave was

included in the total career length because ATP data did not specify whether contributions were made while working as a hairdresser or being on maternity leave.

5.3.3 Pilot study

The questionnaire was sent to 10 employees at the National Allergy Research Centre. Feedback was provided regarding the structure of the questionnaire and on whether the questions were easy to understand. The questionnaire was further tested on six hairdressers working in two hairdressing salons in Denmark (contact details were provided by the Danish Hairdressers and Beauticians Union). Each hairdresser was interviewed by telephone regarding their perceptions of the questionnaire.

5.3.4 Distribution of the questionnaires

The questionnaires were first distributed electronically on 19 May 2020 using REDCap software (Vanderbilt University, Nashville, TN, USA; hosted by The Capital Region of Denmark) to a digital mailbox (e-boks) linked to every resident in Denmark with a valid social security number.⁸⁵ The questionnaire was redistributed electronically on 26 May 2020 to non-respondents. Participants who did not respond to the electronic questionnaire were sent a paper copy of the questionnaire via the postal service in June 2020. Finally, the questionnaire was redistributed digitally to any remaining non-respondents on 3 September 2020.

6. Main results

6.1 Data from registries

6.1.1 Danish national archives

Hairdressers graduating from 1985–2007

A total of 8,630 hairdressers were included in the original dataset from the 2009 study. A response rate of 61.7% (5,324/8,630) was obtained. The CPR numbers of 2.0% (105/5,324) of respondents were not included in the dataset; therefore, these respondents could not be followed-up. All available CPR numbers were valid according to Statistics Denmark (Figure 3), yielding a total of 5,219 of 8,525 hairdressers available for follow-up.

6.1.2 Danish Hairdressers and Beauticians Union

Hairdressers graduating from 2008–2018

A total of 4,833 hairdressers who had graduated from 2008–2018 were identified through the Danish Hairdressers and Beauticians Union. Although all the CPR numbers were valid, three were duplicates, yielding a study population of 4,830 hairdressers (Figure 3).

Data on the particular year of graduation

Data on the particular year of graduation was available for hairdressers graduating from 1994–2018 (n = 10,082). These data were only used in manuscript III to construct the two cross-sections of hairdressers (graduating from 2004–2007 and 2015–2018). A total of 1,236 hairdressers who graduated from 2004–2007 and 1,215 hairdressers who graduated from 2015–2018 were identified. When these samples were matched with the datasets that included all hairdressers who graduated from 1985–2007 (n = 8,525) and from 2008–2018 (n = 4,830), 37.2% (460/1,236) and 100.0% (1,215/1,215) of each population could be identified, respectively.



Figure 3. Delineation of the study population

6.1.3 The Danish labour market supplementary pension scheme (ATP)

The ATP database provided data on all payments made from the hairdressing profession from 1964–2020. The ATP dataset was matched with the entire study population (hairdressers graduating from 1985–2018) using social security numbers. ATP data were available for 89.9% (7,668/8,525) of all hairdressers graduating from 1985–2007 and for 99.6% (4,813/4,830) of hairdressers graduating from 2008–2018. The reasons for the missing data remain unclear.

6.2 Response to the questionnaires

6.2.1 Follow-up study of hairdressers graduating from 1985–2007.

A total response rate of 50.1% (2,614/5,219) was obtained. The response rates at each distribution of the questionnaire on 19 May 2020, 26 May 2020, June (duration of the month) 2020 and 3

September 2020 were 13.4% (700/5,219), 11.4% (510/4,519), 27.6% (1,106/4,009) and 10.3% (298/2,903), respectively (Figure 4).

6.2.2 Cross-sectional study of hairdressers graduating from 2008–2018

A total response rate of 30.7% (1,485/4,830) was obtained. The response rates at each distribution of the questionnaire on 19 May 2020, 26 May 2020, June (duration of the month) 2020 and 3 September 2020 were 10.5% (506/4,830), 6.3% (271/4,324), 15.3% (610/4,053) and 2.8% (98/3,443), respectively (Figure 4).



Figure 4. Cumulative response rates (curves) and response rates at each distribution point (columns). A follow-up questionnaire was sent to all hairdressers graduating from 1985–2007 (blue). A cross-sectional questionnaire was sent to all hairdressers graduating from 2008–2018 (green).

6.2.3 Data entry of postal questionnaires

Data from all questionnaires that were returned digitally were stored automatically by the REDCap software (Vanderbilt University). Data from questionnaires that were returned by post had to be entered manually into the same software.

The proportion of respondents who returned postal questionnaires was 42.3% (1,106/2,614) among the hairdressers who graduated from 1985–2007 and 41.5% (620/1,495) among the hairdressers who graduated from 2008–2018.
Random samples of returned postal questionnaires were selected to check that data were being entered accurately. A total of 9.3% (103/1,106) of postal questionnaires returned from hairdressers who graduated from 1985–2007 and 7.3% (45/620) of postal questionnaires returned from hairdressers who graduated from 2008–2018 were selected.

The 1985–2007 questionnaire had 167 items. A total of 103 questionnaires were checked, corresponding to a combined 17,201 items; a total of 18 mistakes were identified, corresponding to 0.1% (18/17,201) of all the items checked. The 2008–2018 questionnaire had 171 items. A total of 45 questionnaires were checked, corresponding to a combined 7,695 items; a total of 11 mistakes were identified, corresponding to 0.1% (11/7,695) of all the items checked.

6.3 Baseline characteristics of the study populations

6.3.1 Follow-up study of hairdressers graduating from 1985–2007

The study population was 96.3% (2,518/2,614) female. Age was not normally distributed (Shapiro– Wilk test for normality, P < 0.001). The median age was 49 years (range, 33–80 years) and the age distribution of the study population was as follows: 10.7% (280/2,614) were aged 31–40 years, 48.0% (1,254/2,614) were aged 41–50 years, 40.4% (1,055/2,614) were aged 51–60 years and 1.0% (25/2,614) were aged > 60 years. Years in the trade was not normally distributed (Shapiro–Wilk test for normality, P < 0.001). The median number of years worked in the trade was 10 (range, 1–38) and 54.7% (1,305/2,385) of the study population had worked in the trade for less than 10 years.

6.3.2 Cross-sectional study of hairdressers graduating from 2008–2018

The study population was 96.3% (1,430/1,485) female. Age was not normally distributed (Shapiro– Wilk test for normality, P < 0.001). The median age was 31 years (range, 21–64 years) and the age distribution of the study population was as follows: 49.5% (735/1,485) were aged 21–30 years, 46.5% (691/1,485) were aged 31–40 years, 3.5% (52/1,485) were aged 41–50 years and 0.5% (7/1,485) were aged > 60 years. Years in the trade was not normally distributed (Shapiro–Wilk test for normality, P < 0.001). The median number of years worked in the trade was 8 (range, 1–18) and 56.4% (836/1,481) of the study population had worked in the trade for less than 8 years.

6.4 Analysis of non-respondents

6.4.1 Follow-up study of hairdressers graduating from 1985-2007

Non-respondents tended to be male (7.9% [469/5,911] of non-respondents vs. 3.7% [96/2,614] of respondents; OR, 2.3; 95% confidence interval [CI], 1.8–2.9) and were more often aged from 31–40 years (13.2% [783/5,911] of non-respondents vs. 10.7% [280/2,614] of respondents; OR, 1.3; 95% CI, 1.1–1.5) and aged from 41–50 years (51.4% [3,037/5,911] of non-respondents vs. 48.0% [1,254/2,614] of respondents; OR, 1.1; 95% CI, 1.0–1.3) compared to respondents. No difference in response rate was observed among hairdressers aged > 60 years (1.0% [58/5,911] of non-respondents were more likely to have worked in the trade for less than 10 years than respondents (63.8% [3,371/5,285] of non-respondents vs. 54.7% [1,305/2,385] of respondents; OR, 1.5; 95% CI, 1.3–1.6).

When respondents were compared with non-respondents (who had responded to the baseline questionnaire), there was no difference in the lifetime prevalence of HE at baseline (41.5% [1,052/2,532] of non-respondents vs. 43.2% [1,100/2,547] of respondents; OR, 0.9; 95% CI, 0.8– 1.0; P = 0.24), no difference in the proportion of hairdressers with a history of AD (22.1% [564/2,250] of non-respondents vs. 22.1% [568/2,569] of respondents; OR, 1.0; 95% CI, 0.9–1.1) and no difference in the proportion of hairdressers who had left the trade at baseline (44.5% [1,136/2,250] vs. 43.9% [1,133/2,581] of respondents; OR, 1.0; 95% CI, 0.9–1.1).

6.4.2 Cross-sectional study of hairdressers graduating from 2008–2018

Non-respondents tended to be male (6.0% [200/3,345] of non-respondents vs. 3.7% [55/1,485] of respondents; OR, 1.7; 95% CI, 1.2–2.2) and were more often aged from 21–30 years (53.8% [1,798/3,345] of non-respondents vs. 49.5% [735/1,485] of respondents; OR, 1.2; 95% CI, 1.0–1.3; P = 0.006), but less often aged from 31–40 years (43.4% [1,451/3,345] of non-respondents vs. 46.5% [691/1,485] of respondents; OR, 0.9; 95% CI, 0.8–1.0; P = 0.04) and less often more than 40 years of age (2.9% [96/3,345] of non-respondents vs. 4.0% [59/1,485] of respondents; OR, 0.7; 95% CI, 0.5–1.0; P = 0.04) compared to respondents. Non-respondents were more likely to have worked in the trade for less than 8 years than respondents (56.4% [836/1,481] of respondents vs. 63.6% [2,118/3,332] of non-respondents; OR, 1.3; 95% CI, 1.2–1.5).

6.5 Manuscript I: Long-term follow-up of hand eczema in hairdressers: a prospective cohort study of hairdressers graduating from 1985–2007

The lifetime prevalence of HE increased from 42.4% (2,152/5,080) at baseline (graduation [1985–2007]) to 2009) to 45.2% (1,180/2,612) at follow-up (from 2009 to 2020; OR, 1.1; 95% CI, 1.0–1.2; P = 0.02). Simultaneous decreases in the 1-year prevalence from 20.6% (1,047/5,080) to 12.0% (314/2,612; OR, 0.5; 95% CI, 0.5–0.6; P < 0.001) and in the point prevalence from 7.1% (361/5,080) to 4.7% (124/2,612; OR, 0.7; 95% CI, 0.6–0.9; P = 0.001) were observed from baseline to follow-up. The decrease in 1-year prevalence affected both current hairdressers (P < 0.001) and hairdressers who had left the trade (P < 0.001). The decrease in point prevalence was only statistically significant for current hairdressers (P < 0.001).

A decrease in IR of OHE from 42.8 cases (95% CI, 40.8–44.8)/1,000 person-years at baseline to 3.4 cases (95% CI, 2.5–4.6)/1,000 person-years during follow-up (IRR, 0.08; 95% CI, 0.06–0.11) was observed. Thus, almost no new cases of OHE were observed during follow-up. Similarly, the median time to onset of OHE was 2.0 years (range, 0–24 years), with 70.5% (541/767) of individuals having disease onset during their apprenticeship and 90.9% (679/767) of individuals having disease onset within 8 years of beginning their apprenticeship. There was no statistically significant difference in the time to disease onset between hairdressers with a history of AD (median, 2.0 years; range, 0–24 years) and hairdressers without a history of AD (median, 1.0 year; range, 0–17 years; Mann–Whitney U test, P = 0.18).

Among hairdressers with HE at baseline, 34.6% (372/1,075) had persistent HE (HE both at baseline and during the follow-up period) and 65.4% (703/1,075) were in remission (had HE at baseline, but not during the follow-up period). Multivariate logistic regression analyses adjusted for sex, age and occupational status as an ex-hairdresser found that the risk factors for HE at follow-up were: a) HE at baseline (aOR, 10.1; 95% CI, 7.3-13.8); b) a previous positive patch test (aOR, 4.5; 95% CI, 3.0-6.8); and c) a history of AD (aOR, 1.9; 95% CI, 1.4-2.4). Performing wet work at baseline was not identified as a risk factor for having HE within the follow-up period, but was borderline significant (aOR, 1.3; 95% CI, 1.0-1.6; P = 0.06).

Among hairdressers with persistent HE, HE frequency was stable in 55.7% (201/361), decreasing in 36.3% (131/361) and increasing in 8% (29/361). Multivariate logistic regression analyses adjusted for sex, age, and a history of AD found that individuals with persistent HE who had worked continuously as hairdressers from baseline through follow-up had a greater risk of increasingly

frequent HE, compared to individuals with persistent HE who had already left the trade at baseline (aOR, 2.6; 95% CI, 1.03–6.50).

6.6 Manuscript II: Occupational hand eczema reduces career length in hairdressers: a prospective cohort study of Danish hairdressers graduating from 1985–2007

The median career length of the hairdressers in our study population was 13.0 years (95% CI, 12.2–13.8). When the hairdressers were stratified by history of OHE (yes/no), the median career length of hairdressers with a history of OHE was 12.0 years (95% CI, 11–13) and the median career length of hairdressers with no history of OHE was 14.0 years (95% CI, 12.6–15.4; log rank test, P < 0.001). When hairdressers with a history of OHE were further stratified by the frequency of HE, the median career lengths were 7.0 years (95% CI, 5.6–8.4), 12.0 years (95% CI, 10.7–13.3) and 20.0 years (95% CI, 14.6–25.4) for hairdressers with OHE 'almost all the time', 'several times' and 'once', respectively.

Cox regression analyses adjusted for sex, age and a history of AD showed that the adjusted hazard ratio (aHR) for having left the trade was 1.20 (95% CI, 1.0-1.4) for hairdressers who had OHE, compared to hairdressers who did not have OHE. When the hairdressers with OHE were stratified by the frequency of HE, the aHR for having left the trade was 1.9 (95% CI, 1.6-2.3) for those with OHE 'almost all the time', 1.2 (95% CI, 1.1-1.4) for those with OHE 'several times' and 0.8 (95% CI, 0.6-1.0) for those with OHE 'once', compared to hairdressers who did not have OHE.

Hairdressers with OHE 'almost all the time' often had a history of AD (20.0% [50/250]), contact allergies (64.4% [161/250]), particularly to hair dyes (27.6% [69/250]) (Figure 5a–c). Logistic regression analyses adjusted for sex and age found that hairdressers with OHE 'almost all the time' had an increased risk of having AD (aOR, 4.4; 95% CI, 1.9–10.1), a positive patch test (aOR, 3.8; 95% CI, 1.4–10.4) and an allergy to hair dyes (aOR, 4.0; 95% CI, 1.5–10.5) compared to hairdressers with OHE 'once'.



Figure 5a. Proportion of hairdressers with a history of atopic dermatitis stratified by the frequency of occupational hand eczema. aOR: adjusted odds ratio; CI: confidence interval.



Figure 5b. Proportion of hairdressers with a history contact allergy stratified by the frequency of occupational hand eczema.



Figure 5c. Proportion of hairdressers with a history of various contact allergies, stratified by the frequency of occupational hand eczema.

The proportion of ex-hairdressers with OHE who reported leaving the trade (partly) because of HE was 51.7% (307/594). This corresponded to 22.4% (307/1,370) of all ex-hairdressers and 11.7% (307/2,614) of the entire study population. The proportion of ex-hairdressers with OHE who left the trade (partly) because of HE increased with the frequency of HE, including 86.4% (154/178) of ex-hairdressers who had OHE 'almost all the time' 40.7% (142/349) of ex-hairdressers who had OHE 'several times' and 15.4% (10/65) of ex-hairdressers who had OHE 'once' (Figure 6).

Logistic regression analyses adjusted for sex and age found that a history of AD (aOR, 2.2; 95% CI, 1.2–4.0), a previous positive patch test (aOR, 5.1; 95% CI, 2.3–11.0) and a history of allergy to hair dyes (aOR, 9.4; 95% CI, 3.4–25.6) were associated with leaving the trade (partly) because of HE. When the model was adjusted to take the frequency of HE into account, a history of AD was no longer statistically significant (aOR, 1.53; 95% CI, 0.80–2.90), the association with contact allergies decreased slightly (aOR, 4.72; 95% CI, 2.05–10.83), and the association with allergy to hair dyes remained relatively unchanged (aOR, 9.63; 95% CI, 3.17–29.29).



Figure 6. Proportion of hairdressers that had left the trade (total columns) and the proportion with occupational hand eczema who left the trade (partly) because of hand eczema (green section of column).

6.7 Manuscript III: A nationwide skin protection programme introduced in hairdressing vocational schools was followed by a decreased risk of occupational hand eczema

When hairdressers graduating before (2004–2007) and after (2015–2018) implementation of the nationwide skin protection programme in 2011 were compared, a decrease in the IR of OHE from 57.5 (95% CI, 48.4–68.4) to 42.0 (95% CI, 34.6–50.9) cases/1,000 person-years (IRR, 0.73; 95% CI, 0.56–0.95) was observed (Figure 7). Corresponding decreases in the career time prevalence of OHE from 42.8% (128/299) to 29.0% (102/352), in the 1-year prevalence of OHE from 33.9% (81/239) to 23.9% (75/314) and in the point prevalence of OHE from 14.1% (26/184) to 8.1% (21/260) were observed in hairdressers graduating before and after implementation of the programme, respectively (Figure 8).

Logistic regression analyses adjusted for sex, age and a history of AD found a decreased risk of career time OHE (aOR, 0.55; 95% CI, 0.40–0.77) and a decreased risk of having had OHE within the past year (aOR, 0.61; 95% CI, 0.42–0.90) among hairdressers who were trained after implementation of the programme. The same logistic regression model performed on current hairdressers and further adjusted for statistically significant changes in current occupational exposures and current domestic wet work exposures (cleaning and taking care of children under 4

years of age), showed a decreased risk of having current OHE (aOR, 0.31; 95% CI, 0.12–0.95) among hairdressers who were trained after implementation of the programme (Figure 8).



Figure 7. Incidence rates of occupational hand eczema in the two cross-sections of hairdressers graduating before (2004–2007) and after (2015–2018) implementation of the nationwide skin protection programme. IRR: incidence rate ratio.



Figure 8. Prevalence of occupational hand eczema in the two cross-sections of hairdressers graduating before (2004–2007) and after (2015–2018) implementation of the nationwide skin protection programme. Adjusted odds ratios (aOR) of having career time, 1-year, or current hand eczema. Odds ratios were adjusted for sex, age, and history of atopic dermatitis.

