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Differences between hairdressers and consumers in skin exposure to hair cosmetic products: a review

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Abstract and keywords

Hairdressers are at high risk of developing occupational hand eczema. Opinions on the health and safety concerns of non-food consumer products, such as cosmetics and their ingredients, consider the exposure of a ‘common consumer’, which may not account for occupational exposure of hairdressers. As result, there is a parlous scenario in which serious safety concerns about occupational exposures are present. The purpose of this review is to compare the frequency of exposure to various types of hair cosmetic products among hairdressers and consumers. Database searches for this review yielded a total of 229 articles. 7 publications were ultimately included. The analysis showed that – dependent on the task – hairdressers were exposed 4 to 78 times more than consumers regarding a wide spectrum of hair cosmetic products used in the daily working life ranging from shampoo, conditioner, oxidative and non-oxidative hair colours, and bleaching agents. The highest frequency was found for colouring hair with oxidative hair colour. Consumer usage frequency does not appear to be appropriate for representing hairdresser exposure. The current standards do not effectively address the occupational risks associated with hairdressers’ use of cosmetics. The findings of this study should cause current risk assessment procedures to be reconsidered.

Keywords: contact dermatitis, exposure, hairdressers, occupational, occupational diseases, skin diseases

1 Introduction

Hairdressers are subjected to a high degree of occupational skin strain within their professional surroundings, mainly arising from frequent wet work and skin contact to detergents and hairdressing chemicals.¹⁻³ This occupational skin exposure may lead to adverse skin reactions of irritant and/or allergic nature. Thus, prevalence of occupational dermatoses, mostly hand eczema, is very high in hairdressers causing personal suffering due to illness as well as high financial burden due to health expenditures for society.^{4,5}

In the European Union (EU), utilisation of carcinogenic, mutagenic, or substances toxic for reproduction (CMR) in cosmetic products is restricted by the so-called Cosmetics Regulation, which however allows exceptions to this basic principle, making it possible to use such substances in cosmetic products after adequate safety assessment and appropriate risk management (mostly, maximum permissible concentrations).⁶ The Scientific Committee on Consumer Safety (SCCS) elaborates opinions on health and safety risks of non-food consumer products, including cosmetic products and their ingredients, whereby the exposure to such products by a ‘common consumer’ is taken into account. Such typical exposure is outlined in the SCCS ‘Notes of Guidance’ (NoG)⁷ which, in turn, are based on empirical data on product use in consumers.^{8,9} The exposure of hairdressers – who are subjected to such substances throughout their daily working life – is however not considered in the process of the evaluation of the SCCS leading to opinions which may not adequately address occupational exposure of hairdressers. This leads to the precarious situation that grave safety concerns with regard to occupational exposures remain.

Against this background, the objective of the present paper is to examine the frequency of exposure – as reported in literature – to important types of hair cosmetic products as well as of wet work in hairdressers compared to non-hairdressers, termed ‘consumers’ (representing ‘clients’) or ‘self-users’.

2 Methods

2.1 Hairdressers’ exposure

Literature searches were performed in February 2021. The time period from 1990 to 2020 was taken as eligible publication period. We systematically searched for ((Hairdressers* OR Hairdressing apprentice*) AND (skin) AND (exposure*)) in Pubmed/Medline and Web of Science–Core Collection (WoS). Only English search terms were used. Search results were

exported from Medline and WoS in a suitable format and imported into Zotero libraries, documenting the number of references contributed by each ex-/import set. In the Zotero library, bibliographical duplicates were identified and the entry including less information (e.g. no abstract) were discarded. The remaining unified library was exported in Research Information System Format (RIS) and imported into a new Rayyan (Rayyan QCRI) project by a reviewer for eligibility based on title, key words and abstract. The final set of references eligible for full text screening was exported from Rayyan in Bibtex format for import into the Zotero cloud-based reference database, after the initial set of references was archived.