Among current hairdressers, improvements in the regular use of protective gloves were observed for the following activities: shampooing before cutting the hair (from 12.6% [21/167] to 62.9% [122/194]; OR, 11.8; 95% CI, 6.8–20.3), shampooing after hair dyeing or perming (from 57.5% [96/167] to 90.0% [175/194]; OR, 6.8; 95% CI, 3.9–12.0), creating permanent waves (from 37.4% [34/91] to 76.1% [51/67]; OR, 5.3; 95% CI, 2.6–10.8), colouring eyebrows/lashes (from 0.7% [1/139] to 13.2% [23/174]; OR, 21.0; 95% CI, 2.8–157.7), and mixing hair dyes (from 10.9% [16/147] to 23.2% [36/155]; OR, 2.5; 95% CI, 1.3–4.7). In addition, more hairdressers always used new gloves (increased from 86.8% [177/202] to 94.0% [234/248]; OR, 2.4; 95% CI, 1.2–4.7) and more hairdressers used nitrile gloves instead of gloves made from other materials (increased from 21.0% [38/181] to 74.0% [182/246]; OR, 10.7; 95% CI, 6.8–16.9).

Compared with hairdressers before implementation of the programme, we observed no statistically significant improvements in the regular use of protective gloves among hairdressers who were trained after implementation of the programme for the following activities: full head hair colouring with oxidative hair dyes (97.4% [151/155]), full head hair colouring with semi-permanent hair dyes (96.8% [215/222]), bleaching (85.2% [52/61]), creating highlights with a cap (89.1% [106/119]), creating highlights with foil (47.4% [163/344]) and creating permanent waves (53.8% [85/158]). Furthermore, there were no statistically significant improvements in the proportion of hairdressers who used moisturizer, wore rings at work, or used ventilation when mixing hair dyes.

7. General discussion

7.1 Long-term follow-up of hand eczema in hairdressers: a prospective cohort study of hairdressers graduating from 1985–2007 (manuscript I)

In manuscript I we examined the prevalence, incidence, and risk of HE in hairdressers followed for up to 35 years. Developments in these outcomes were assessed over an 11-year follow-up period from baseline in May 2009 (2–24 years after graduation) to May 2020 (13–35 years after graduation). A marginal increase in the lifetime prevalence of HE from 42.4% at baseline to 45.2% at follow-up was observed. Thus, almost no new cases of HE occurred during follow-up. This was further illustrated by comparison of the intervals from graduation to baseline and from baseline to follow-up yielding an IRR of HE of 0.08 and more than 90% of hairdressers with OHE had experienced disease onset by their eighth year in the profession.

Long-term onset of HE was previously assessed among Swedish hairdressers by Lind *et al.*, who found that 40% of these hairdressers experienced disease onset during their apprenticeships and 71% had onset within 5 years after their graduations (follow-up period: range, 1–25 years).¹⁸ The low rate of onset during the apprenticeship may be due to fully qualified hairdressers who never worked professionally in the trade being excluded from this study as they may have experienced disease onset during their apprenticeships. Nevertheless, the results of this study support our finding that most hairdressers with OHE had experienced disease onset by the first few years after graduation. Furthermore, a prospective study of Dutch hairdressing apprentices who did not have HE at baseline found that 51% of these apprentices had developed HE at 8-year follow-up.⁸⁶ This is consistent with the long-term level of prevalence observed in our study and correlates with the drastic decrease in incident HE after the eighth year in the profession. A survey of Norwegian hairdressers working in salons reported that only 27.2% of those hairdressers with HE had experienced disease onset during their apprenticeships.⁸⁷ However, this observation may have been influenced by selection bias, because hairdressers with HE may have already left the trade.¹⁶

Early onset of HE among hairdressers is not a new phenomenon and has been reported from the 1950s until the present day (see section 2.1.2.). Many of these early studies attributed early onset of HE to shampooing, which was performed exclusively by hairdressing apprentices.^{21,88} Whether hairdressing apprentices still perform most shampoos is unclear. A recent study indicated that apprentices are exposed to extensive wet work: 63.7% of Danish hairdressing apprentices training

in 2013 reported performing more than 2 hours of wet work per day.³⁷ However, 86.6% of fully qualified Danish hairdressers working in 2009 reported performing more than 2 hours of wet work per day. Therefore, wet work appears to be more equally distributed between hairdressers and apprentices in more recent times.⁵² Nonetheless, these levels of wet work are excessive, and recently trained hairdressers may still be at risk of early onset ICD.

The times to onset of OHE did not differ significantly between hairdressers with and without a history of AD, highlighting the importance of occupational exposure. AD is generally considered an important risk factor for contact dermatitis; therefore, hairdressers with AD may be expected to experience earlier onset of OHE. Perhaps the excessive occupational exposure quickly exceeds the threshold for contact dermatitis, even in hairdressers with normal skin barrier function. Similarly, the attributable fraction of AD to HE in hairdressers was previously estimated as merely 10%.¹⁸ We may have found differences in the times to onset of OHE if we had measured changes in days or months rather than years.

We observed remission in 65.4% of hairdressers who had HE at baseline. Furthermore, only 23.5% of hairdressers with HE at baseline had experienced HE within 1 year of follow-up. This level of remission is higher than that previously reported in both the general population and among patients with HE reported to an insurance company.^{89,90} In a 15-year follow-up study of HE in the general population, only 34% of individuals with HE reportedly experienced remission and 44% had symptoms within 1 year of follow-up.⁸⁹ Furthermore, albeit in a more selective population, only 28% of individuals with HE reported to an insurance company experienced remission at a 12-year follow-up and 70% had experienced HE within 1 year.⁹⁰ The high rate of remission observed in our study may be due to the large proportion of hairdressers who left the profession (57.3% of the population at follow-up, manuscript II), because career change is generally beneficial for the prognosis of OHE.⁹³

We found that the risk factors associated with having HE at follow-up included previous HE (aOR, 10.1), a previous positive patch test (aOR, 4.5), and a history of AD (aOR, 1.9). Thus, both contact allergies and atopy negatively impact disease prognosis. Both a history of AD and contact allergies are risk factors for both incident and persistent HE in the general population.⁹¹ Interestingly, a history of AD (OR, 9.0) is a stronger predictor of persistent HE in the general population than a history of contact allergies (OR, 2.5).⁹² These risk factors had a very different influence on our study population, and this may be due to the allergens in cosmetic hair products and the large

proportion of hairdressers being allergic to hair dyes.⁹³ Hairdressers with persistent HE who had worked in the trade continuously from baseline to follow-up were more likely than those who had left the trade to experience exacerbation in the frequency of their HE (aOR, 2.6). Thus, continuous affiliation with hairdressing results in poorer prognoses. Small studies of hairdressers who attended dermatology clinics had previously made this observation, but without tests for statistical significance and risk estimates.^{21,28,35}

Regardless of the high remission rate, one-third of hairdressers had persistent often frequently relapsing HE. This corresponds to 14.2% of our study population, indicating that a substantial proportion of hairdressers are continuously affected by HE over the long term.

7.2 Occupational hand eczema reduces career length in hairdressers: a prospective cohort study of Danish hairdressers graduating from 1985–2007 (manuscript II)

In manuscript II we examined the influence of OHE on career length in hairdressers followed for up to 35 years after graduation. Hairdressers with OHE had a shorter career span than hairdressers who did not have OHE, particularly if the HE was frequently relapsing. The median career length decreased from 14 years to 12 years for hairdressers with OHE and decreased further to a median of 7 years for hairdressers who had OHE 'almost all the time'. The aHR of leaving the trade increased by 20% for hairdressers with OHE and by 90% for hairdressers who had OHE 'almost all the time'. Previous research has suggested that hairdressers with recognized OHE are less likely to retain their jobs (OR, 2.8).⁷ Our results indicate that this observation may apply to hairdressers in general.

We found the risk factors for leaving the trade (partly) because of HE included a history of AD (aOR, 2.2), a previous positive patch test (aOR, 5.1) and allergy to hair dyes (aOR, 9.4). Previously identified risk factors for a change in profession among patients with recognized OHE included young age, a positive patch test (regardless of relevance) and severe HE. The particularly short career durations of hairdressers with OHE 'almost all the time' is consistent with these observations because such risk factors, at least to some extent, correlate with the characteristics of this subgroup. A previous study suggested that having a contact allergy decreased the likelihood of career change.⁹⁴ The authors speculated that this was due to individuals trying to avoid known allergens. We found that having a previous positive patch test, particularly if this was due to hair dyes, was associated with career change, suggesting this may not be the case in hairdressers. This strong association with hair dye allergies is interesting because 97.7% of current hairdressers reported

always wearing gloves when using permanent hair dye in the baseline study.⁴⁸ This suggests that perhaps i) hairdressers that had left the trade because of hair dye allergies had already done so before the baseline study and may not have used gloves, ii) gloves were not being used correctly, as suggested by 20.2% of hairdressers reporting that they reused protective gloves or iii) the potency of hair dyes (notably paraphenylenediamine) complicates hair dyeing procedures once allergic despite using gloves.⁵⁶

Interestingly, specific allergies to preservatives, fragrances and nickel were not associated with leaving the trade because of HE. Danish hairdressers patch tested from 2002–2011 were more likely to be allergic to paraphenylenediamine, but not more likely to be allergic to fragrances, preservatives or nickel than other patients who were patch tested.⁹³ Nevertheless, occupational procedures may be more complicated for hairdressers who are allergic to ingredients in cosmetic hair products or nickel-containing tools. A Danish investigation from 2009 found that only low levels of nickel were released from hairdressers' scissors possibly explaining the lack of association with nickel.⁹⁵ The lack of association with fragrances and preservatives is more obscure but possibly related to lower potency compared with paraphenylenediamine.

HE has reportedly motivated career change in the general population, but generally to a lesser extent than we found in our study. A 15-year follow-up study of individuals with HE found that 8% changed career because of HE at baseline and an additional 3% had changed career at follow-up.^{89,96} By comparison, we found that approximately half of the hairdressers with OHE left the trade (partly) due to HE. Therefore, OHE was an important factor in the decision to leave hairdressing.

7.3 A nationwide skin protection programme, implemented in hairdressing vocational schools, was followed by a decreased risk of occupational hand eczema (manuscript III)

In manuscript III we examined incident HE in hairdressers trained before and after implementation of a nationwide skin protection programme in Danish hairdressing vocational schools. We observed a decrease in the IR of OHE from 57.5/1,000 person-years to 42.0/1,000 person-years in hairdressers trained before and after implementation of the programme, respectively. A corresponding decrease in the career time prevalence of OHE from 42.8% to 29.0% was also observed. Logistic regression analyses adjusted for sex, age and AD found that the risk of developing OHE had approximately halved in hairdressers trained after implementation of the

programme. We believe these observations are associated with implementation of the skin protection programme for three reasons.

First, no decrease in the lifetime prevalence of HE was observed in the general population during the same period. A systematic review and meta-analysis of the general population that compared studies published from 1964–2007 (total prevalence, 14.9%; females, 18.3%) and from 2008–2019 (total prevalence, 14.7%; females, 19.4%) found nearly identical pooled estimates of the lifetime prevalence of HE.¹⁷ Thus, the decreased prevalence observed in our study is probably not due to factors protecting against HE in the general population.

Second, a study that compared the IRs of recognized OHE in Denmark from 2007–2012 and from 2013–2018 found a statistically significant decrease among hairdressers (IRR, 0.64; P < 0.001), but no decrease among workers in other occupations that involved wet work: nursing home workers: IRR, 1.1 (P = 0.30); hospital workers: IRR, 0.92 (P = 0.08); child/nursery care workers: IRR, 1.6 (P < 0.001); cleaning personnel: IRR, 0.93 (P = 0.47); food production workers: IRR, 0.94 (P = 0.59); and restaurant workers: IRR, 0.95 (P = 0.45).⁸

Third, the initial intervention study evaluating the effect of the skin protection programme found a decrease in the risk of HE in the intervention group (aOR, 0.59) that was similar to the decrease in risk observed in our study (aOR, 0.55). Additionally, the initial intervention study observed improved compliance (i.e., regular glove use) among hairdressers in the intervention group when: *i*) shampooing before cutting the hair, *ii*) shampooing after dyeing the hair (although not statistically significant) and *iii*) colouring the eyebrows. We observed improved compliance for the same tasks (P < 0.05). Therefore, the decreased risk of OHE following implementation of the skin protection programme may be due to better skin protection.

As reported in manuscript I, most hairdressers experience HE onset during their apprenticeships (70.5%) or within 8 years of work from the beginning of their apprenticeships (> 90%). We assessed hairdressers 6–9 years after beginning their apprenticeships; therefore, most would have experienced HE onset by the time of the survey. In addition, the career time prevalence of HE among hairdressers trained before implementation of the skin protection programme (42.8%) was similar to estimates reported in other studies.¹⁶ The lower career time prevalence of HE observed among hairdressers trained after implementation of the programme (29.0%) may therefore approximate the actual long-term prevalence in this group, indicating that the skin protection programme results in long-term primary prevention rather than postponing onset.

In Germany, secondary and tertiary prevention of OHE has been supported by implementation of SIP and TIP programmes.⁷⁸ Key elements of the TIP programme are inpatient rehabilitation and outpatient support, whereas the SIP focuses on improved disease management, primarily via patient education. The SIP and TIP programmes have enabled hairdressers with HE to remain in their professions.^{80,97} Thus, not only is education effective for secondary prevention of HE but it is also effective for primary prevention, as indicated by our results.

8. Considerations on methodology

8.1 Hairdressers lost to follow-up

The long follow-up periods reported in manuscripts I and II increase the risk of selective failure to respond to the questionnaire (response rate at follow-up: 30.5% of all hairdressers graduating from 1985–2007). Because the main outcomes in these manuscripts were related to HE and career status (i.e., leaving the trade), selective non-response may affect our estimates of these outcomes and the strength of the factors associated with them. When respondents and non-respondents at follow-up were compared, we observed no statistically significant differences in the proportions of individuals who had ever had HE at baseline, who had a history of AD at baseline, or the proportions of exhairdressers at baseline. Thus, we expected no selection bias for these parameters during follow-up.

In addition, career length estimates were similar, regardless of whether non-respondents at followup were included (table 1). Therefore, there is little evidence of selective non-response from baseline to follow-up.

	Only including resp (n = 2, as described in	oondents in 2020 374) manuscript II	Including both respondents and non- respondents in 2020 (<i>n</i> = 4,598)		
OHE	Years in the trade	Cox regression	Years in the trade	Cox regression	
	Median (95% CI)	aHR (95% CI)	Median (95% CI)	aHR (95% CI)	
Never	14.0 (12.6–15.4)	1 (reference)	15.0 (13.9–16.1)	1 (reference)	
Once	20.0 (14.6–25.4) 0.78 (0.62–1.0)		17.0 (13.4–20.6)	0.84 (0.70-1.01)	
Several times	12.0 (10.7–13.3)	1.20 (1.05–1.36)	12.0 (11.0–13.0)	1.22 (1.10-1.34)	
Almost all the time	7.0 (5.6–8.4)	1.90 (1.59–2.26)	9.0 (8.0-10.0)	1.79 (1.57–2.10)	
	Log rank test: all <i>P</i> ≤		Log rank test: all P <		
	0.001, except never		0.001, except never		
	vs. once (<i>P</i> = 0.024)		vs. once (P = 0.046)		

Table 1. Years in the trade assessed using Kaplan–Meier survival analysis. Information on career length and career status was available for non-respondents (2020) at baseline (2009). Cox regression with the outcome of being an exhairdresser (yes/no) with years worked in the trade as time variable and adjusted for sex, age, and history of atopic dermatitis. aHR: adjusted hazard ratio; CI: confidence interval; OHE: occupational hand eczema.

An analysis of all hairdressers lost to follow-up (total response rate, 30.7% [2,614/8,525]) found that non-respondents tended to be male and to have worked in the trade for less than 10 years. Because female sex is associated with HE, this may have confounded our estimate. However, males only accounted for 6.6% (565/8,525) of the cohort; therefore, the impact of this confounding factor was probably limited. Because non-respondents tended to have worked fewer years in the trade than

respondents, we may have overestimated the career length of hairdressers. However, contributions to ATP were not mandatory for independent hairdressers and an investigation made by ATP in 2012 reported that 26% of independent hairdressers had not contributed from 2005–2009.⁹⁸ Hence, an underestimation of the overall career length is also a possibility.

8.2 Exclusion of hairdressing apprentices.

The decision to include only fully qualified hairdressers was predetermined by the baseline study. Because hairdressing apprentices often develop OHE (manuscript I) and HE decreases career length (manuscript II), we may have underestimated both of these outcomes by excluding hairdressing apprentices. The POSH study, which prospectively followed hairdressing apprentices from 1992–1994, reported that 48.1% (1,218/2,532) were lost to follow-up throughout the study. A questionnaire survey of apprentices who were lost to follow-up found that 39.1% reported having HE and 71.7% had stopped training (among whom 30.1% stated that skin problems were one of the reasons for leaving the trade).¹⁹ Thus, the prevalence of HE seems relatively stable, when compared to our findings for fully qualified hairdressers. Therefore, including only fully qualified hairdressers may not introduce bias into this estimates. The proportion that had left the trade (discontinued apprenticeship) was higher than the proportion that had left the trade in our study, why we may underestimate the proportion leaving the trade.

8.3 Definition of outcome variables

8.3.1 Self-reported hand eczema

The use of self-reported outcomes comes with the concern of sufficient sensitivity and specificity of items used in a questionnaire. Bregnhøj *et al.* evaluated the NOSQ item "*have you ever had hand eczema*?" (yes/no) and found a sensitivity of 70.3% and a specificity of 96.3% compared to clinical examinations, when used in hairdressing apprentices (18 months after beginning their apprenticeships).²⁹ Yngevson *et al.* validated the questionnaire item "*have you ever had or do you now have eczema or another rash on your fingers, finger webs, palms, back of hands or wrists?"* and found a sensitivity of 73% and specificity of 98.5% compared to clinical examinations, when used in schoolchildren.⁹⁹ Additionally, the specificity of self-reported 1-year prevalence of HE is approximately 96–99% and the specificity of self-reported current HE is approximately 99%.^{99,100}

Thus, diagnosis-based questionnaire items apparently have sufficient sensitivity (> 70%) and very good specificity (> 95%). Using questions from the NOSQ means that we are more likely to underestimate than overestimate true prevalence og HE.

We defined OHE as HE characterized by onset while the individual was training as a hairdressing apprentice or working as a qualified hairdresser. This definition is likely to have high sensitivity (i.e., correctly identify most true cases of OHE), but lower specificity (i.e., cases may be falsely categorized as OHE when, in reality, they are unrelated to the hairdressing profession). We found that 84.9% (956/1,126) of hairdressers graduating from 1985–2007 (manuscript I) suspected that their HE was either caused or exacerbated by the hairdressing profession, indicating that this definition had an acceptable level of specificity.

The frequency of HE was used as a measure of disease severity. Hairdressers with HE were asked "*how often have you had hand eczema*?" (once, for less than 2 weeks/once, for more than 2 weeks/several times/almost all the time). How the frequency of HE correlated with the severity of HE is unknown. The cross-section of hairdressers graduating from 2008–2018 was provided with a validated photographic guide to assess the severity of HE.¹⁰¹ When hairdressers with HE provided both information on the frequency of their HE and feedback on the validated photographic guide (99.0%), we found a significant trend ($P \le 0.001$) towards increasing severity as the frequency of HE increased (Table 2).

	Assessmen "which grou ha	t of severity usi p does your hai ands are most s				
NOSQ-2002	Mild	Moderate	Severe	Very severe	Total	Chi square
"How often have you had hand eczema?" ⁸³	% (n/n _{total)}	% (n/n _{total)}	% (<i>n/n</i> total)	% (n/n _{total)}	% (<i>n/n</i> total)	test for trend
Once	52.7 (59/112)	33.9 (38/112)	10.7 (12/112)	2.7 (3/112)	100.0 (112/112)	<i>P</i> < 0.001
Several times	32.2 (112/348)	52.6 (183/348)	14.1 (49/348)	1.1 (4/348)	100.0 (348/348)	<i>P</i> = 0.001
Almost all the time	9.3 (11/118)	44.9 (53/118)	33.1 (39/118)	12.7 (15/118)	100.0 (118/118)	<i>P</i> < 0.001

Table 2. Comparison of hairdressers graduating from 2008–2018 with hand eczema (n = 584), reporting both the frequency of hand eczema and its severity when worst, as assessed using a photographic guide (n = 578/584). The response options 'once for less than 2 weeks' and 'once for more than 2 weeks' were combined. NOSQ: Nordic Occupational Skin Questionnaire.

8.3.2 A history of atopic dermatitis

Thyssen *et al.* have validated the use of the UKWP criteria for diagnosing a history of AD in an adult population.⁸⁴ They obtained a sensitivity of 77% and a specificity of 91% when using the major criterion and two minor criteria. The sensitivity decreased to 60% and the specificity increased to 98% when the major criterion was combined with three minor criteria. In manuscript I, we defined a history of AD by using two minor criteria. However, after reviewing the results from manuscript I, we used three minor criteria to define a history of AD in manuscripts II and III.

Mortz *et al.* demonstrated that when individuals have previously had HE, this increases the risk of recall bias in evaluating the history of AD using the Hanifin and Rajka criteria.¹⁰² Because the Hanifin and Rajka criteria served as the template for designing the UKWP criteria, study populations assessed using the UKWP criteria may also be affected by recall bias. This observation may partly explain the lower prevalence of AD observed among hairdressers graduating after implementation of the skin protection programme who also had a lower lifetime prevalence of self-reported HE (manuscript III).

9. Conclusions

Incident HE among hairdressers occurs predominantly during the apprenticeship or in the first few years of professional work. The scientific literature has consistently reported that hairdressers frequently experience early onset of HE and our investigation supports this observation. Although incident HE may occur at any time during the career of a hairdresser, there is a drastic decrease in incident HE after the eighth year in the profession (including the apprenticeship), potentially limiting the effects of primary prevention to this time frame.

Although a history of AD is a well-established risk factor for contact dermatitis, we did not find that AD history influenced the time to onset of HE. Therefore, skin protection is warranted, even in hairdressers with normal skin barrier function.

In hairdressers, OHE has a poor prognosis and one-third of those affected continue to have persistent, often frequently relapsing, HE. Risk factors associated with a poor prognosis include a history of AD, a history of contact allergies and continuous work as a hairdresser. Therefore, occupational exposure has an important effect on the course of the disease and the skin protection training programme implemented in Danish hairdressing vocational schools may also function as secondary prevention in this regard, in line with the SIP programme in Germany.

The poor long-term prognosis of OHE and the negative impact of the disease on career span highlight the importance of preventive measures to reduce the burden of the disease and enhance job retention. The evidence-based skin protection programme that has been implemented in Danish vocational schools reduced incident HE and improved compliance with skin protective measures. We recommend implementing such training programmes in all hairdressing vocational schools to prevent incident OHE and alleviate the long-term adverse effects of the disease.

10. Future perspectives

Although implementation of the evidence-based skin protection programme was followed by a decrease in incident OHE, approximately one-third of hairdressers still develop OHE (29.0%). Thus, there is still room for improvement and future interventions should target reducing the lifetime prevalence of HE among hairdressers to levels approximating those typically observed in the general population (i.e., 14.7%; females, 19.4%; males, 12.4%). It may not be possible to reach these levels, but they may serve as an aim to guide interventions.

The European Society for Contact Dermatitis recommends that prevention strategies should follow STOP principles (substitution/elimination, technological measures, organizational measures and personal protective equipment).¹⁰³ Successful substitution strategies have previously involved replacing permanent wave solutions containing glyceryl thioglycolate with solutions containing cysteamine hydrochloride. However, the presence of allergens in cosmetic hair products is an unsolved problem and the necessity for wet work is an inherent characteristic of the trade. Thus, wearing protective gloves will remain necessary for hairdressers. Skin-protection programmes that promote the use of protective gloves should be implemented, but ongoing risk assessments of occupational exposures in hairdressing will be required to update evidence-based skin protection recommendations.

Regular monitoring of morbidity and exposure data is necessary to maintain continuous risk assessment. As suggested in the position paper of the COST Action StanDerm (TD 1206), notification of recognized occupational OHE should be standardized to facilitate comparisons across different registries and notification rates of OHE among hairdressers is necessary to increase the reliability of these registries.^{13,14} Furthermore, clinical patch test data, (in combination with basic clinical characteristics) such as those collected by the European Surveillance System on Contact Allergies (ESSCA), should be used to monitor sensitization patterns among hairdressers.^{62,104} We found that contact allergies affected both the long-term prognosis of HE and decisions on whether to leave the hairdressing profession (manuscripts I and II), illustrating the importance of monitoring contact allergies in hairdressers. Furthermore, the increased use of protective gloves among hairdressers puts them at risk of sensitization to rubber accelerators, which needs to be monitored.

We found that approximately one-third of hairdressers with HE continued to experience HE over the long term. Whether this HE can be strictly categorized as chronic HE remains unclear.

50

Therefore, future epidemiological research on HE among hairdressers should evaluate the prevalence of chronic HE. One recommended definition of chronic HE in epidemiological studies is: HE that persists for more than 3 months or recurs two or more times within 1 year.¹⁰⁵

Protective gloves made of nitrile probably offer the best protection against hair dyes, but quantitative data evaluating the level of protection against other chemicals in cosmetic hair products are difficult to obtain.⁵⁶ General requirements for protective gloves are defined by EN 420, with additional requirements defined by EN ISO 374 (including permeation, penetration and degeneration characteristics) for gloves used to protect against chemicals. To achieve certification by EN ISO 372 standards, a glove should be able to withstand permeation by at least 1 of 18 predefined chemicals for more than 10 minutes.¹⁰⁶ Only 2 of these 18 chemicals (toluene and hydrogen peroxide) are used in hairdressing. Therefore, this certification may be less applicable for occupational exposure to allergens among hairdressers. Consequently, hairdressers may find it difficult to choose a glove that is suitable for their work environment and a common standard that facilitates this choice would be beneficial. Currently, The European Committee for Standardization is developing a standard (CEN/TC162/WG8) for protective gloves used in hairdressing; this will specify permeation requirements for occupationally relevant allergens.

The European Union stipulates that the responsibility for a safe workplace lies with the employer (directive 89/391/EEC) and that personal protective equipment must be used when exposure to occupational hazards is unavoidable (directive 89/656/EEC). The occupational hazards of hairdressing in terms of the risk of developing HE seems established and such measures to increase the availability of protective gloves would likely enhance compliance among hairdressers.

In 2015, the Danish Executive Order for hairdressing vocational training was updated, introducing mandatory skin protection training and requirements for glove use during the final apprenticeship exam to qualify as a hairdresser.⁷⁵ Our evaluation of the skin protection programme (manuscript III) included hairdressers training after the introduction of the skin protection programme in 2011, but before hairdressing apprentices had to pass a written exam on the chemical work environment and glove use was evaluated as part of the final exam. Thus, incident HE and compliance with glove use should be assessed in hairdressing training from 2015 onwards to investigate whether there has been further improvement in these outcomes.

11. Manuscripts

Manuscript I

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. J Eur Acad Dermatol Venereol. 2022 Feb; 36 (2): 263–270. doi: 10.1111/jdv.17794. Epub 2021 Nov 16. PMID: 34747547.

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ORIGINAL ARTICLE

Long-term follow-up of hand eczema in hairdressers: a prospective cohort study of Danish hairdressers graduating from 1985 to 2007

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Abstract

Background Occupational hand eczema is common among hairdressers and implementing effective preventive measures requires a good understanding of the disease's epidemiology.

Objective To investigate the long-term development of hand eczema (HE) in hairdressers.

Methods A prospective cohort study of all hairdressers graduating from Danish hairdressing vocational schools from 1985 to 2007 was conducted. A self-administered questionnaire was sent in 2009 with follow-up in 2020. Data from the Danish labour market supplementary pension scheme provided information on yearly affiliation with the hairdressing trade. **Results** The cumulative lifetime prevalence of HE increased from 42.3% at baseline to 45.2% at follow-up (odds ratio [OR], 1.1; 95% confidence interval [CI], 1.0-1.2). The incidence rate decreased from 42.8 cases/1000 person-years (95% CI, 40.8–44.8) at baseline to 3.4 cases/1000 person-years (95% CI, 2.5–4.6) within the follow-up period. HE onset occurred within 8 years of beginning an apprenticeship for >90% of cases and occurred within the apprenticeship period for 68% of cases. The risk factors associated with having had HE at baseline were a previous positive patch test (adjusted OR [aOR], 5.3; 95% CI, 4.2–6.6), a history of atopic dermatitis (aOR, 3.4; 95% CI, 2.9–4.0) and female sex (aOR, 1.8; 95% CI 1.4–2.3). The most important risk factors at follow-up were previous HE (aOR, 10.1; 95% CI, 7.3–13.8) and a positive patch test within the follow-up period (aOR, 4.5; 95% CI, 3.0–6.8). Among the hairdressers who had HE at baseline, 65.5% exhibited remission, whereas 34.6% had persistent and often severe HE at follow-up. Hairdressers with persistent HE were the subgroup of the study population most frequently affected by the risk factors identified for HE.

Conclusions Primary prevention of HE should focus on hairdressing apprentices and fully trained hairdressers who have recently graduated. Approximately one-third of trained hairdressers develop persistent and often severe HE, emphasizing the need for early intervention.

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Conflict of interest

Martin Havmose is supported by an unrestricted research grant from the Danish hairdressers Union and the Hairdressers association. Jacob Pontoppidan Thyssen has received a consulting fee honorarium from Pfizer and an honorarium for lectures, presentations, speakers bureaus, manuscript writing or educational events from LEO Pharma. Claus Zachariae has no conflicts of interest to declare. Jeanne Duus Johansen is supported by an unrestricted grant for research grant from the Danish hairdressers Union and the Hairdressers association and is president elect for the European Society of Contact Dermatitis (unpaid position) and chair for The Danish Cosmetic Council under The Ministry of Environment (unpaid position).

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Introduction

Occupational contact dermatitis is a common problem and hairdressing is among the professions that are most frequently affected.^{1–3} Hairdressers are frequently exposed to irritants and allergens, because shampooing entails prolonged wet work and allergens are present in hair dyes, permanent wave solutions,

bleaching and hairstyling products, as well as in protective gloves.^{4,5} Consequently, the incidence rate (IR) of hand eczema (HE) among hairdressers is estimated to be more than two-fold higher than that in the general population⁶ and the cumulative lifetime prevalence reportedly ranges from 29.1% to 42.3%.^{6,7}

As occupational HE (OHE) generally has a negative effect on job retention⁸ and the majority of hairdressers exhibit early onset of HE,^{6,7} it is not surprising that there is a high HE-related dropout rate among hairdressing apprentices.^{9,10} Consequently, evidence-based skin protection programmes have been implemented in hairdressing vocational schools for primary prevention of OHE.¹¹ However, the negative impact of HE on job retention extends to practising hairdressers that reported almost half of them had left the trade, with 23.1% reporting HE as a reason for their departure.⁷ At present, our understanding of the long-term course of HE in hairdressers is poor and the need for primary prevention in the later stages of a hairdresser's career is not known.

We present a study of a prospective cohort of trained hairdressers that was established in 2009. These hairdressers graduated from 1985 to 2007 and were followed up in 2020. We evaluated developments in the prevalence and incidence of HE and its associated risk factors as well as prognoses for hairdressers who reported HE at baseline.

Materials and methods

A prospective cohort study of hairdressers graduating from Danish vocational schools from 1985 to 2007 was conducted. A questionnaire was first sent in May 2009 with follow-up in May 2020.⁷ Only respondents from the May 2009 study were included for follow-up (Fig. 1).

Data from registries

The Danish National Archives provided data for the questionnaire study in 2009. The data included the social security number of every hairdresser who received the questionnaire and the questionnaire responses. The baseline characteristics of the study population are shown in Table 1. The Danish labour market supplementary pension scheme (ATP) provided information on payments from the hairdressing trade for hairdressers who graduated from 1985 to 2007.

The questionnaire

The questionnaire had previously been validated when it was used in May 2009.⁷ In brief, validated questions on HE from the Nordic Occupational Skin Questionnaire (NOSQ-2002)¹² were used. Atopic dermatitis (AD) was defined according to the UK working party criteria.¹³ Changes were made to accommodate the follow-up period from 2009 to 2020. For example, the question *"have you ever had hand eczema"* used in the 2009 questionnaire, was changed to *"have you had hand eczema, since 2009"*. A pilot study was performed on six hairdressers, who were interviewed by telephone, to ensure the questions were clear and relevant to the work environment. Data from the questionnaire were self-reported.

Definition of outcome variables

HE was defined as an affirmative answer to the question "have you ever had hand eczema?" (yes/no). A cumulative lifetime



Figure 1 Delineation of the study population.

 Table 1
 Baseline characteristics of respondents

Questionnaire	2009 (Baseline) % (<i>n</i> /n _{total})	2020 (Follow-up) % (<i>n</i> /n _{total})	OR (95Cl)
Respondents	61.2	50.1	0.6
	(5219/8525)	(2614/5219)	(0.6–0.7)
Female	95.7	96.3	1.2
	(4997/5219)	(2518/2614)	(0.9–1.5)
Age			
Median (range)	37 (21–69)	49 (33–80)	-
21–30	17.8 (929/5219)	NA	NA
31–40	51.9	10.7	0.1
	(2709/5219)	(280/2614)	(0.1–0.1)
41–50	29.5	48.0	2.2
	(1542/5219)	(1254/2614)	(2.0–2.4)
51–60	0.7	40.4	103.2
	(34/5219)	(1055/2614)	(73.0–145.9)
>60	0.1	1.0	10.1
	(5/5219)	(25/2614)	(3.9–26.3)
Atopic dermatitis	21.7	21.7	1.0
	(1131/5218)	(567/2613)	(0.9–1.1)
Ex-hairdressers	44.2	57.3	1.7
	(2269/5132)	1491/2604	(1.5–1.9)

Comparison of baseline and follow-up data.

OR, Odds ratio; 95Cl, 95% confidence interval; NA, not applicable.

prevalence was calculated by adding new cases since 2009, identified by an affirmative answer to the question "Have you had hand eczema, since 2009?". A similar procedure was used for other self-reported outcomes. The IR of HE was defined as the number of hairdressers reporting the onset of HE as hairdressing apprentices or as certified hairdressers divided by the number of person-years worked as a hairdresser. Years in the trade until the onset of HE were defined as the number of years from the start of the apprenticeship to the year of onset. Respondents could grade the severity of their HE by the frequency of HE as "once", "several times" or "almost all the time". A positive patch test was defined as an affirmative answer to the question "Have you ever had a positive patch test?" (yes/no). Respondents could report the results of the patch test. The duration of wet work was investigated by asking "How long do you have wet hands during a workday?" $(\langle 2/2-4/\rangle 4h)$. A hairdresser could be categorized as having left the trade (i.e. become an ex-hairdresser) based on their response to the question "what is your current occupation?" (I work as a hairdresser/I no longer work as a hairdresser).

Statistical analysis

The Chi-squared test was used to compare proportions, and the Wilcoxon signed-rank test was used to compare continuous variables that were not normally distributed. The 95% confidence intervals (CI) were calculated for crude odds ratios (ORs) as Ln(OR) and for incidence rate ratios (IRRs) as Ln(IRR),

where Ln is the natural logarithm. Risk factors and risk indicators for having had HE at baseline and at follow-up were assessed by logistic regression. The variable about a positive patch test was given three levels. Those that have never been patch tested (1 (reference)), those that tested negative (2) and those that tested positive (3). This was done to accommodate the inherent risk of having hand eczema when being patch tested. A positive patch tests for nickel alone were excluded because Danish hairdressers previously have been shown to have the same prevalence of nickel allergy as the general population.¹⁴ Statistical analysis was performed using SPSS (ver. 25; IBM, Armonk, NY, USA) and Excel (MS Office 365; Microsoft Corp., Redmond, WA, USA) software.

The study was approved by the Danish Data Protection Agency (P-2019-346).