2.2 Consumers' exposure

Typical use frequencies of hair cosmetics by consumers (when normally applied by professionals in a hairdressing salon) and self-users (when applying hair cosmetics at home) have been considered together. Some products are usually applied only in a hair salon (e.g. waving agents or hair relaxers), others frequently at home (e.g. shampoos and oxidative or non-oxidative hair colours). Data on consumers' exposure mainly was taken from the NoG, as far as available, which refer back to Hall *et al.* (2007) as well as Hall *et al.* (2011),^{8,9}, who suggest a framework for conducting population exposure assessments regarding European consumer exposure to cosmetic products.

2.3 Data extraction

In a first step we extracted data on hairdressers' exposure including frequency of procedures using corresponding products, mean duration of procedures, the share of hairdressers who usually conduct the respective procedure and the share of hairdressers usually wearing gloves whilst conducting the respective procedure. Regarding consumers' exposure, frequency of procedures using corresponding products, mean duration of procedures, and the share of people who usually conduct the respective procedure were extracted. Study characteristics (type of investigation, country, study design/method, study population, age range and sex of the study population) of the included studies were recorded using a publication record form (PRF).

For hairdressers, data on exposure was extracted from the respective studies. Data on mean duration of procedures, data on the share of hairdressers who usually conduct the respective procedure, and data on the share of hairdressers usually wearing gloves whilst conducting the respective procedure was taken from Uter *et al.* (1998),¹⁰ who assessed risk factors for hand dermatitis in a cohort of hairdressing apprentices.

In a second step, the aforementioned data was condensed and has undergone further refinement. For displaying the frequency of procedures using certain products we decided to use median values for data obtained in hairdressers. In order to provide greater clarity, we extracted the mean duration of procedures for hairdressers and consumers as well as the share of hairdressers and consumers who usually conduct the respective procedure. All procedures usually only performed by hairdressers were discarded since these cannot be compared to consumers regarding exposure. The following procedures were taken out of further consideration: cutting wet hair (without previous colouring), cutting wet hair (after colouring), highlighting the hair (mostly using bleach with 6-9% hydrogen peroxide) and lowlighting (mostly using oxidative hair colour with 6% hydrogen peroxide) the hair using foil, highlighting the hair (mostly using bleach with 6-9% hydrogen peroxide) and lowlighting (mostly using oxidative hair colour with 6% hydrogen peroxide) the hair using a cap, perming the hair using waving/perm lotion (acid, alkaline, and exothermic perms), colouring eyelashes and/or eyebrows with oxidative hair colour using mostly 3% hydrogen peroxide).

2.4 Daily exposure doses per area

From the included studies, data on frequency of use were available. However, the most relevant dose-metric for risk assessment concerning skin sensitization is the dose per area. Hence, information about daily exposure doses per skin area were calculated with the following calculation formula:

$$(amount / skin surface area) \times daily exposure frequency$$

Data on the amount is taken from the SCCS Notes of Guidance (NoG) for the testing of cosmetic ingredients and their safety, 11th revision⁷ which refer back to Hall *et al.* (2007)⁹, Hall *et al.* (2011)⁸, Colipa 16.01.97 BB-97/007¹¹, and the Scientific Committee on Cosmetic products and Non-Food Products intended for consumers (SCCNFP) SCCNFP/0321/00¹². Dose per area for hairdressers was calculated with the skin surface area (SSA) for hands (860cm²); dose per area for consumers (clients in a hairdressing salon) was calculated with the SSA for ½ head (580cm²). The aforementioned SSAs for application were indicated according to the NoG⁷ which refer back to Bremmer *et al.* (2006)¹³ and Bremmer *et al.* (2006)¹⁴. Data on daily exposure frequency was calculated from the respective information given in Table 2.

2.5 Exposure factor

The factor by which hairdressers are higher exposed as consumers was calculated using the following formula:

$$\frac{\text{frequency of exposure for hairdressers} + \text{frequency of exposure for consumers}}{\text{frequency of exposure for consumers}}$$

In the designed formula it was laid down that hairdressers additionally are subjected to an exposure as consumers themselves. Consumers' exposure is considered as reference exposure in this calculation. Data on exposure frequency regarding hairdressers was taken from the respective information given in Table 2. Frequency of exposure regarding consumers was taken from the NoG which refer back to Hall *et al.* (2007) as well as Hall *et al.* (2011).^{8,9}

3 Results

3.1 Study selection

A flow diagram of the study selection concerning hairdressers' exposure is presented in Figure 1. Initial searches generated 229 individual study records. After elimination of bibliographic duplicates, 170 references remained and were screened. Manual searching of references retrieved another 2 references. After elimination of publications irrelevant because they did not give details on the frequency of use of product categories, we arrived at a final number of 7 publications considered for this review.

3.2 Characteristics of included studies concerning hairdressers' exposure

3.2.1 Study types

The included studies covered a prospective population-based cohort study including a questionnaire survey combined with clinical examinations (n=1), an observational study (n=1), an observational study combined with a questionnaire survey (n=1), questionnaire surveys (n=2), and questionnaire surveys combined with clinical examinations (n=2). The study characteristics are summarised in a PRF and can be found in the appendix (Table A1).

3.2.2 Population studied

All studies either reported on the exposure of hairdressers (n=5) or hairdressing apprentices (n=2). Of the two studies reporting on hairdressing apprentices, one study only included final year hairdressing apprentices, who have an almost equal exposure in comparison to hairdressers

who have finished training, and one study included hairdressing apprentices from all three apprenticeship years (according to the German dual training system) so that it can be assumed that the exposure of the apprentices may be comparable to the exposure of trained hairdressers. Thus, hairdressing apprentices are counted as hairdressers in the present review.

The included studies were all conducted within the EU, namely in Finland (n=1), Sweden (n=1), Denmark (n=1), France (n=1), Croatia (n=1) and Germany (n=2). In 5 studies reporting on gender, the proportion of women amongst the study population was 89.0% (n=1), 95.7% (n=1), and 100% (n=3). Within 3 studies giving detailed information about the age of the participants, the age ranged from 15 to 54 years (n=1), 19 to 50 years (n=1), and 22 to 65 years (n=1).

3.2.3 Exposure studied

All of the 7 included studies provided details on the frequency of use of / quantification of exposures to hair cosmetic products in hairdressers.

3.3 Synthesis of results

3.3.1 Exposure to hair cosmetic products in hairdressers compared to consumers

Within the 7 reviewed studies, data on the 12 procedures alongside with concomitantly used product types were available. Most of the identified tasks are performed exclusively by hairdressers (Table 1). Data on hairdressers' exposure including frequency of procedures using corresponding products, mean duration of procedures, the share of hairdressers who usually conduct the respective procedure and the share of hairdressers usually wearing gloves whilst conducting the respective procedure as well as consumers' exposure including frequency of procedures using corresponding products, mean duration of procedures, and the share of people who usually conduct the respective procedure were extracted and summarised in Table A2.

Whilst shampooing/washing the hair, consumers and/or self-users are exposed to shampoo one time per day⁷, whereas hairdressers are exposed to shampoo for up to 12 times per day with a mean duration of 7.5 minutes for each washing procedure.^{10,15-19} The study by Uter et al. has shown that this task is done by 99.8% of hairdressers and that gloves – which should be used carrying out the task – are worn regularly by 23.9% of the hairdressers only.¹⁰ During deep conditioning the hair with hair conditioner, consumers and/or self-users are exposed to hair conditioning products 0.28 times per day²⁰ in contrast to hairdressers who are exposed to hair conditioners for up to five times per day with a mean duration time of 10 minutes plus possibly