Results

A total of 5219 respondents from the baseline study were identified. A response rate of 50.1% (2614/5219) was obtained at follow-up, corresponding to 30.1% (2614/8525) of all hairdressers graduating from 1985 to 2007 (Fig. 1). Information on payments to the Danish labour market supplementary pension scheme was available for 90.9% (4746/5212) of the study population.

Baseline characteristics of respondents at follow-up

Compared to respondents from the baseline study (2009), there was no difference at follow-up (2020) in the proportion of respondents who were women (2518/2614 [96.3%]; OR, 1.2; 95% CI, 0.9–1.5) and there was no difference in the proportion of graduates who had a history of AD (567/2613 [21.7%]; OR, 1.0; 95% CI, 0.9–1.1). As expected, there was an increase across all age strata, and 88.3% (2309/2614) of respondents were 41–60 years old at follow-up. The proportion of ex-hairdressers had increased 1.7-fold (95% CI1.5–1.7) from 44.2% (2269/5132) to 57.3% (1491/2604).

Comparison of respondents and non-respondents at follow-up

Among the non-respondents, 4.8% (126/2605) were male (OR, 1.3; 95% CI, 1.0–1.7; P = 0.04) and 68.1% (1774/2605) were aged 31–50 years (OR, 1.5; 95% CI, 1.3–1.7). Compared with respondents, there were no differences in the proportions of non-respondents who had a history of AD (564/2605 [21.7%]; OR, 1.0; 95% CI, 0.9–1.1), who had HE at baseline (1052/2533 [41.5%]; OR, 0.9; 95% CI, 0.8–1.0), who were ex-hairdressers at baseline (1136/2551 [44.5%]; OR, 1.0; 95% CI, 0.9–1.0) and there were no differences in the geographical distribution of respondents and non-respondents.

Prevalence and incidence of HE: developments from 2009 to 2020 From 2009 to 2020, the lifetime prevalence of HE

increased from 42.3% (2152/5080) to 45.2% (1180/2612; OR, 1.1; 95% CI, 1.0–1.2). There was a decrease in the 1-year prevalence of HE from 20.6% (1047/5080) in 2009 to 12.0% (314/2612; OR, 0.5; 95% CI, 0.4–0.7) in 2020 and a decrease in the point prevalence of HE from 7.1% (361/5080) in 2009 to 4.7% (124/2612) in 2020.

The decrease in 1-year prevalence affected both current hairdressers (OR, 0.4; 95% CI, 0.3–0.5) who had worked continuously in the trade (*cont. hairdressers*) and ex-hairdressers (OR, 0.7; 95% CI, 0.6–0.9) who had continuous status as exhairdressers from baseline to follow-up (*cont.* ex-hairdressers). A decrease in point prevalence was only observed in *cont.* hairdressers (OR, 0.5; 95% CI, 0.4–0.7; Table S1, Supporting Information).

The IR of occupation-related HE was 42.8 (95% CI, 40.8-44.8)/1000 person-years in the period from graduation to baseline in 2009. The IR in the follow-up period from 2009 to 2020 was 3.4 (95% CI, 2.5–4.6)/1000 person-years, corresponding to an IRR of 0.08 (95% CI, 0.06-0.11)/1000 person-years.

A slight increase in the proportion of *cont*. hairdressers who exhibited first appearance of occupation-related HE occurred between 2009 (963/1048 [91.9%]) and 2020 (380/406 [93.6%]; OR, 1.7; 95% CI, 1.1–2.7). No changes were observed in the proportions of hairdressers with HE and a concomitant history of AD (Table S1, Supporting Information).

First appearance of HE from graduation (1985–2007) to 2020 Among those hairdressers who exhibited first appearance of occupation-related HE after the start of their apprenticeship and who provided information on the date onset (n = 767/1994), 63.1% (484/767) exhibited onset during their apprenticeship. By the eighth year in their profession, >90% of these hairdressers had developed their HE. This was the case at the seventh year for hairdressers with AD and at the ninth year for hairdressers with no AD (Fig. 2).

Course of HE from 2009 to 2020 Among those hairdressers with no HE at baseline in 2009, 95.1% (1336/1405) still had no HE in 2020 (I) and 4.9% (69/1405) presented as new cases (II) at follow-up. Among those hairdressers with HE at baseline, 65.4% (703/1075) exhibited remission (i.e. no HE from 2009 to 2020) (III) and 34.6% (372/1075) still had HE (IV) (Table 2).

Characteristics of new cases (II)

Compared to hairdressers with HE at the baseline (III and IV), new cases (II) were more likely to only have had HE once (OR, 2.0; 95% CI, 1.2–3.5; P = 0.01), were less likely to have occupation-related first appearance of HE (OR, 0.2; 95% CI, 0.2–0.7; P = 0.002) and were less likely to believe that their HE was caused or exacerbated by hairdressing (OR, 0.2; 95% CI, 0.1–0.3; P < 0.001). For new cases, there were borderline





JEADV 2022, 36, 263-270

Table 2 Follow-up data on hand eczema

Subgroup	No hand eczema at baseline or at follow-up I	New onset of hand eczema at follow-up II	Hand eczema at baseline, but not at follow-up III	Hand eczema both at baseline and at follow-up IV
Hand eczema at baseline (graduation (1985–2007) to 2009)	(-)	(-)	(+)	(+)
Hand eczema during follow-up (2009–2020)	(-)	(+)	(-)	(+)
% continuing in subgroup % (95CI) from baseline to follow-up	95.1 (<i>n</i> = 1336)	4.9 (<i>n</i> = 69)	65.4 (<i>n</i> = 703)	34.6 (<i>n</i> = 372)
Female % (95CI)	95.1	97.1	97.7	98.1
	(1271/1336)	(67/62)	(687/703)	(365/372)
Age % (95Cl)				
Median (range)	50 (34–71)	47 (34–64)	49 (36–80)	47 (34–61)
31–40	9.0	20.3	11.1	14.8
	(120–1336)	(14/69)	(78/703)	(55/372)
41–50	46.6	37.7	50.4	52.2
	(662/1336)	(26/69)	(354/703)	(194/372)
51–60	43.3	40.6	38.0	32.8
	(579/1336)	(28/69)	(267/703)	(122/372)
>60	1.1	1.4	0.6	0.3
	(15/1336)	(1/69)	(4/703)	(1/372)
Atopic dermatitis % (95CI)	11.2	24.6	31.0	46.1
	(150/1336)	(17/69)	(218/703)	(171/371)
Debut as a hairdressing apprentice/hairdresser % (95CI)	NA	82.1	92.4	93.3
		(55/67)	(635/687)	(347/372)
Suspected by the hairdresser to be caused or exacerbated by	NA	56.1	83.2	91.7
the hairdressing profession % (95CI)		(37/66)	(578/695)	(341/372)
Frequency of hand eczema				
Once	NA	28.4	23.8	2.7
		(19/67)	(164/690)	(10/372)
Several times	NA	62.7	63.3	51.3
		(42/67)	(437/690)	(191/372)
Almost all the time	NA	9.0	12.9	46.0
		(6/67)	(89/690)	(1/1/3/2)
Positive patch test <i>ever</i> % (95Cl)	7.1	24.6	19.7	44.1
(minus isolated nickel allergy)	(95/1336)	(17/69)	(139/703)	(164/372)
wet work > 2 n/day (2020)	49.0	42.0	41.2	45.8
Cont bairdroopera (2020)	(639/1303)	(29/69)	(284/690)	(168/367)
Cont. nanuressers (2020)	44.0 509/1216	31.9 22/60	00.7 051/606	J2.J 101/267
Ex-bairdressers (2020)	52.6	65.2	61 5	64.8
LA-11011 01 03 00 3 (2020)	701/1332	45/69	432/703	241/372
Years in the trade	10 (0-38)	8 (1-31)	10 (1-35)	8.0 (1-36)
median (range)		0(101)		0.0 (1 00)

Hairdressers who provided information on having had hand eczema at baseline (graduation to 2009) and in the follow-up period (2009–2020; n = 2480). Results presented as percentages (n_{cases}/n_{total}).

57

(+), hand eczema present; (-), hand eczema absent; NA, Not applicable; 95Cl, 95% confidence interval.

significant associations with a history of AD (OR, 0.6; 95% CI, 0.3–1.0; P = 0.05) and hairdressers who were aged 31–40 years (OR, 1.8; 95% CI, 1.0–-3.3; P = 0.06). There was no association with a previous positive patch test (OR, 0.8; 95% CI, 0.5–1.5; P = 0.47), female sex (OR, 0.8; 95% CI, 0.2–3.6; P = 0.80) or being an ex-hairdresser (OR, 1.1; 95% CI, 0.7–1.8; P = 0.75). Thus, new cases were more likely to have mild HE and their HE was perceived as non-occupational.

Comparison of hairdressers in remission (III) and those with persistent HE (IV)

Compared to hairdressers in remission (III), those with persistent HE (IV) tended to have HE "*almost all of the time*" (OR, 3.1; 95% CI, 2.4–4.0), suspected their HE was caused or exacerbated by hairdressing (OR, 2.2; 95% CI, 1.5–3.4), had a history of AD (OR, 3.1; 95% CI, 2.4–4.1; P < 0.001) and had previously had a positive patch test (OR, 3.2; 95% CI, 2.4–4.2). No

differences were associated with sex (OR, 1.9; 95% CI, 0.8-4.5; P = 0.67), age distribution ($P_{range} = 0.08-0.58$), being an exhairdresser (OR, 0.9; 95% CI, 0.7-1.1) or having occupation-related first appearance of HE (OR, 1.1; 95% CI, 0.7-1.9). Thus, hairdressers with persistent HE were the subgroup with the most frequent HE and the most likely to have a history of AD and a positive patch test.

Changes in the frequency of HE in hairdressers with persistent HE (IV)

Among graduates with HE in both 2009 and 2020, the disease was stable in 55.7% (201/361), improving in 36.3% (131/361), and becoming worse in 8% (29/361) of the hairdressers (Table 3). Worsening HE was observed more frequently in *cont*. current hairdressers (14/115 [12.2%]) than in *cont*. ex-hairdressers (8/172 [4.7%]; OR, 2.8; 95% CI, 1.2–7.0) and improving HE was observed more frequently in *cont*. ex-hairdressers (78/172 [45.3%]) than in *cont*. current hairdressers (78/172 [32.2%]; OR, 1.7; 95% CI, 1.1–2.9; Table S2a,b, Supporting Information). We observed no differences in worsening (5.6%; 10/170; OR, 0.6; 95% CI, 0.3–1.2) or improvement (35.3%; 60/170; OR, 0.9; 95% CI, 0.6–1.4) of HE disease condition in graduates with or without AD.

Risk factors for HE: multivariate logistic regression From graduation (1985–2007) to baseline (2009). Risk factors for ever reporting HE, first appearing when the hairdresser was an apprentice or fully trained, were AD (adjusted odds ratio [aOR], 3.4; 95% CI, 2.9–4.0), having a previous positive patch test (aOR, 5.3; 95% CI, 4.2–6.6) and having a previous negative patch test (aOR, 2.4; 95% CI, 2.0–2.8; Table S4, Supporting Information). Female sex (aOR, 1.8; 95% CI, 1.3–2.6), being an ex-hairdresser and age were risk indicators. Performing wet work for more than 4 h/day was borderline significant (aOR, 1.3; 95% CI, 1.0–1.6; P = 0.06).

From baseline (2009) to follow-up (2020). The primary risk factor for having HE in the follow-up period from 2009 to 2020 was a history of previous HE from baseline to follow-up (aOR, 10.1; 95% CI, 7.3–13.8). Similar to the results obtained for the period from graduation to baseline, a positive patch test (aOR,

4.5; 95% CI, 3.0–6.8) and a negative patch test (aOR, 2.2; 95% CI, 1.4–3.3) were risk factors. The influence of AD on developing HE was reduced in the follow-up period (aOR 1.9; 95% CI, 1.4–2.4) and female sex (aOR, 0.9; 95% CI, 0.4–2.1) and being an ex-hairdresser were no longer risk indicators (aOR, 1.1; 95% CI, 0.8–1.5).

Discussion

In this study, we followed hairdressers for up to 35 years after their graduation. We observed a slight but statistically significant increase in the lifetime prevalence of HE from 42.3% at baseline in 2009 to 45.2% at follow-up in 2020. The IRR of HE first appearing in hairdressers was 0.08, when the periods of graduation to baseline and baseline to follow-up were compared. This indicates almost a complete halt in the incidence of HE. In addition, more than 90% of hairdressers experienced HE onset by the eighth year in their profession and among these, HE first appeared in 63.1% of them during their apprenticeship. Our data indicate that new onset of HE among hairdressers was primarily associated with the apprenticeship and the first few years of professional work. A similar pattern was described previously in a Swedish study⁶ of hairdressers who graduated from 1970 to 1995 and who were surveyed in 1996. That study found that HE first appeared during the apprenticeship or within the first 5 years after graduation in 40% and 31% of the hairdressers respectively. The proportion of these hairdressers who exhibited HE onset during their apprenticeship was substantially lower than in our study, perhaps due to different inclusion criteria, because in the Swedish study, graduates who had never worked as hairdressers were excluded. The cumulative prevalence of HE among German hairdressing apprentices who were clinically examined throughout their training was reportedly 43.3%,¹⁰ which is similar to the lifetime prevalence found in our study. Given the minimal incidence of HE at later career stages, the high rate of onset during the apprenticeship observed in our study may not be unrealistic.

We identified a history of AD, a positive patch test and a negative patch test as risk factors for OHE. Having a positive rather than a negative patch test result more than doubled the risk of HE, emphasizing the importance of the allergic component for

Table 3	Changes	in the	frequer	ncies	of HE
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Timeframe	From graduation (1985–2007) to 2009				
From 2009 to 2020	Frequency of hand eczema	Once	Several times	Almost all the time	Total
	Once	2.2 (8)	7.5 (27)	5.3 (19)	15.0 (54)
	Several times	3.0 (11)	40.4 (146)	23.5 (85)	67.0 (242)
	Almost all the time	0.6 (2)	4.4 (16)	13.0 (47)	18.0 (65)
	Total	5.8 (21)	52.4 (189)	41.8 (151)	100.0 (361)

Changes in the frequencies of HE in trained hairdressers (% [*n*]) with hand eczema at baseline and at follow-up (%_{total} [*n*]). Dark green indicate disease stability. Disease stability was observed in 55.7% of the hairdressers (95% confidence interval [CI], 50.4–60.9). The disease condition improved in 36.3% (95% CI, 31.3–41.5) and worsened in 8% (95% CI, 5.1–11.3) of the hairdressers.

HE. It was not possible to determine whether the allergies were occupational in origin. However, they may well be occupational because allergic contact dermatitis was reportedly responsible for 46.7% and 71% of cases of recognized occupational contact dermatitis in Danish¹⁵ and Australian¹⁶ hairdressers respectively. HE was also associated with female sex, occupational status as an ex-hairdresser and decreasing age. AD¹⁷ and female sex¹⁸ are already well-known risk factors for HE, and HE reportedly contributes to career termination.⁷ Interestingly, female sex ceased to be a risk factor during the follow-up period, perhaps because fewer new cases were associated with hairdressing. The primary risk factor for HE at follow-up was previous HE, which highlights the need for early primary prevention.

An overall improvement in HE was evident, with a decreasing 1-year- and point-prevalence and with remission observed in 65.4% of the graduates who had HE at baseline. The rate of remission in our study was high compared to that observed in previous studies. In a 12-year follow-up of patients who reported occupational skin disease to an insurance company, Meding et al.¹⁹ found that 28% of the patients had recovered completely and 70% of them had HE within 12 months. Among Finnish hairdressers²⁰ diagnosed with OHE and subsequently followed up for 7-14 years, 19 of 32 (59.4%) exhibited symptoms within 12 months. In contrast, only 23.5% of graduates who had HE at baseline in our study exhibited HE within 12 months at 11-year follow-up. We do not know the proportion of our study population who had clinically diagnosed OHE, but many participants may have had transient dermatitis that did not require contact with healthcare services, probably explaining the high remission rate.

Despite the high rate of remission, it is noteworthy that 34.6% of hairdressers with HE have persistent and often severe dermatitis. This corresponds to 14.2% of the study population, indicating that a substantial proportion of graduates are affected many years after graduation. Graduates with persistent HE were more likely to be female, have a history of AD or a positive patch test, highlighting the importance of these risk factors for HE. Interestingly, there were no major differences in the number of years spent working as a hairdresser until the onset of HE between those who had a history of AD and those who did not. This suggests that excessive exposure to hairdressing irritants and allergens quickly exceeds the threshold for contact dermatitis, even in individuals with normal skin barrier function. Although hairdressers with a history of AD were more likely to develop HE and need career guidance for that reason, early primary prevention seems equally important for apprentices, regardless of their atopic disposition.

Strengths and limitations

Our study population comprised only graduated hairdressers, potentially underestimating the prevalence of HE, due to OHErelated dropout among apprentices. Assessing the severity of HE in terms of the frequency of HE is susceptible to recall bias but enabled us to compare follow-up and baseline results. Additionally, some individuals may be unable to remember whether they had HE since 2009 or when their HE began. However, this is an inherent flaw of questionnaire studies in general and is a necessary compromise that enables us to record the dynamics of HE over the course of these hairdressers' careers. The use of the UK working party criteria is reportedly less sensitive in study populations with other skin comorbidities.²¹ Our quantification of wet work did not specify time periods and participants described wet work durations only in general terms. However, our large cohort and good response rate were study strengths. Furthermore, non-respondents and respondents did not differ in the lifetime prevalence of HE at baseline.

Conclusions

Primary prevention of HE should focus on hairdressing apprentices and fully trained hairdressers who have recently graduated. Approximately one-third of trained hairdressers develop persistent and often severe HE, emphasizing the need for early intervention.

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Data availability statement

Data available on request due to privacy/ethical restrictions.

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Supporting information

Additional Supporting Information may be found in the online version of this article:

Table S1. Follow-up on hairdressers graduating from Danishvocational schools from 1985–2007.

Table S2. (a) Changes in the frequencies of hand eczema among *cont. ex-hairdressers* with hand eczema at baseline and at follow-up ($\%_{total}$ (n)). (b) Changes in the frequencies of hand eczema among *cont. current hairdressers* with hand eczema at baseline and at follow-up ($\%_{total}$ (n)).