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additional 12.5 minutes due to potentially following head massage each.^{10,17} Deep conditioning is done by 90.5% of hairdressers and 11.5% of hairdressers reported to wear gloves while doing this task; head massages are conducted by 91.7% of hairdressers and 8.4% of hairdressers wear gloves massaging the head.¹⁰ Cutting wet hair is done either without previous colouring or previous colouring. The former strategy avoids exposure of hairdressers to residual dye monomers, as it is known that coloured hair exposes hairdressers to substances released from the hair colour. Consumers as well as self-users are not exposed to wet hair during cutting hair. Hairdresser are exposed to wet, uncoloured hair for up to 9.9 times per day and to coloured hair for approx. 2 times per day with a mean duration of a haircut being 25.0 minutes each.^{10,15,17-19,21} 93.5% of the hairdressers conduct this task, and 1.3% of them use gloves for it.¹⁰

Regarding colouring the hair of the full head with permanent/oxidative hair colour using 6-12% hydrogen peroxide, consumers and/or self-users are exposed 1 time per month in contrast to hairdressers who are exposed to permanent/oxidative hair colour for up to 4 times per day.^{10,15-19,21} In terms of colouring the hair of a full head with semi-permanent oxidative hair colour using 2-3% hydrogen peroxide or non-oxidative hair colour, consumers or self-users are exposed 1 time per week regarding semi-permanent, non-oxidative hair colour and 1 time per month regarding semi-permanent oxidative hair colour, whereas hairdressers are exposed to such colouring agents for about 3 times per week.^{16,17} Whilst colouring roots/regrowth only using oxidative/non-oxidative hair colours according to previous treatment, consumers and/or self-users are exposed a maximum of 1 time per week regarding semi-permanent, non-oxidative hair colour and 1 time per month regarding semi-permanent oxidative hair colour in contrast to hairdressers who are exposed to the used agents approx. 3 times per week.¹⁷ The mean duration of each of the colouring services mentioned above is 15.0 minutes, and the services are conducted by 99.3% of the hairdressers, of whom 95.2% wear gloves during this task.¹⁰

There is no scientific data on consumers' exposure for highlighting the hair (mostly using bleach with 6-9% hydrogen peroxide) and lowlighting (mostly using oxidative hair colour with 6% hydrogen peroxide) the hair using (aluminium) foil and using a cap. Presumably, the aforementioned procedures are usually not conducted by self-users. Hairdressers, however, are reportedly exposed to bleach or oxidative hair colour while using foils for bleaching/colouring 1.2 times per week and while using a cap for bleaching/colouring 0.84 times per day.^{17,18} Also, scientific data on mean durations as well as the share of hairdressers conducting these tasks and wearing gloves while doing so are not available. For using bleach – mostly with 6-9% hydrogen

peroxide – for bleaching hair on the full head, data for consumers and/or self-users are not available. It nevertheless needs to be considered that for consumers/self-users the label *full head* only applies for first time bleaching, after that full head refers to root/regrowth only since already bleached hair cannot be bleached as often as desired in contrast to colouring the hair with oxidative or non-oxidative hair colours. In contrast, hairdressers are exposed to bleach – mostly using 6-9% hydrogen peroxide – whilst bleaching the hair of the full head or also the root/regrowth 2.5 times per day with a mean duration of 15 minutes for each procedure, which is done by 96.9% of hairdressers, of which 77.9% wear gloves meanwhile.^{10,16,21}

For perming the hair, data for consumers' exposure is lacking and self-use is highly unlikely. Hairdressers, in contrast to consumers, are exposed to different types of perming lotions (acid, alkaline, and exothermic perms) and apply perming solutions 2 (acid perm) to 3 (alkaline perm) times a day with a mean duration of 5.0 minutes per procedure (acid and alkaline perm) conducted by 44.3 (alkaline perm) and 97.5% (acid perm) of hairdressers whilst 29.2% (alkaline perm) and 34.7 (acid perm) wear gloves in each perm solution appliance process.^{10,15,17}

Exposure data on colouring eyelashes and/or eyebrows has only been laid out in one study, revealing that hairdressers are exposed to oxidative hair colour using mostly 3% hydrogen peroxide conducting this task 0.8 times per day with no further specification on mean duration, share of hairdressers conducting this task and share of hairdressers wearing gloves while carrying out the task.¹⁷ For consumers, there is no data available for this exposure; self-use, however, is very rare.

Table 2 summarises data on the daily dose per area and the exposure factor by which hairdressers are higher exposed to hair cosmetic products than consumers. For washing the hair with shampoo, the dose per area is 60.81395 to 145.95349 mg/cm²/day for hairdressers and 18.03448 mg/cm²/day for consumers. The exposure of hairdressers regarding shampoo is 6 to 13 times higher compared to consumers. Deep conditioning the hair with hair conditioner provides a dose per area from 4.55814 to 22.79070 mg/cm²/day for hairdressers and 1.89241 mg/cm²/day for consumers. Exposure for hair conditioner is 5 to 19 times in hairdressers than in consumers. Whilst colouring hair with permanent/oxidative hair colour using 6-12% hydrogen peroxide (full head), a dose per area from 0.24689 to 1.54711 mg/cm²/day is given in hairdressers and of 0.00039 mg/cm²/day in consumers. Hairdressers are 32 to 78 times more exposed regarding permanent/oxidative hair colour using 6-12% hydrogen peroxide than

consumers. For colouring hair with semi-permanent oxidative hair colour using 2-3% hydrogen peroxide or non-oxidative hair colour (full head), the dose per area is 0.01465 mg/cm²/day for hairdressers and 0.00241 mg/cm²/day for consumers. The exposure of hairdressers is 4 times higher compared to consumers for semi-permanent oxidative hair colour using 2-3% hydrogen peroxide or non-oxidative hair colour (full head). Regarding colouring hair (root/regrowth only) using oxidative/non-oxidative hair colours according to previous treatment, the dose per area amounts to 0.01220 mg/cm²/day for hairdressers and 0.00014 mg/cm²/day for consumers. Exposure is 13 times higher in hairdressers than in consumers for oxidative/non-oxidative hair colours according to previous treatment (root/regrowth only). In terms of bleaching the hair with bleach using mostly using 6-9% hydrogen peroxide (full head), the dose per area for hairdressers ranges from 0.01523 to 0.09599 mg/cm²/day and is 0.00039 mg/cm²/day for consumers. Hairdressers are 9 to 49 times higher exposed compared to consumers regarding bleach using mostly using 6-9% hydrogen peroxide (full head).

3.3.2 Exposure to wet work in hairdressers compared to consumers

Further, information about wet work exposure in hairdressers was extracted (Table 3). These data support the known fact that hairdressers are exposed to a considerable amount of wet work within their daily working life which can sum up to even more than 4 hours per working day for a considerable amount of hairdressers,^{15,17,22} whereas wet work is likely less performed by the 'common consumer'.²³

4 Discussion

In this paper we have shown that hairdressers are exposed up to 78 times more than ordinary consumers regarding customary hair cosmetic products. This applies for a wide spectrum of products ranging from shampoo, conditioner, oxidative and non-oxidative hair colours, and bleaching agents. Assuming largely comparable product composition, the daily dose per area of single product ingredients can be compared (hairdressers versus consumers).

To the best of our knowledge, this is the first review to compare occupational exposure in hairdressers with exposure in consumers regarding relevant potentially skin harming products. In order to assess typical use frequencies of hair cosmetics by consumers, data from the SCCS NoG for the testing of cosmetic ingredients and their safety, 11th revision,⁷ were taken into account, as far as available. For assessing hairdressers' exposure, a structured literature search was conducted, leading to the inclusion of seven studies in the present review. All included

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study types can be regarded as adequate, although the fact that questionnaire surveys possibly suffer from a certain bias due to the subjective nature of the answers should be mentioned. The study populations cover a wide age structure so that the age of the included hairdressers may reflect the overall age structure in the hairdressing trade. Since the largest proportion of workers in the hairdressing sector of the EU is female,^{20,21} the present high female share amongst hairdressers was to be expected and does thus not constitute a potential bias.