Table S3. Exposure to wet work/day and a history of a positive patch test.

Table S4. Logistic regression.

Manuscript II

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Original research

Occupational hand eczema reduces career length in hairdressers: a prospective cohort study of Danish hairdressers graduating from 1985 to 2007

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ABSTRACT

Background Occupational hand eczema (OHE) is common in hairdressers, and many leave the trade because of the disease. However, the exact impact of OHE on career length is unknown.

Objective To assess the effect of OHE on career length and risk factors associated with leaving the trade because of OHE in hairdressers followed-up for up to 35 years.

Methods A prospective cohort study of Danish hairdressers graduating between 1985 and 2007 (n=5219) was performed. A questionnaire was sent in 2009 and 2020. The Danish Labor Marked Supplementary Pension Scheme provided information on affiliation to the hairdressing profession. Career length was assessed by Kaplan-Meier analyses.

Results The median survival time was 12.0 (95% CI 11.0 to 13.0) years in graduates with OHE and 14.0 (95% CI 12.6 to 15.4) years in graduates without OHE (p<0.001). Graduates with a frequency of hand eczema (HE) of 'once', 'several times' and 'almost all the time' had a median survival time of 20.0 (95% CI 14.6 to 25.4), 12.0 (95% CI 10.7 to 13.3) and 7.0 (95% CI 5.6 to 8.4) years, respectively. Graduates with OHE that left the trade (partly) because of HE constituted 11.7% of the study population. Factors associated with leaving the trade because of HE included a history of atopic dermatitis (adjusted OR (aOR) 2.2 (95% CI 1.2 to 4.0), a history of a positive patch test (aOR 5.1 (95% CI 3.4 to 25.6).

Conclusion Career length is reduced in hairdressers with OHE, especially if frequently relapsing or caused by contact allergy, for example, to hair dyes.

INTRODUCTION

Occupational hand eczema (OHE) is a common work-related skin condition in hairdressers. The incidence rate of recognised OHE in Denmark is 33.4/10 000 hairdressers per year, making hairdressing the most commonly affected profession.¹ OHE often causes job change, a decrease in quality of life and has a high cost-of-illness to society. Therefore, a better understanding of its consequences is needed when planning prevention and giving career guidance to patients with OHE.^{2.3}

The lifetime prevalence of hand eczema (HE) has been estimated to 45.2% in hairdressers.⁴ Factors associated with OHE in hairdressers are wet work,

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Occupational hand eczema (OHE) is a common work-related disease in hairdressers. High rates of dropouts during apprenticeship have been reported and the career length of hairdressers that have left the trade has been estimated to be less than 10 years. This has been attributed partly to hand eczema, but the exact impact of OHE on career length is unknown.

WHAT THIS STUDY ADDS

- ⇒ OHE reduces the career length of hairdressers, particularly if frequently relapsing. When compared with hairdressers without OHE, the risk of leaving the trade is increased by 20% by having OHE and by 90% if reporting to have had OHE 'almost all the time'. This corresponds to a reduction in the career length by 2 and 7 years, respectively.
- ⇒ Hairdressers with OHE 'almost all the time' is a vulnerable subgroup characterised by a high prevalence of atopic dermatitis (AD) and a high prevalence of contact allergies.
- ⇒ The decision to leave the trade (partly) because of hand eczema was often caused by contact allergies, especially if due to hair dyes.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND/OR POLICY

⇒ There is a need for preventing OHE in hairdressers. When implementing preventive strategies to reduce the incidence of OHE in hairdressers, contact allergies, especially to hair dyes, should be considered as an important exposure in addition to wet work. Special protection is warranted in hairdressers with a history of AD.

a history of a positive patch test reaction and a history of atopic dermatitis (AD).^{4 5} The excessive exposure to irritants and allergens in hairdressing leads to onset of OHE already during apprenticeship. Studies including clinical examinations have shown a prevalence of moderate-to-severe HE in up to 43.2% of hairdressing apprentices and 31.9% of fully trained hairdressers.^{4 6–8}

Among hairdressing apprentices who did not complete apprenticeship, 30.1% of German

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1

apprentices gave 'skin problems' and 42.1% of Danish apprentices gave 'HE' as (partial) reason for dropping out.^{7 9} Furthermore, a study on fully trained hairdressers showed that hairdressers who had left the trade had worked an average of 8.4 years in the trade, and that 23.1% of them gave HE as part of the reason for their career change.¹⁰ Factors associated with leaving the trade because of HE included a high frequency of HE and a history of AD.

No studies have previously assessed the impact of OHE on career length in hairdressers. We aimed to estimate the effect of OHE on career length in hairdressers in a population followed-up for up to 35 years. Additionally, we re-examined the risk factors for leaving the trade because of HE with an emphasis on contact allergies.

METHODS

A prospective cohort study of hairdressers graduating from Danish vocational schools between 1985 and 2007 was performed. A detailed description of methods and delineation of the study cohort has previously been published.⁴ In brief, all hairdressers graduating between 1985 and 2007 (n=8525) from the Danish Hairdressers Union were asked to participate in a survey. A postal questionnaire was first sent in 2009. Another follow-up questionnaire was sent in 2020 to respondents of the 2009 questionnaire (n=5219). A response rate of 61.2% (5219/8525) was obtained in 2009 and a response rate of 50.1% (2614/5219) was obtained in 2020 corresponding to 30.1% (2614/8525) of all hairdressers graduating form 1985–2007. Only data from respondents from the follow-up questionnaire in 2020 were included in the present study.

Data from registries

The Danish Labor Market Supplementary Pension scheme (ATP) provided information on payments made from the hairdressing profession for individuals in the cohort. ATP is a mandatory pension scheme in Denmark. Each contribution is tagged with the date of payment and type of profession. Employers are obliged to contribute on behalf of their employees if the employee works >10 hours/week. It is voluntary for independent hairdressers to contribute on their own behalf. ATP data includes payments from the beginning of apprenticeship which for Danish hairdressing apprentices constitutes 148 weeks (excluding 60 weeks in school).¹¹ The time worked as a hairdresser was calculated as the sum of the number of years that a graduate had contributed to ATP. Thus, the yearly affiliation to the trade encompassed both the years worked as apprentice and as a fully trained hairdresser and did not contain potential career gaps, except maternity leave during continued employment, which was included in the numerator of individual person time.

Definition of outcome variables

HE was defined as an affirmative answer to the question 'have you ever had hand eczema?' (yes/no). OHE was defined as HE with onset during hairdressing apprenticeship or during work as a fully trained hairdresser. The onset of HE was assessed by the questions 'When the hand eczema started, were you then a...' (hairdressing apprentice/fully trained hairdresser/other) and 'When did you have hand eczema for the first time?' (year). It was possible for respondents to grade the frequency of their HE responding to the question 'how often have you had eczema on your hands?' as 'once', 'several times' or 'almost all the time'. To have left the hairdressing trade (thus being an ex-hairdresser) was defined by the second response alternative to the question 'what is your current occupation? '(I work as a hairdresser/I no longer work as a hairdresser)'. To have left the trade because of HE was defined as an affirmative answer to the question 'I left the trade because of hand eczema' (*yes/no*). See the online supplemental material for the definition of AD and patch test results.

Statistics

Overall, OHEs influence on career duration was assessed by Kaplan-Meier analysis and OHEs influence on being an ex-hairdresser by Cox regression. A logistic regression was used to assess factors associated with deciding to leave the trade because of HE among hairdressers with OHE.

Comparison of categorical data were done by χ^2 tests. When performing Kaplan-Meier analysis, occupational status in terms of being an ex-hairdresser was used as the outcome and yearly affiliation to the hairdressing trade was the time scale. Career duration was reported as the median survival time. Graduates still working as a hairdresser at the end of the study period (March 2020) were censored. No other censoring events were considered. The study population was stratified by OHE (yes/no) and by the frequency of HE (once/several times/almost all the time). A log-rank test was used to test for statistically significant differences in survival between these subgroups. Further, two Cox-regression models were used to estimate the size of this difference, quantified as adjusted HRs (aHR). Both contained occupational status as an ex-hairdresser (vs being a current hairdresser) as the outcome variable, and sex (male/female), age (21-30/31-40/41-50/51-60/>60 years) and a history of AD (yes/no) as covariates. Further, one model additionally included OHE (yes/no), and the other the frequency of OHE (never/ once/several times/almost all the time) as the respective explanatory variable of interest.

Factors associated with HE as a specific reason to have left the trade were solely analysed in the subgroup of ex-hairdressers with OHE, and therefore did not include censored individuals. In this subgroup, a logistic regression model was chosen to assess these factors. Thus, among ex-hairdressers with OHE, a comparison was made between those stating to have left the trade because of HE and those that left for other reasons. The dichotomous outcome variable was to have left the trade because of HE (vs to have left the trade but not because of HE, despite having (had) HE). Explanatory variables were sex (male/female), age (21-30/31-40/41-50/51-60/>60 years), a history of AD (yes/no), frequency of HE (once/several times/almost all the time), patch test history (not patch tested/negative patch test/positive patch test) and allergy to hair dyes, preservatives, perfume, nickel or other were used as explanatory variables. Wet work was not included in the analysis, as only information on current wet work was available, which was confirmed by 86.8% (2465/2848) of current hairdressers in the baseline study of this cohort and only in 5.8% of ex-hairdressers.⁴ As a consequence of the homogeneity of wet work as an exposure, it was not identified as a risk factor for OHE. A logistic regression model was used to identify risk factors for having a frequency of HE of 'almost all the time' versus 'once'. Explanatory variables were sex, age, a history of AD, a history of positive patch test and contact allergies. A p value<0.05 considered significant. Statistical calculations were performed in IBM SPSS Statistics V.25.

RESULTS

Characteristics of the study population

The characteristics of the study population have previously been published.⁴ In brief, 50.1% (2614/5219) hairdressers graduating from Danish vocational schools from 1985 to 2007 responded to the follow-up questionnaire in 2020. 96.3% (2518/2614)

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 Table 1
 Occupational status and characteristics of Danish hairdressers graduating from 1985 to 2007

Variable	Current hairdressers % (n _{cases} /n _{total)}	Ex-hairdressers % (n _{cases} /n _{total)}	Total % (n _{cases} /n _{total)}	Ex-hairdressers vs current hairdressers (model I) *adjusted HR (95% CI)	Ex-hairdressers vs current hairdressers (model II) *adjusted HR (95% CI)
Hairdressers graduating from 1985 to 2007	42.7 (1117/2614)	57.3 (1497/2614)	100.0 (2614/2614)	Not included	Not included
Female	95.1 (1062/1117)	97.3 (1456/1497)	96.3 (2518/2614)	1.36 (0.96 to 1.92), p=0.82	1.33 (0.94 to 1.89), p=0.10
Age					
31–40	11.3 (126/1117)	10.3 (154/1497)	10.7 (280/2614)	1.0 (reference)	1.0 (reference)
41–50	50.6 (565/1117)	46.0 (689/1497)	48.0 (1254/2614)	1.05 (0.88 to 1.26), p=0.56	1.05 (0.88 to 1.25), p=0.60
51–60	37.4 (418/1117)	42.6 (637/1497)	40.4 (1055/2614)	1.29 (1.08 to 1.55), p=0.006	1.32 (1.10 to 1.59), p=0.003
>60	0.7 (8/1117)	1.1 (17/1497)	1.0 (25/2614)	1.61 (0.87 to 2.97), p=0.13	1.73 (0.94 to 3.21) p=0.08
A history of atopic dermatitis	4.5 (50/1113)	7.0 (105/1456)	6.0 (155/2569)	1.26 (1.01 to 1.56), p=0.04	1.15 (0.93 to 1.44), p=0.20
Occupational hand eczema					
Never	63.9 (709/1110)	56.0 (853/1492)	59.3 (1544/2602)	Not included	1.0 (reference)
Once	8.5 (94/1110)	5.4 (81/1492)	6.7 (175/2602)		0.78 (0.62 to 1.0), p=0.05
Several times	21.8 (242/1110)	26.2 (391/1492)	24.3 (633/2602)		1.20 (1.05 to 1.36), p=0.007
Almost all the time	5.9 (65/1110)	12.4 (185/1492)	9.6 (250/2602)		1.90 (1.59 to 2.26), p<0.001
Lifetime prevalence	36.5 (408/1117)	44.1 (660/1495)	40.9 (1068/2612)	1.22 (1.09 to 1.36), p=0.001	Not included

Bold font indicates p<0.05.

*The adjusted HR was estimated by Cox regression. Two models are included in the table. The models differ on the variable of OHE. Model I contain the variable of OHE (yes/no). Model II contains OHE on an ordinal scale (never/once/several times/almost all the time).

OHE, occupational hand eczema.

of respondents were women, the median age at follow-up was 49.0 years (range 33–82) and 6.0% (155/2569) had a history of AD. The lifetime prevalence of OHE was 40.9% (1068/2612) (table 1). Graduates with OHE reported a frequency of HE of 'once', 'several times' and 'almost all the time' in 16.5% (175/1058), 59.8% (633/1058) and 23.6% (250/1058) of cases. In 2020, 57.3% (1497/2614) of respondents were ex-hairdressers (figure 1). Respondents and non-respondents in 2020 were identical in 2009 in terms of the proportion of ex-hairdressers, the prevalence of HE and the prevalence of a history

of AD. ATP data were available for 91.2% (2385/2614) of the study population.

Kaplan-Meier survival analysis: career duration

A median survival time of 13.0 (95% CI 12.2 to 13.8) years was observed for the total study population. Graduates with OHE had had a median survival time of 12.0 (95% CI 11.0 to 13.0) years and graduates without OHE had a median survival of 14.0 (95% CI 12.6 to 15.4 (p<0.001) years (online supplemental



Figure 1 Proportion of hairdressers graduating from 1985-2007 that leaves and rejoins the trade across time.

Havmose M, et al. Occup Environ Med 2022;0:1-7. doi:10.1136/oemed-2022-108230

Table 2 Characteristics and career length of graduates with or without occupational hand eczema (OHE)							
		Frequency of OHE			*Adjusted OR (95% CI)		
	Never had OHE	Once	Several times	Almost all the time	'Almost all the time' vs 'once'		
Proportion % (n/n _{total})	59.3 (1544/2602)	6.7 (175/2602)	24.3 (633/2602)	9.6 (250/2602)			
Female % (n/n _{total})	95.3 (1472/1544)	96.0 (168/175)	98.1 (621/633)	98.0 (245/250)	1.4 (0.4 to 5.2), p=0.60		
Age % (n/n _{total})							
31–40	8.7 (134/1544)	16.0 (28/175)	13.7 (87/633)	12.4 (31/250)	1.0 (reference)		
41–50	46.4 (717/1544)	44.6 (78/175)	50.6 (320/633)	53.2 (133/250)	1.4 (0.7 to 2.9), p=0.27		
51–60	43.6 (673/1544)	37.7 (66/175)	35.4 (224/633)	34.4 (86/250)	0.9 (0.5 to 1.9), p=0.85		
>60	1.3 (20/1544)	1.7 (3/175)	0.3 (2/633)	NA	NA		
History of atopic dermatitis % (n/n _{total})	2.8 (42/1506)	5.2 (9/174)	8.4 (53/629)	20.0 (50/250)	4.4 (1.9 to 10.1), p<0.001		
Patch test % (n/n _{total})							
Never been patch tested	78.0 (1202/1542)	66.9 (117/175)	58.9 (373/633)	24.8 (62/250)	1.0 (reference)		
Patch test negative	10.1 (156/1542)	11.4 (20/175)	10.6 (67/633)	10.8 (27/250)	2.4 (1.2 to 4.7), p=0.01		
Patch test positive	11.9 (184/1542)	21.7 (38/175)	30.5 (193/633)	64.4 (161/250)	3.8 (1.4 to 10.4), p=0.01		
Allergy % (n/n _{total})							
Hair dyes	1.1 (17/1542)	4.0 (7/174)	6.3 (40/633)	27.6 (69/250)	4.0 (1.5 to 10.5), p=0.005		
Perfume	2.3 (36/1542)	5.2 (9/174)	6.3 (40/633)	13.2 (33/250)	0.5 (0.2 to 1.4), p=0.19		
Preservatives	1.2 (19/1542)	2.3 (4/175)	4.3 (27/633)	12.4 (31/250)	1.7 (0.5 to 5.6), p=0.36		
Nickel	6.9 (106/1542)	10.3 (18/175)	16.7 (106/633)	36.0 (90/250)	1.7 (0.7 to 4.1), p=0.23		
Other	6.1 (94/1542)	11.4 (20/175)	13.1 (83/633)	29.2 (73/250)	1.0 (0.4 to 2.4), p=0.98		
Median career length (years; (95% CI)	14.0 (12.6 to 15.4)	20.0 (14.6 to 25.4)	12.0 (10.7 to 13.3)	7.0 (5.6 to 8.4)	Not included in model		
Ex-hairdressers % (n/n _{total})	54.1 (835/1544)	46.3 (81/175)	61.8 (391/633)	74.0 (185/250)	Not included in model		
Left the trade (partly) because of hand eczema % (n/n,,)	NA	15.4 (10/65)	40.7 (142/349)	86.5 (154/178)	Not included in model		

Bold font indicates p<0.05.

*Factors associated with having hand eczema 'almost all the time' were assessed by a logistic regression model (n=425) with the outcome of the frequency of hand eczema (almost all the time/once).

NA, not applicable.

table 1, online supplemental figure 1). The median survival times decreased with an increasing frequency of OHE. Graduates with a frequency of HE of 'once', 'several times' and 'almost all the time' had a median survival time of 20.0 (95% CI 14.6 to 25.4), 12.0 (95% CI 10.7 to 13.3) and 7.0 (95% CI 5.6 to 8.4) years, respectively. Graduates with a frequency of HE of 'once' had higher median survival time than hairdressers without OHE (p=0.02) (table 2, figure 2).

The median survival time in the subgroup of all ex-hairdressers (n=1330) was 7.0 (95% CI 6.6 to 7.4) years. No difference was observed between the median survival time of ex-hairdressers with and without OHE being 7.0 (95% CI 6.5 to 7.5) in both subgroups (p=0.63) (online supplemental table 1). Thus, ex-hairdressers with and without OHE did not differ in the tendency leaving the trade. However, ex-hairdressers with OHE stating *specifically* to have left the trade because of HE had




a lower median survival than ex-hairdressers with OHE stating *not* to have left because of HE being 6.0 (95% CI 5.4 to 6.6) and 8.0 (95% CI 7.2 to 8.8) (p=0.001), respectively (online supplemental table 1, online supplemental figure 2).

Cox regression: the association between OHE and being an ex-hairdresser

Graduates with OHE had a higher risk of leaving the trade, compared with graduates without OHE (aHR 1.2 (95% CI 1.0 to 1.4) (table 1). Leaving the trade was additionally associated with a history of AD (HR 1.3 (95% CI 1.0 to 1.6)). Further, an interaction between a history of AD and OHE (aHR 1.4, 95% CI 1.1 to 1.8) was identified. Graduates with a frequency of HE of 'almost all the time' (aHR 1.9 (95%CI 1.6 to 2.3) and 'several times' (aHR 1.2 (95% CI 1.1 to 1.4) had an increased risk of leaving the trade, when compared with graduates without OHE (reference) (table 1). Graduates who had only had OHE 'once' had a decreased risk being ex-hairdressers (aHR 0.8 (95% CI 0.6 to 1.0)). An interaction between a history of AD and a frequency of HE of 'almost all the time' (aHR 2.1 (95% CI 2.1 to 1.5–3.0) was found. No interaction with a frequency of HE of 'once' or 'several times' were found.

Proportion of ex-hairdressers who left the trade because of HE

The proportion of ex-hairdressers with OHE that stated HE as (part of) the reason to leave the trade was 51.7% (307/594). Conversely, 48.3% (287/594) of those with OHE that left trade did so for other reasons (online supplemental figure 3). Ex-hairdressers with OHE that left the trade because of HE constituted 11.7% (307/2614) of the study population and 22.4% (307/1370) of all ex-hairdressers.

Logistic regression: factors associated with reporting to have left the trade because of HE

Among ex-hairdressers with OHE, those stating to have left the trade because of HE were characterised by (a) a history of AD, (b) a history of a positive patch test and (c) allergy to hair dyes, when compared with ex-hairdressers with OHE that left for other reasons (table 3). Among ex-hairdressers that left the trade because of OHE 17.3% had a history of AD (adjusted OR (aOR) 2.21 (95% CI 1.23 to 3.98). A total of 60.9% (187/307) had history of a positive patch test (aOR 5.05 (95% CI 2.31 to 11.02); risk estimated with negative or lacking patch test as reference. A positive patch test specifically to hair dyes were seen in 26.1% (80/307) of ex-hairdressers that left the trade because of OHE (aOR 9.37 (95% CI 3.43 to 25.61), reference being those testing negative along with those in whom patch testing was not performed). No association was found with sex, age, debut of OHE as a hairdressing apprentice or fully trained hairdresser, a history of a negative patch test or allergy to perfume, preservatives, nickel.

DISCUSSION

In this study we assessed the effect of OHE on career length in hairdressers followed-up for up to 35 years after graduation. Career length in hairdressers with OHE was reduced with frequency of HE being an important determinant for reduced career length. Compared with graduates without OHE, the risk of leaving the trade increased by 20% in graduates with OHE and by 90% in graduates with a frequency of OHE of 'almost all the time', according to Cox regression analyses. Half of graduates with a frequency of OHE of 'almost all the time' had left the trade by the 7th year in the profession, compared with the same attrition achieved only in the 14th year in graduates without OHE. These estimates include the time worked as a hairdressing apprentice (148 weeks or 2.8 years), indicative of OHE having

 Table 3
 Characteristics of ex-hairdressers with occupational hand eczema that left the trade (n=594), either because of hand eczema or for other reasons

	Left the trade because of	hand eczema	
	Yes (n=307)	No (n=287)	Adjusted OR (95% CI)
Ex-hairdressers with occupational hand e	eczema		
Female	98.7 (303/307)	97.6 (280/287)	0.99 (0.28 to 3.55), p=0.99
Age			
31–40	12.4 (38/307)	11.5 (33/287)	1.0 (reference)
41–50	50.5 (155/307)	45.6 (131/287)	0.99 (0.55 to 1.80), p=0.98
51–60	37.1 (114/307)	41.9 (126/301) 42.5 (122/287)	0.76 (0.41 to 1.39), p=0.37
>60	0.0 (0/307)	0.3 (1/287)	_
A history of atopic dermatitis	17.3 (53/304)	7.3 (21/287)	2.21 (1.23 to 3.98), p=0.01
Patch test			
Not tested	30.3 (93/307)	67.2 (193/287)	1.0 (reference)
Negative	8.8 (27/307)	11.5 (33/287)	1.68 (0.95 to 2.98), p=0.08
Positive	60.9 (187/307)	21.3 (61/287)	5.05 (2.31 to 11.02), p<0.001
Allergy			
Hair dyes	26.1 (80/307)	1.7 (5/287)	9.37 (3.43 to 25.61), p<0.001
Preservatives	11.7 (36/307)	3.1 (9/287)	0.89 (0.37 to 2.13), p=0.79
Perfume	12.4 (38/307)	4.2 (12/286)	0.64 (0.28 to 1.48), p=0.30
Nickel	33.2 (102/307)	12.9 (37/287)	0.79 (0.40 to 1.58), p=0.51
Other	26.4 (81/307)	9.1 (26/287)	0.90 (0.45 to 1.80), p=0.77
Bold font indicates p<0.05.			

*The adjusted OR was obtained from a logistic regression model with the outcome 'I left the trade because of hand eczema' (yes/no).

Havmose M, et al. Occup Environ Med 2022;0:1-7. doi:10.1136/oemed-2022-108230

a considerable impact on career length.¹¹ In addition, graduates with OHE 'almost all the time' were identified as a vulnerable subgroup with a high proportion of ex-hairdressers (74.0%), a high prevalence of history of AD (20%) and a high prevalence of contact allergies (64.4%). Interestingly, having had OHE 'once' decreased the risk of being an ex-hairdresser (aHR 0.78; border-line significance). Thus, hairdressers with HE 'once' may represent a substratum of the study population whose skin tolerates the work environment, either due to a low prevalence of AD or due to knowledge of preventing of HE, that is, compliance with glove use and use of emollients. Such compliance with protective measures may be related to the wish to remain in the job. Despite these favourable conditions, they still experience a single episode of HE, most likely because of the high exposure to irritants and allergens in hairdressers' work environment.

A general tendency to leave the trade was evident, as ex-hairdressers with and without OHE had identical career length in terms of a median of 7 years. Career termination in hairdressers seems therefore to be multifactorial with OHE being one of many reasons to leave the trade. This is in line with other notable reasons such as 'musculoskeletal complaints' 'allergies', 'various personal reasons' and 'work conditions' previously having been reported.^{5 10} ¹² Nevertheless, graduates with OHE that left the trade (partly) because of HE constituted 11.7% of our study population and had a shorter career length (median 6 years) compared with those that left for other reasons (median 8 years).

We identified the associations with reporting to have left the trade because of OHE to be: (1) a history of AD, (2) a history of a positive patch test reaction and (3) an allergy to hair dyes. In patients with recognised OHE seen by a dermatologist, risk factors for job change were previously identified as young age, a positive patch test (regardless of relevance) and severe HE.¹³ As these risk factors largely overlap with the associations of deciding to leave the trade because of OHE, both the tendency of OHE to reduce career length in the total study population and particularly in hairdressers stating to have left the trade because of OHE is not surprising. Interestingly, in a 7-year follow-up study of patients with HE, contact sensitisation was found to be inversely related to job change.¹⁴ The authors speculated that this was due to knowledge of how to avoid the offending allergens. We found the association with leaving the trade to be almost two times higher for hair dye allergy compared with a history of a positive patch test in general. Thus, hair dye allergy seems to lead to career change rather than preventive avoidance in hairdressers. This inability to remain in the profession is explained by the high prevalence of hair dye allergy among hairdressers and the high frequency of hair dye exposing procedures performed by hairdressers.^{4 15 16} No association was seen with allergy to nickel, preservatives or fragrances. As the prevalence of nickel allergy in Danish hairdressers and matched controls patch tested in Denmark is identical and Danish hairdressers' tools generally seem to release low levels of nickel, this lack of association seems reasonable.^{15 17} Our cohort has graduated since three epidemics of contact allergy to preservatives, namely methylchloroisothiazolinone (MCI) in combination with methylisothiazolinone (MI) in the 1980s, methyldibromo glutaronitrile (MDBGN) in the 1990s and MI in the 2000s.¹⁸ As the latter was caused primarily by cosmetics, including rinse-off products, the lack of association with preservatives is not as obvious. Moreover, in a perhaps more selected clinical sample of hairdressers patch tested for suspected contact allergy to hair cosmetic ingredients, a roughly tripled prevalence of preservative contact allergy (to MDBGN and MCI/MI at the time) compared with consumers also tested for hair cosmetic-related contact dermatitis has been

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identified.¹⁹ Concerning MI alone, MI was first introduced in the European baseline series in 2014, possibly leading to a (general) underdiagnosis of MI contact allergy until that time which is why hairdressers leaving the trade before 2014 due to MI allergy may not have known the cause of their disease.²⁰ Lastly, the lack of association with contact allergy to nickel, preservatives, and perfumes may be explained by these not being as relevant and potent allergens as hair dyes, represented by *p*-phenylenediamine.

The tendency of OHE to cause early career change has previously been shown by Meding *et al*, who conducted a follow-up study of patients with HE from Swedish general population. In their cohort, 8% had changed profession because of OHE at baseline, compared with only 3% at a 15-year follow-up.^{21 22} Most of the abandoned jobs were high-risk occupations for OHE like hairdressing, but the prevalence of job change because of OHE was much lower compared with our findings. Overall, hairdressers seem to change profession because of HE much more often than the general working population.

STRENGTHS AND LIMITATIONS

Our study population only comprised graduated hairdressers, that is, individuals who dropped out already during apprenticeship were not taken into account. In Germany, the proportion of hairdressing apprentices who drop out has been estimated to 48.1% (1218/2532) with 39.1% (245/560) reporting skin problems as a reason.⁷ Thus, the overall proportion leaving the trade because of HE is potentially underestimated. The use of ATP data to estimate the yearly affiliation to the trade provided a precise and objective estimate for each participant in the cohort but does come with the shortcoming of payments to ATP only being mandatory for employed hairdressers, and not for selfemployed. The career length may therefore be underestimated if graduates become salon owners, decide not to contribute on their own behalf and stay in the trade. A publication from ATP stated that 26% of salon owners did not contribute on their own behalf in the period 2005-2009, however the proportion of salon owners in our study is unknown.²³ The effect of agerelated retirement seems negligible as only 1.1% of our study population was above 60 years of age. The definition of OHE as HE with onset as apprentice or as fully trained hairdresser is expected to be highly sensitive, but potentially includes graduates with non-occupational HE. Furthermore, this definition of OHE potentially introduces an immortal time bias in the survival analysis of hairdressers with OHE, as participants with OHE needed to have worked a certain time in the trade to have had a chance to get OHE, in contrast to those without OHE, who could leave anytime. However, the median time to onset of OHE was merely 2.0 years, including apprenticeship, (online supplemental figure 4) which is why we deemed immortal time bias to be of limited impact.

In terms of secular trends in the Kaplan-Meier survival analysis, no significant difference in median survival time for hairdressers graduating from 1985 to 1993 and from 1994 to 2007 was observed, being 13.0 (95% CI 11.8 to 14.2) and 14.0 (95% CI 12.7 to 15.3) (p=0.08) respectively. However, hairdressers graduating from 1994 to 2007 tended more than those graduating from 1985 to 1993 to report to have had HE (OR 1.4, 95% CI 1.2 to 1.6) and have allergy to hair dyes (OR 1.5, 95% CI 1.0 to 2.1). No difference was observed in the proportion with a high frequency of HE or with a history of a positive patch test (online supplemental table 2). Although some of the factors associated with deciding to leave the trade because of HE changed across time, these differences were deemed small enough to perform an overall Kaplan-Meier survival analysis. This is a compromise that in turn provides a valuable insight into the impact of OHE in a cohort of hairdressers, spanning almost a complete career length.

CONCLUSION

The career length in hairdressers with OHE is decreased, with the frequency of HE being an important risk factor. Contact allergy, especially to hair dyes, is a strong indicator of leaving the hairdressing profession because of HE.

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by The Danish Data Protection Agency (reference number P-2019-346). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request from the National Allergy Research Centre, Denmark. Data consist of de-identified questionnaire data and career length estimates based on ATP data.

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Manuscript III

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Title: A nationwide skin protection program introduced in hairdressing vocational schools was followed by a decreased risk of occupational hand eczema.

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Conflicts of interest: Dr. Thyssen is an advisor for AbbVie, Almirall, Arena Pharmaceuticals, Coloplast, OM Pharma, Aslan Pharmaceuticals, Union Therapeutics, Eli Lilly & Co, LEO Pharma, Pfizer, Regeneron, and Sanofi-Genzyme, a speaker for AbbVie, Almirall, Eli Lilly & Co, LEO Pharma, Pfizer, Regeneron, and Sanofi-Genzyme, and received research grants from Pfizer, Regeneron, and Sanofi-Genzyme. Dr. Uter has received research funds from IFRA (www.ifraorg.org) for an epidemiological surveillance project on fragrance allergies. The remaining authors have no conflicts of interest to declare.

Abstract:

Background. Compliance with glove use and safe work practices are important factors in primary prevention of occupational hand eczema (OHE) in hairdressers.

Objective. To assess the risk OHE and compliance with skin protective measures in hairdressers trained before and after implementation of a nationwide skin protection program in Danish hairdressing vocational schools in 2011.

Methods. A repeated cross-sectional study was performed. A questionnaire was sent in 2009 and 2020. The Danish Labour Market Supplementary Pension Scheme provided information on yearly payments from the hairdressing profession.

Results. A response rate of 66.6% (305/460) was obtained in the 2009 survey and of 29.9% (363/1215) in the 2020 survey. The career time prevalence of OHE decreased from 42.8% to 29.0% (adjusted odds ratio 0.55 (95% confidence interval (CI) 0.40-0.77) and the incidence rate of OHE decreased from 57.5 (95%CI 48.4-68.4) to 42.0 (95%CI 34.6-50.9) per 1000 person years (incidence rate ratio 0.73 (95%CI 0.56-0.95) between the two surveys. A statistically significant (P<0.05) increase in glove use when doing wet-work and when handling hair dyes, permanent wave solutions and bleaching products was observed in the 2020 compared to the 2009 survey. **Conclusion.** Our data suggest that skin protection training during apprenticeship reduces the risk of OHE in hairdressers. The lack of primary prevention of OHE in hairdressing vocational schools may be a missed opportunity in the prevention of the disease.

Key words: contact dermatitis, disposable gloves, hairdressers, occupational, primary prevention

1. Introduction

Hairdressers are exposed to wet-work and an array of skin irritants and allergens, such as hair dyes, permanent wave solutions, persulfates, preservatives, fragrances, and rubber accelerators. Consequently, about 40%¹ develop occupational hand eczema (OHE), often with early onset². As OHE in hairdressers both decreases career length^{3,4} and has an unfavorable prognosis², prevention of the disease is important.

Career guidance of individuals with atopic dermatitis (AD) has for many years been a key component in primary prevention of OHE^{5,6}. However, AD may be less important than believed as hairdressing apprentices less often have a history of AD compared to the general population⁷ and the etiological fraction of AD in hairdressers with hand eczema (HE) has been estimated to amount to just 10%⁸. The potential for further prevention seems therefore to be in the domain of limiting exposure to skin hazardous substances in the work environment. To this end, promotion of disposable protective gloves is mainstay, but efficacy is potentially hampered by low compliance and incorrect use⁹.

In 2011, an evidence-based skin protection program was implemented nationwide in Danish hairdressing vocational schools. The program educates hairdressing apprentices on skin biology, contact allergy/urticaria and how to prevent occupational skin disease. The apprentices are taught by specially trained vocational school teachers, involving formats such as oral presentations, theoretical group work and practical training which includes glove size measurement. The initial roll-out of the program in 2008 was evaluated in an interventional study¹⁰, documenting a reduction in incident hand eczema during apprenticeship if being in the intervention group receiving skin protection training. This was followed by the nationwide roll-out in 2011 and by 2015 the executive order on hairdressing vocational training was updated, requiring apprentices to pass a theoretical and practical exam based on the content of the skin protection program.

The nationwide evidence-based skin protection program is based on the evidence-based skin protection program in the 2008 intervention study¹⁰, which serves as the template for the teaching material "the chemical work environment – hairdresser"¹¹ authored by the National Allergy Research Centre in Denmark. The teaching material centers around 11 recommendations with 7 relating to glove use (use gloves when you wash, dye, bleach and perm, disposable gloves must be

clean/never reuse disposable gloves, use gloves as long as necessary but as brief as possible, do not wear rings at work, use cotton gloves underneath protective gloves), 3 relating to safe work routines (cut before you dye the hair, mix in a separate ventilated cabinet and use an unscented lipid-rich moisturizer) and 2 relating to the time off work (use gloves when doing wet work in your spare time, use warm gloves when outside when it is cold). Hairdressers are further advised to use nitrile gloves without rubber accelerators. These recommendations are identical to the evidence-based skin protection program used in the 2008 intervention study.¹⁰

We aimed to compare the prevalence and incidence of OHE, the impact of constitutional and exposure-related risk factors as well as compliance with skin protective measures in hairdressers trained before and after implementation of the nationwide skin protection program in 2011.

2. Materials and methods

A self-administered questionnaire was sent to all hairdressers graduating from 1985-2007 in May 2009³ and to all hairdressers graduating from 2008-2018 in May 2020. In the present study, only hairdressers graduating from 2004-2007 who received a questionnaire in May 2009 and all hairdressers graduating from 2015-2018 who received a questionnaire in May 2020 were included (Figure 1). Thus, each cross section spanned four graduation years and received a questionnaire two years after the last graduation year had completed their training (answered the questionnaire 2-5 years after graduation). As hairdressing vocational training in Denmark takes 4 years, the first graduation years having been enrolled in the training program nationwide started their training in 2011 and graduated in 2015. No exclusion criteria were applied.