All of the included studies (n=7) provided details on the frequency of use of/quantification of exposures to hair cosmetic products in professional hairdressers. Since the time period from 1990 to 2020 was taken as eligible publication period it has to be mentioned that the frequency of exposure to important types of addressing cosmetics might have undergone a change over the last years depending on current trends and changing preferences. In the future, the current frequency of exposure to important types of hair cosmetic products in hairdressers may be assessed via observational studies and in consumers via questionnaire surveys. The latter should also differentiate between consumers (subjected to exposure mainly on the scalp and only partly on the hands) – and professional hairdressers (exposed mainly on the hands in the occupational setting). Obviously, as consumers themselves, some hairdressers might also be more exposed to hair cosmetic products within their private surroundings, this being a not quantifiable add-on exposure to the occupational exposure. As a default, the same exposure pattern as laid down in the NoG was used for the self-use share of exposure in hairdressers. It was not only substantiated that hairdressers are exposed to products at a much higher rate than the ordinary consumer whilst conducting many working tasks, but also that a considerable amount of identified procedures is usually only performed by hairdressers, such as perming the hair using diverse types of perming solutions (Table 1). These procedures provide a set of hairdressing-exclusive services on their own and provide an extra exposure for hairdressers which consumers presumably do not have.

As data on 12 procedures alongside with concomitantly used product types were available, many of the most relevant procedures exposing hairdressers to hair cosmetic products are covered in this review. However, there are other additional tasks conducted within the hairdressing trade exposing workers to further cosmetic products on which no data are yet available. Additional sources of exposure to potentially harmful substances are listed in Table 4, among them cosmetic glues for applying eyelashes, nails, and hair extensions, hot wax and sugaring paste for hair removal, hair styling and setting products as well as metallic work tools.

Occupational exposure may be fluctuating due to changing product formulations. Regarding acrylates, two current investigations focus on the increasing usage of (meth)acrylates in gel nail paints – such as daylight curing ‘hybrid’ gel nail polish – and their role as sensitizers.^{24,25} With regard to the common contact allergens nickel and cobalt, two recent studies found release of these metal allergens in allergologically relevant amounts from a broad spectrum of tools which are used on a daily basis in hairdressing.^{26,27} The frequency of use of the products listed in Table 4 could be evaluated in forthcoming studies. As permanent remodelling of the hair structure – i.e., curling or straightening – with various new methods (i.e., so-called Brazilian blowouts or keratin treatments for smoothing the hair structure) has gained more popularity over the last years, the utilised chemicals prospectively need particular attention regarding dermal and/or respiratory effects in hairdressers.

It was also shown that concerning all procedures which should only be conducted wearing adequate protective gloves, the share of hairdressers actually wearing gloves is disenchanting. Especially against the background of hairdressers reusing already worn gloves,²⁸ contamination due to wrong usage or whilst taking off the gloves,²⁹ breakthrough times of gloves,³⁰ and the fact that some substances used in hairdressing products (e.g. *p*-phenylenediamine (PPD) used in hair colour) penetrate glove material³¹ making glove use not as effective as envisaged. Correct utilisation of suitable gloves according to the type of conducted tasks should always be promoted. This is especially relevant for hairdressers with a high exposure in their working life, but also should not be neglected in consumers using hairdressing chemicals at home. Regarding the second group, data is lacking and could be gathered in future studies. Concerning glove use while shampooing, such protection can probably be deemed exceptional in consumers.