2.1 Data from registries

The Danish hairdressers and Beauticians Union provided social security number on all hairdressers graduating from 2004-2007 and 2015-2018. Information on sex and date of birth is encoded in the social security number. Statistics Denmark provided postal address for all identified hairdressers. The Danish Labour Market supplementary Pension Scheme (ATP) provided information on payments made from the hairdressing trade from all identified hairdressers, thereby indicating whether a hairdresser was still working.

2.2 Definition of outcome variables

To have had OHE was defined by two questionnaire items, First, to have had HE was defined as an affirmative answer to the question "have you ever had hand eczema?" (yes/no). Second, to have had OHE was defined as HE with onset as a hairdressing apprentice or later as a fully trained hairdresser. Onset of HE was assessed by the question "When the hand eczema started, were you a..." (hairdressing apprentice/fully trained hairdresser/other). The year of onset of HE was assessed by the question "When did you have eczema on your hands for the first time?" (year). Period prevalences were assessed by the question "When did you last have hand eczema?" (I have it currently/not currently, but within the last 3 months/between 3-12 months ago/more than 12 months ago). It was possible for respondents to grade their HE by the frequency of HE (once/several times/almost all the time). A history of AD was defined according to the UK Working Party Criteria and was diagnosed by having the major criterion in combination with 3 minor criteria, to increase specificity.^{12,13} To have had an itchy skin condition served as the major criterion. To have had onset before the age of 2 years, a history of generally dry skin, a history of asthma or hay fever and a history of flexural involvement served as minor criteria. A history of a positive patch test was defined by an affirmative answer to the question "have you ever been tested for allergy with a patch test on your back?" (yes/no). Respondents could report the result of the patch test as (no allergy/perfume/nickel/hair dye/preservatives/other) with multiple response option. Questions used to assess compliance to skin protective measure will be reported in conjunction with the results. To have performed a work task was assessed by the question "How many times in the past week have you performed the following (state the number of times) (shampoo/cut in wet hair/full head hair colouring (permanent)/full head hair colouring (semi-permanent)/bleaching/highlights (cap)/highlights (foil)/permanent waves/colouring eye lashes. To have performed a task was defined by having performed it at least once in the week prior to the survey. Years worked in the trade was defined as the number of years a hairdresser had contributed to ATP. To have left the hairdressing profession was assessed by the question "what is your current occupation" (I work as a hairdresser/I no longer work as a hairdresser).

2.3. Statistics

A chi square test was used to test for a statistically significant difference when comparing categorical variables and a Mann-Whitney U test was used to test for a statistically significant difference when comparing two continuous variables. A p-value<0.05 was considered statistically

significant. Proportions were calculated among respondents to an item in the questionnaire. The prevalence of OHE was calculated as the proportion with OHE during their career as a hairdressing apprentice/hairdresser (career time OHE), within 1 year and currently. A period effect of the career time prevalence of OHE within each cross section was assessed by a Cochran-Armitage test for trend. The incidence rate (IR) of OHE was calculated as the number of cases divided by the number of cumulated person years worked in the trade provided by the ATP. A logistic regression model was used to calculate the adjusted odds ratio (aOR) of having OHE in each cross-section. To have had OHE as a hairdresser (yes/no), within 1 year (yes/no) or currently (yes/no) was used as the outcome in 3 different models with graduation year (2004-2007/2015-2018) used as the explanatory variable of interest. The model was adjusted for sex (female/male), age (21-30/31-40/>40), and a history of atopic dermatitis (yes/no) as defined above. Additionally, the aOR of having OHE currently in each cross section was estimated in current hairdressers, further adjusting for significant changes in current exposures (tasks performed in the week prior to the survey and domestic wetwork exposure if significant in bivariate analysis).

When comparing the two cross sections (2015-2018 vs. 2004-2007), a difference in response rate was seen (29.9% vs. 66.6%) potentially reflects a respondent-dependent selection bias that could compromise the comparison. To adjust for this in the regression models, the probability of participation was calculated for predefined, identical groups in each cross section to construct group-specific weights calibrated to sum up to 1 over the entire dataset. The groups were defined by sex, age (quartiles based on the empirical distribution) and years in the trade (quartiles based on the empirical distribution). The group specific weight was then assigned to each member of the respective group to adjust for differential participation in regression modelling.

3. Results

The study population comprised a total of 2135 hairdressers with 460 graduating from 2004-2007 and 1675 graduating from 2015-2018. As mentioned above, a response rate of 66.6% (305/460) and 29.9% (363/1215) was obtained from the 2004-2007 and the 2015-2018 cross sections respectively.

3.1 Baseline characteristics of the study population and analysis of non-respondents.

In total, 96.4% (664/668) of the study population were women. The median age was 26.0 years (range 21-54) with most (83.5%, 557/668) being aged 21-30 years. The median time worked in the

trade was 8.0 (95%CI 7.8-8.2) years and 28.8% (192/666) no longer worked as hairdressers. Graduates with a history of atopic dermatitis accounted for 8.3% (55/665) of the study population. Comparing hairdressers graduating from 2004-2007 and 2015-2018, no statistical difference was found in terms of sex, age, and the proportion of ex-hairdressers (Table 1). However, hairdressers graduating from 2004-2007 had worked slightly fewer years in the trade (P<0.001), while hairdressers graduating from 2015-2018 tended less often to have a history of atopic dermatitis (OR 0.6 (95%CI 0.3-1.0).

Comparing respondents and non-respondents in the 2004-2007 and the 2015-2018 cross sections respectively, no statistical difference was found in terms of sex and age. Respondents in the 2004-2007 cross section had worked more years in the trade than non-respondents (P=0.001). No statistical difference was seen in career length comparing respondents and non-respondents in the 2015-2018 cross section (P=0.36) (Table S1).

3.2. Occupational hand eczema: Prevalence, incidence, onset, frequency of hand eczema and patch testing

The IR of OHE decreased from 57.5 (95%CI 48.4-68.4)/1000 person in the 2004-2007 sample years to 42.0 (95%CI 34.6-50.9)/1000 person years in the 2015-2018 samples. This yielded an incidence rate ratio (IRR) of 0.73 (95%CI 0.56-0.95) comparing the 2015-2018 cross section with the 2004-2007cross section. A corresponding decrease in the career time prevalence of OHE from 42.8% (128/299) to 29.0% (102/352) (OR 0.5, 95%CI 0.4-0.8) was found. Additionally, a decrease in both the 1-year and the point prevalence from 33.9% (81/239) to 23.9% (75/314) (OR 0.6, 95%CI 0.4-0.9) and from 14.1% (26/184) to 8.1% (21/260) was found comparing the 2004-2007 cross section with the 2015-2018 cross section. No period effect of the career time prevalence was observed in the 2004-2007 cross section ($P_{trend} = 0.81$) or in the 2015-2018 cross section ($P_{trend}=0.22$) (Table S6a and S6b). No statistical difference between the samples was observed, in the proportion having onset during apprenticeship (OR 0.7, 95%CI 0.3-1.7), in the number of years in the profession until onset (median 1.0 year, P=0.53) of OHE or in the frequency of HE (Table 2, Table S2).

No pronounced difference in the proportion that had been patch tested (OR 1.5, 95%CI 0.8-2.7) or in the proportion that had a positive (OR 1.4 (95%CI 0.7-2.8)) or a negative patch test (OR 1.4, 95%CI 0.6-3.1) was found. The proportion with a positive patch test that were sensitized to *hair*

dyes decreased from 65.0% (13/20) in the 2004-2008 to 19.0% (4/21) in the 2015-2018 cross section, respectively (OR 0.2 (95%CI <0.1-0.6) (Table 2).

3.3. Quantification of work tasks and skin hazardous exposures

The frequencies of the work tasks performed in the week prior to answering the questionnaire are summarized in Table S3. A decrease in the proportion of current hairdressers having performed full head hair colouring with permanent hair dyes (from 85.7% (150/175) to 73.8% (158/214) (OR 0.5 (95%CI 0.3-0.8)), highlights with cap (from 51.7% (89/172) to 25.8% (55/213) (OR 0.3 (95%CI 0.2-0.5)), root growth colouring (from 94.6% (141/149) to 71.1% (150/211) (OR 0.1 (95%CI 0.1-0.3)) and permanent waves (from 54.0% (94/174) to 31.8% (68/214) (OR 0.4 (95%CI 0.3-0.6)) from 2004-2007 to 2015-2018 was found. Despite no statistical difference in the proportion of hairdressers performing the tasks, a decrease in the number of times hair washes and (P=0.04) and colouring of eyelashes/eyebrows (P=0.03) performed per week was found.

3.4. Logistic regression: risk of OHE adjusted for changes in the prevalence of AD and skin exposures

A logistic regression model with the outcome of career time OHE (yes/no), adjusted for sex (male/female), age (21-30/31-40/>40) and a history of atopic dermatitis (yes/no) found the aOR of having had OHE in the 2015-2018 cross section to be 0.55 (95%CI 0.40-0.77) compared to the 2004-2007 cross section. The same model, but with the 1-year prevalence and point prevalence as the outcome found an aOR of 0.61 (95%CI 0.42-0.90) and 0.51 (95%CI 0.28-0.94) respectively. By additionally adjusting for non-participation an aOR of 0.54 (95%CI 0.38–0.75), 0.62 (95%CI 0.42–0.92) and 0.52 (95%CI 0.27–0.98) was obtained for the career time prevalence, the 1-year prevalence and the point prevalence, respectively.

To account for changes in exposure, a logistic regression model with current OHE (yes/no) as the outcome, adjusted for sex, age and a history of AD and significant changes in the proportion of current hairdressers having performed work tasks (full head hair dye with permanent, highlights with cap, root regrowth colouring and permanent waving) (table 3S) as well as significant changes in domestic exposure (cleaning and taking care of children <4 years of age) (table S4) was performed on current hairdressers. This yielded an aOR 0.31 (95%CI 0.12-0.95) if graduating from 2015-2018 compared to 2004-2007.

3.5. Compliance to skin protection programme among current hairdressers

3.5.1 Protective gloves

Almost all current hairdressers in both samples reported to use protective gloves (98.1% (455/462) at work (OR 1.6, 95%CI 0.4-7.4) (table 3). The proportion wearing gloves >4 hours/day increased from 2.0% (4/200) to 9.7% (24/248) (OR 5.3, 95%CI 1.8-15.4) and the proportion wearing gloves 0.5-1 hours/day increased from 13.0% (26/200) to 21.0% (52/248) (OR 1.8, 95%CI 1.1-3.0)., while a simultaneous decrease in the proportion wearing gloves 2-3 hours/day from 37.5% (75/200) to 26.2% (65/248) (OR 0.6, 95%CI 0.4-0.9) was found.

3.5.2 Glove use in relation to exposure

An increase in the proportion reporting always using gloves was seen for the following tasks: performing shampoos before cutting hair, performing shampoos after hair dying/perming, performing permanent waves, dying eyebrows/lashes and mixing hair dyes (table 3, figure 2). The most notable increases in glove use were seen for colouring eye lashes/eyebrows (from 0.7% to 13.2%, OR 21.0 (95%CI 2.8-157.7) and for shampoos (from 12.6% to 62.9%, OR 11.8 (95%CI 6.8-20.3) and for shampoos after hair dyeing/perming (from 57.5% to 90.0%, OR 6.8 (95%CI 3.9-12.0). As almost all hairdressers always used gloves when doing full head hair dying in both cross sections, limited room for improvement was available. More hairdressers wore gloves when mixing hair dyes, increasing from 10.9% to 23.2% (OR 2.5, 95%CI 1.3-4.7).

3.5.3 Glove types

A shift in the glove types used towards nitril gloves and away from polyvinylchloride (PVC) and natural rubber latex (NRL) gloves was noted (Table 3). The proportion using nitril gloves increased from 21.0% (38/181) to 74.0% (182/246) (OR 10.7, 95%CI 6.8-16.9), while a decrease in the proportion using PVC gloves from 52.5% (95/181) to 12.2% (30/246) (OR 0.1, 95%CI 0.1-0.2) and NRL gloves from 21.0% (38/181) to 3.3% (8/246) (OR 0.1, 95%CI 0.1-0.3) was evident. No statistical difference was seen in the proportion using polyethylene (PE) (0.5% (1/181) in the 2004-2007 sample and 0.0% (0/246) in the 2015-2018 sample, P = 0.24) gloves or rubber household gloves (OR 0.7, 95%CI 0.1-3.7). These gloves types were used by 0.2% (1/427) and 0.5% (2/427) in total, respectively.

3.5.4 Correct glove use

Hairdressers are advised not to reuse disposable gloves. The proportion using a new pair of disposable gloves all the time increased from 86.8% (177/202) to 94.0% (234/248) (OR 2.4, 95%CI 1.2-4.7). Hairdressers are additionally advised not to wear rings at work, to avoid compromising the fit of protective gloves. No statistical difference in the proportion of hairdressers wearing rings at work was found, being 32.9% (69/210) and 36.5% (96/263) (OR 1.2, 95%CI 0.8-1.7) in the 2004-2007 and the 2015-2018 cross section respectively. Hairdressers are further advised to use gloves if necessary but as brief as possible, to use cotton gloves underneath disposable gloves and to use protective gloves when doing wet work in their spare time. Information on self-reported compliance to these recommendations are only available for the 2015-2018 cross section being 91.2% (229/251), 0.4% (1/250) and 40.2% (100/249), respectively.

3.6 Other protective measures

In total, 90.7% (420/463) of current hairdressers in both samples use moisturizer on their hands, with no statistical difference in the prevalence and frequency of use comparing the two samples (table S5). Information on whether the moisturizer was unscented was only available for the 2015-2018 sample, with 65.0% (147/226) stating that their moisturizer did not contain perfume. No statistical difference was observed in the proportion using ventilation when mixing hair dyes. Information of whether hairdressers cut the hair before dying the hair or use warm gloves when cold outside, were only available for the 2015-2018 cross section with 55.9% (142/254) and 92.3% (230/249) being compliant to these measures, respectively.

4. Discussion

In this study we compared hairdressers trained before and after implementation of an evidencebased skin protection program in Danish hairdressing vocational schools. The IRR of OHE comparing hairdressers being trained before and after implementation was 0.73, corresponding to a decrease in the career time prevalence from 42.8% to 29.0%. Regression analysis adjusted for the decreased proportion of hairdressers with a history of AD and statistically significant changes in occupational exposures, supported these findings, yielding an almost halved risk of OHE if trained after implementation. The adjusted regression model left enrolment in the program as a primary difference when comparing hairdressers trained before and after implementation, indicative of the

79

decreased IR of OHE to be a result of improved compliance with skin protective measures. A recent systematic review¹⁴ of HE in the general population, found no decrease in the lifetime prevalence when comparing studies published before and after 2007, suggesting that the decreased career prevalence observed in our study not being due to general factors protecting against HE in the general population. Additionally, a recent study¹⁵ found a decrease in the IR of recognized OHE in Danish hairdressers from 2012 onwards (IRR 0.64), while no simultaneous decrease were seen for other wet-work occupations, further suggesting that the decreased risk of OHE if trained after implementation of the skin protection program likely being due to an increase in compliance with skin protective measures.

The intervention study in 2008¹⁰ initially testing the skin protection program, found a decreased risk of HE in hairdressing apprentices at an 18-month follow-up (aOR 0.59). However, a 6-year followup study¹⁶ of the intervention group (performed 7.5 years after beginning apprenticeship, including the initial 18-month follow-up) no longer found an effect in terms of prevalence of HE. This is worrisome as compliance with skin protective measures may not translate into safe practice once working in salons. The lack of effect was explained by the authors to be due to the study populations no longer being well matched since an improvement in work habits was still visible. Our study population was examined 6-9 years from beginning apprenticeship, thus evaluating the effect of the skin protection program in the same timeframe as the 6-year follow-up study. We found both a decrease in the IR of OHE and an improvement in work habits, suggesting that this interpretation was correct. Furthermore, the decreased risk of having HE in the initial intervention study is fairly similar to the decreased risk of career time OHE in our study (aOR 0.55). Therefore, by bridging our findings with the findings of the initial intervention study, the positive effect of the skin protection program does seem to be visible both during apprenticeship and in the early years as a professional (6-9 years from beginning apprenticeship). It has previously been shown² that >90% of hairdressers with OHE have had onset within 8 years from beginning apprenticeship. Thus, the career time prevalence of OHE found in hairdressers graduating after implementation (29.0%) may approximate the actual long-term prevalence. This hypothesis is supported by the career time prevalence found in hairdressers trained before implementation (42.8%) to be similar to estimates reported in other studies¹. In conclusion, skin protection training in hairdressing vocational schools does not seem to postpone onset of OHE, but rather to be an effective measure of primary prevention.

Prevention of occupational hand eczema in hairdressers have so far mainly focused on secondary and tertiary prevention. In Germany, a tertiary individual prevention program (TIP) has since 1994 been offered to patients, including hairdressers with OHE¹⁷. The TIP consists of a combination of inpatient rehabilitation and long-term outpatient dermatological treatment and support. In 2005, a secondary individual prevention program (SIP) was added to this prevention scheme. The SIP aims to achieve remission at an early disease stage by improving disease management particularly through patient education. Both the TIP¹⁸ and the SIP¹⁹ have been shown effective in helping hairdressers with OHE to remain in the profession. The positive results of the SIP are interesting, since patient education on disease management and prevention is an essential part of the program. Thus, not only is patient education on skin protection effective as secondary prevention, but also as primary prevention in hairdressing apprentices as indicated by our results. The lack of skin education in hairdresses.

Finally, the 2015-2018 cross section comprises hairdressers graduating after the initial roll-out of the skin protection program, but before the Danish executive order on hairdressers vocational training was updated, requiring hairdressing apprentices to pass both a written exam on the chemical work environment and showcase compliance with preventive measures during the final apprenticeship exam. Despite observing a halved risk of OHE if trained after the implementation of the skin protection program, about 1 in 3 hairdressers still had OHE. Thus, there is still a room for improvement. The introduction exams relating to the skin protection program is potentially the key to a further reduction in incident OHE in hairdressers.

5. Strengths and Limitations

The differing response rates in each cross section potentially reflect differential selection bias in the two samples. However, regression analysis adjusted differential participation in the two samples did not alter the risk of OHE. The reason for the differing response rates is not known, but generally response rates to surveys have been declining in the past decades.²⁰ Compliance with skin protective measures is only known for current hairdressers, while ex-hairdressers that have left the trade because of HE (potentially caused by poor compliance to skin protective measures) do not show in our results. We may therefore overestimate the effect of the skin protection program. However, the initial intervention study that both had a matched control group and track of dropouts,

found a similar decrease in the risk of HE suggesting that our findings despite these limitations are fairly accurate. The questionnaires were sent in May 2009 and May 2020. In Denmark there was a COVID19-lockdown of hairdressers from the 16th of March to the 19th April 2020. The questionnaire was sent on the 19th of May 2020, one month after the reponing of hairdressers. If the period following the lockdown was extra busy for hairdressers, a potential bias in the prevalence of hand eczema would be expected to tilt towards an increase. As we documented a decreased prevalence following the intervention, this was not of immediate concern. Further, since most hairdressers develop hand eczema during apprenticeship, a one-month lock down of fully trained hairdressers would not be expected to cause the decreased prevalence observed in our study. Our study benefit from being register-based which provide certainty of the graduation year and a reliable estimate of the risk time for each hairdresser provided by the ATP. It was therefore possible to compare two identical cross-sections of hairdressers trained before and after implementation and adjust for time worked in the trade. Additionally, self-assessment of hand eczema in hairdressers using the NOSQ-2002 have previously been validated to have a sensitivity of 70.3% and a specificity of 99.8% why comparison with identical questionnaires seemed reasonable.^{21,22}

6. Conclusion

Our data suggest that skin protection training during apprenticeship reduces the risk of OHE in hairdressers. The lack of primary prevention of OHE in hairdressing vocational schools may be a missed opportunity in the prevention of the disease.

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Figures legend



Figure 1. Study design. A comparison of hairdressers trained before (2004-2007) and after (2015-2018) implementation of a nationwide skin protection program in 2011 was done. A questionnaire was sent to the 2004-2007 and 2015-2018 cross sections in 2009 and 2020 respectively. Longitudinal lines illustrate years as a hairdresser since graduation (blue: 2004-2007, green: 2015-2018).



Figure 2. Compliance with glove use in relation to work tasks. Proportion of hairdressers who reported to *always* use gloves for specific tasks, among hairdressers who had performed the respective task the previous week prior to answering the questionnaire.

	2004-2007	2015-2018	Total	2015-2018 vs. 2004-2007
Female	96.2% (293/305)	96.7% (351/363)	96.4% (644/668)	OR 1.2 (95%CI 0.5-2.7)
Age				
21-30	83.6% (255/305)	88.2% (302/363)	83.3% (557/668)	
31-40	14.4% (44/305)	10.5% (38/363)	12.3% (82/668)	$P_{trend} = 0.14$
>40	2.0% (6/305)	1.4% (5/363)	1.6% (11/668)	
History of atopic dermatitis	10.6% (32/302)	6.3% (23/363)	8.3% (55/665)	OR 0.6 (95%CI 0.3-1.0)
Ex-hairdressers	30.5% (93/303)	27.3% (99/363)	28.8% (192/666)	OR 0.8 (95%CI 0.6-1.2)
Years worked in the trade				
Min	3.0	1.0	1.0	
Q1	6.0	6.0	6.0	Mann-Whitney U test.
Median	7.0	7.0	7.0	P<0.001
Q2	9.0	8.0	8.0	
Max	11.0	11.0	11.0	

Table 1. Baseline characteristics of the study population. OR: odds ratio, CI: confidence interval. Bold fond indicates P<0.05.

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	2004-2007 % (n/n _{total})	2015-2018 % (n/n _{total})	Total % (n/n _{total})	2015-2018 vs. 2004-2007
Incidence rate of OHE /1000 person years	57.5 (48.4-68.4)	42.0 (34.6-50.9)	49.4 (43.4-56.2)	Incidence rate ratio 0.73 (0.56-0.95)
OHE	% (n/n _{total})	% (n/n _{total})	% (n/n _{total})	OR (95%CI)
Career time	42.8 (128/299)	29.0 (102/352)	35.3 (230/561)	0.5 (0.4-0.8)
1-year (before survey)	33.9 (81/239)	23.9 (75/314)	28.2 (156/553)	0.6 (0.4-0.9)
Point (at survey)	14.1 (26/184)	8.1 (21/260)	10.6 (47/444)	0.5 (0.3-1.0)
Among hairdressers with OHE				
Time to first onset of OHE (median (95%Cl)	1.0 (0.47-1.53)	1.0 (0.42-1.58)	1.0 (0.61-1.39)	P=0.53
Frequency of hand eczema				
Once	21.1 (27/128)	25.7 (26/101)	23.1 (53/229)	1.3 (0.7-2.4)
Several times	57.0 (73/128)	54.5 (55/101)	55.9 (128/229)	0.9 (0.5-1.5)
Almost all the time	21.9 (28/128)	19.8 (20/101)	21.0 (48/229)	0.9 (0.5-1.7)
History of atopic dermatitis	44.9 (57/127)	34.3 (35/102)	40.2 (92/229)	0.6 (0.4-1.1)
Patch test				
Never	73.6 (92/125)	65.0 (65/100)	69.8 (157/225)	0.7 (0.4-1.4)
Negative	10.4 (13/125)	14.0 (14/100)	12.0 (27/225)	1.4 (0.6-3.1)
Positive	16.0 (20/125)	21.0 (21/100)	18.2 (41/225)	1.4 (0.7-2.8)
Patch test results				
Perfume	15.0 (3/20)	9.5 (2/21)	12.2 (5/41)	0.6 (0.1-4.0)
Preservatives	20.0 (4/20)	9.5 (2/21)	14.6 (6/41)	0.5 (0.1-2.9)
Hair dyes	65.0 (13/20)	19.0 (4/21)	41.5 (17/41)	0.2 (0.0-0.6)
Nickel	50.0 (10/20)	33.3 (7/21)	41.5 (17/41)	0.6 (0.2-2.1)

Evidence-based skin protection	Response	2004-2007	2015-2018	Total	2015-2018 vs. 2004-
program		% (n/n _{total})	% (n/n _{total})	% (n/n _{total})	2007 OR (95%CI)
Do you use gloves at work? (yes/no)	Yes	98.1 (204/208)	98.8 (251/254)	98.5 (455/462)	1.6 (0.4-7.4)
	>4	2.0 (4/200)	9.7 (24/248)	6.3 (28/448)	5.3 (1.8-15.4)
	>3- <4	14.0 (28/200)	10.5 (26/248)	12.1 (54/448)	0.7 (0.4-1.3)
How many hours do you wear	2-3	37.5 (75/200)	26.2 (65/248)	31.3 (140/448)	0.6 (0.4-0.9)
gloves at work	>1- <2	29.5 (59/200)	29.0 (72/248)	29.2 (131/448)	1.0 (0.6-1.5)
	0.5-1	13.0 (26/200)	21.0 (52/248)	17.4 (78/448)	1.8 (1.1-3.0)
	<0.5	4.0 (8/200)	3.6 (9/248)	3.8 (17/448)	0.9 (0.3-2.4)
	Nitril	21.0 (38/181)	74.0 (182/246)	51.5 (220/427)	10.7 (6.8-16.9)
	Latex	21.0 (38/181)	3.3 (8/246)	10.8 (46/427)	0.1 (0.1-0.3)
What type of gloves do you typically	Vinyl	52.5 (95/181)	12.2 (30/246)	29.3 (125/427)	0.1 (0.1-0.2)
use at work?	Polyethylene	0.6 (1/181)	0.0 (0/246)	0.2 (1/427)	NA
	Household rubber	0.6 (1/181)	0.4 (1/246)	0.5 (2/427)	0.7 (0.0-11.8)
	Other	1.7 (3/181)	1.2 (3/246)	1.4 (61/427)	0.7 (0.1-3.7)
	Don't know	2.8 (5/181)	8.9 (22/246)	6.3 (27/427)	3.5 (1-3-9-3)
Disposable gloves must be clean, new	r, and dry/never reuse disposition	able gloves			
Do you use new gloves every time? (yes/no)	Yes	86.8 (177/202)	94.0 (234/248)	91.3 (411/450)	2.4 (1.2-4.7)
Use gloves when you wash dye, bleac	h, and perm				
At which task do you always use aloves?	Hair wash before cutting the hair	12.6 (21/167)	62.9 (122/194)	39.6 (143/361)	11.8 (6.8-20.3)
Claus uno amona hairdannar urbo	Hair wash after hair dying	57.5 (96/167)	90.0 (175/194)	75.1 (271/361)	6.8 (3.9-12.0)
had performed the respective tasks	Full head colouring	99.3 (149/150)	97.4 (151/155)	98.4 (300/305)	0.3 (0.0-2.3)
in the past week.	(permanent hair dyes)				
Hairdressers are advised to use	Full head colouring (semi- permanent hair dyes)	97.2 (106/109)	96.5 (109/113)	96.8 (215/222)	0.8 (0.2-3.5)
gloves when they wash, bleach, dye, and perm.	Colouring of evebrows/lashes	0.7 (1/139)	13.2 (23/174)	7.7 (24/313)	21.0 (2.8-157.7)
	Mixing hair dyes	10.9 (16/147)*	23.2 (36/155)*	17.2 (52/302)	2.5 (1.3-4.7)

Table 3. Compliance with the evidence-based skin protection program: advice related to glove use. NA: not available for the 2004-2007 cross section. OR: odds ratio, CI: confidence interval. NA: not applicable. Bold fond indicates P<0.05.

*Based on those who performed full	Bleaching	93.1 (54/58)	85.2 (52/61)	89.1 (106/119)	0.4 (0.1-1.5)
head colouring with permanent hair	Highlights (with cap)	69.3 (61/88)	70.4 (38/54)	89.1 (106/119)	1.1 (0.5-2.2)
dyes.	Highlights (with foil)	43.8 (67/153)	50.3 (96/191)	47.4 (163/344)	1.3 (0.8-2.0)
	Permanent waves	37.4 (34/91)	76.1 (51/67)	53.8 (85/158)	5.3 (2.6-10.8)
	Cutting the hair	0.0 (0/161)	3.2 (6/190)	1.7 (6/351)	NA
Use gloves for as long as necessary, bu	ıt as brief as possible				
	Always	NA	64.5 (162/251)	NA	NA
Do you use disposable gloves if	More than half the time		13.9 (35/251)	NA	NA
necessary, but as shortly at	Half the time		8.0 (20/251)	NA	NA
possible?	Less than half the time		4.8 (12/251)	NA	NA
	Never		8.8 (22/251)	NA	NA
Use cotton gloves underneath protective gloves					
Do you use cotton gloves underneath disposable gloves? (yes)	Yes	NA	0.4 (1/250)	NA	NA

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13. Appendix

Definition of outcome variables

Outcome	Questionnaire	e item	Definition of outcome	Prerequisite	Used	in manus	cript
	Questionnaire I	Questionnaire II			-	=	≡
Occupational status							
To have left the	What is your current occupation? (I work as a	Identical	2 nd response option	None	×	×	×
hairdressing trade	hairdresser/ <u>I no longer work as a hairdresse</u> r)						
To have left the trade	What were the reasons you left hairdressing?	Identical	1 st response option	To have left the		×	
hairdressing trade	(hand eczema/asthma/allergy/musculoskeletal			hairdressing			
(partly) because of hand	complaints/multiple chemical sensitivity/other			trade			
eczema	disease/pregnancy (physical						
	complaints)/pregnancy (chemicals)						
A history of atopic							
dermatitis							
	Have you ever had itchy skin, causing you to	Not included (available from 2009 study)	The major criterion plus	None	×		
	scratch or rub a lot? (<u>yes</u> /no) (major criterion)		<u>two</u> or more minor				
	How old were you when this skin condition		criteria				
	started? (<u><2 years</u> /2-5 years/6-10 years/>10 years)						
	(minor criterion)						
	Has the skin condition ever affected skin in the						
	folds of elbows, behind knees wrists or around the						
	eyes? (yes/no) (minor criterion)						
	Do you tend to have dry skin? (<u>yes</u> /no)		The major criterion plus	None		×	×
	Has a doctor ever told you that you have hay		three or more minor				
	fever? (yes/no) (minor criterion)		criteria				
	Has a doctor ever told you that you have asthma?						
	(yes/no) (minor criterion)						
Hand eczema							
To ever have had hand eczema	Have you ever had hand eczema (<u>ves</u> /no)		1 st response option	None	×	×	×
To have had hand		Have you had hand eczema, since 2009?	1 st response option	None	×	×	
eczema during follow-up		(yes /no)					

To have had hand	When did the last have hand eczema? (<u>I have it</u>	Identical	1^{st} to 3^{rd} response option	To have had			
eczema within 1 year	currently/not currently, but <3 months ago/3-12 months ago/>12 months ago)			hand eczema			
To have hand eczema currently	When did the last have hand eczema? (<u>I have it</u> <u>currently</u> /not currently, but <3 months ago/3-12 months ago/>12 months ago)	Identical	1st response option	To have had hand eczema	×	×	×
Frequency of hand	How often have you had eczema on your hands?			To have had	×	×	×
eczema	(once, but less than 2 weeks/once, more than 2			hand eczema			
	weeks/several times/almost all the time)						
Frequency of hand		How often have you had hand eczema,		To have had	×	×	
eczema within follow-up		since 2009? (once, but less than 2		hand eczema			
		weeks/once, more than 2 weeks/several times/almost all the time)		during follow-up			
Occupational hand	When you had first onset of hand eczema, where	Identical	2 nd or 3 rd response	To have had	×	×	×
eczema	you then a? (shampoo assistant/ <u>hairdressing</u>		option	hand eczema			
	apprentice/fully trained hairdresser/other)						
First onset of hand	When did you have hand eczema the first time?	Identical		To have had	×		
eczema	(give year)			hand eczema			
Contact allergy							
To have been patch	Have you ever been tested with a patch test on	Have you been tested with a patch test on		None	×	×	×
tested	your back? (<u>yes</u> /no)	your back, since 2009? (<u>yes</u> /no)					
To have contact allergy	What was the results? (no allergy/allergy to	Identical	Second to eighth	To have been	×	×	×
	perfume/ allergy to nickel/ allergy to hair allergy to		response option	patch tested			
	dye/ allergy to preservatives/allergy to						
	acrylates/other allergy)						
Occupational exposures							
(current hairdressers)							
Wet work	How many hours do you have wet hands during a	Identical	5^{th} to 7^{th} response option		×		
	workday? This includes shampooing, cutting wet		cumulated (>2 hours per				
	hair and cleaning. (never/<0.5 /0.5-1/>1 but <2/2-		day)				
	3/>3 but <4/≥4)						
Exposure to specific work	How many times in the past week have you	Identical	To have performed a				×
--	--	-----------	--------------------------	----------------------------	---	---	---
tasks	performed? (fill in number for the respective task):		task ≥1 time in the past				
	 shampooing 		week				
	 cutting wet hair 						
	 Cutting wet hair after hair dying 						
	 Full head hair colouring (permanent) 						
	 Full head hair colouring (semi- 						
	permanent)						
	 Colouring of eyebrows/lashes 						
	 Mixing hair dyes 						
	Bleaching						
	 Highlights (with cap) 						
	Highlights (with foil)						
	 Permanent waves 						
	Cutting the hair						
Compliance with glove					-	-	
use (current hairdressers)							
To use gloves at work	Do you use gloves at work? (<u>yes</u> /no)	Identical	1^{st} response option	None			×
To use gloves when	At which task do you always use gloves?	Identical		To use gloves at			×
washing, bleaching, dyeing, and perming	(Hair wash before cutting the hair/ Hair wash after hair dying or perming/ Full head colouring			work <i>and</i> To have			
	(permanent hair dyes)/ Full head colouring (semi- permanent hair dyes)/ Bleaching/ Highlights (with			performed the			
	cap)/ Highlights (with foil)/ Permanent waves/ Cutting the hair/ Colouring of evebrows/lashes/			task in the week			
	Mixing hair dyes)			prior			
Cut before you dye the hair	Do you cut the hair before dyeing it? (<u>yes</u> /no)	Identical	1^{st} response option				×
	What type of gloves do you typically use at work?			To use gloves at			×
	(vinyr)/iatex/nitrin/polyetnyrene/rubber/otner/don t know)			NIOW			

Mix in a separate	Do you use ventilation when you mix hair dyes?	Identical	1^{st} to 5^{th} response option	None	 ×
ventilated cabinet	(yes, every time/yes, more than half the times/yes,				
	half the times/yes, less than half the times/no,				
	never)				
	Do you use new gloves every time? (yes/no)	Identical	1^{st} response option	To use gloves at	×
Disposable gloves must				work	
be clean new and dry					
	Do you turn your gloves inside out and reuse	Identical	1^{st} response option	To use gloves at	×
Never reuse disposable	them? (yes/no)			work	
gloves					
Use cotton gloves	Do you use cotton gloves underneath protective	Identical	1 st to 4 th response option	To use gloves at	×
underneath protective	gloves? (yes, always/more than half the times/half			work	
	the times/less than half the times/never)				
gloves					
Use gloves as long as	Do you use gloves as long as necessary, but as	Identical	1^{st} to 4^{th} response option	To use gloves at	×
necessary but as shortly	snoruy as possibler (always/more than hall the times/half the times/less than half the			work	
as possible.	times/never)				
Use an unscented lipid	Do you use moisturizer on the hands? (yes, several	Identical	1^{st} to 4^{th} response option	None	×
rich moisturizer	times a day/yes, once a day/yes, more rarely/no,				
	never)				
Do not wear rings when	Do you wear finger rings on while working? (yes,	Identical	1 st to 4 th response option	None	×
you work	every day/yes, several times a week/yes, once a				
•	week/yes, but more rarely than once a week/ no,				
Use gloves when doing	Do you use gloves when doing wet work in your	Identical	1 st to 4 th response option	None	×
wet-work in your spare	spare time? (yes, all the time/more than half the				
	time/haif the time/less than haif the time/hever)				
amu					
Use warm gloves when it	Do you use warm gloves when outside in cold	Identical	1^{st} to 4^{th} response option	None	×
is cold outside.	weather? (yes, an the time/more than hay the time/half the time/less than half the time/never)				



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