Data on wet work has again supported the known fact that this exposure is likely present in considerable extent in hairdressers,^{15,17,22} whereas this is not the case for the ‘common consumer’.²³ Wet work leads to an impairment of the epidermal barrier function concomitant with the genesis of a proinflammatory milieu. Thus, penetration of skin hazardous substances, such as allergens, is facilitated and the risk of the development of allergic contact dermatitis – especially of the hands – is promoted. Recently it was shown that PPD itself, a common ingredient in hair dyes, can turn down the function of tight junctions and stratum corneum proteins, even when there are no clinical symptoms present.³² These effects on the skin and combined exposures to irritants and allergens lead to a higher susceptibility and risk of skin sensitization, which needs to be taken into account in future risk assessment e.g. by applying

extra safety factors. First attempts of quantitative risk assessment have indeed indicated that for PPD and toluene-2,5-diamine (PTD) contact sensitization may occur, when skin protection is not applied adequately.³³ Moreover, aggregated exposure – that is, exposure to the same ingredient via different products – can be expected concerning auxiliary ingredients such as preservatives, fragrances or emulsifiers. This will further increase cumulative exposure to such substances, both in consumers, and, even more so, in hairdressers. It should additionally be specified that the exposure of hairdressers should always be evaluated with the starting level being on the level of a consumer as it was shown that hairdressers tend to apply many hairdressing procedures to themselves.³⁴

5 Conclusion

The results of the present review imply that an assumed frequency of use for consumers is not suitable for representing exposure – and with it, morbidity risk – of hairdressers. Higher exposure leads to a greater risk of skin irritation and sensitisation, which consequently also has ramifications regarding systemic exposure via skin. The regulations in force do not adequately address the occupational dangers linked with the use of cosmetic products in hairdressers. A rethinking of present risk assessment practices should be prompted.

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7 Tables

Table 1: Identified procedures alongside with concomitantly used product types

Procedure with products types	Likely performed by consumers? [†]
1. Shampooing/washing hair using shampoo	yes, possibly daily
2. (Deep) Conditioning hair using hair conditioner	yes, possibly daily
3. Cutting wet hair i) without previously conducted colouring service and ii) after previously conducted colouring service	i) no, ii) no
4. Colouring hair i) with permanent/oxidative hair colour using 6-12% hydrogen peroxide on the full head, ii) with semi-permanent oxidative hair colour using 2-3% hydrogen peroxide or non-oxidative hair colour on the full head, iii) on the root/regrowth only with oxidative/non-oxidative hair colours according to previous treatment	i) yes, possibly monthly ii), yes, possibly monthly iii) yes, possibly monthly
5. Highlighting the hair (mostly using bleach with 6-9% hydrogen peroxide) and lowlighting the hair (mostly using oxidative hair colour with 6% hydrogen peroxide) using (aluminium) foil	no
6. Highlighting the hair (mostly using bleach with 6-9% hydrogen peroxide) and lowlighting (mostly using oxidative hair colour with 6% hydrogen peroxide) the hair using a cap	no
7. Bleaching the hair with bleach using mostly 6-9% hydrogen peroxide on the full head	rarely
8. Perming the hair using waving/perm lotion (acid, alkaline, and exothermic perms)	no
9. Colouring eyelashes and/or eyebrows with oxidative hair colour using mostly 3% hydrogen peroxide	highly unlikely

[†] categories: yes, possibly daily; yes, possibly monthly; rarely; highly unlikely; no

Table 2: Characteristics of exposures of the hands (“H”) and scalp (“S”) in hairdressers and consumers. Procedures including used products alongside with the dose per area and the exposure factor by which hairdressers are higher exposed as consumers

Exposure	Hairdressers			Consumers		Exposure factor¶
	Frequency of procedures using corresponding products (median)	Regular glove wearing (%)†	Dose per area (mg/cm ² /day)‡	Frequency of procedures using corresponding products (median)§	Dose per area (mg/cm ² /day)‡	
Shampooing/washing the hair with shampoo (H and S)	5 - 12 times/day ^{10,17}	23.9	60.8 - 145	1 time/day	18.0	6 - 13
Deep conditioning the hair with hair conditioner (H and S)	1 - 5 times/day ^{10,17}	11.5 (+head massage: 8.4)	4.56 - 22.8	0.28/day	1.89	5 - 19
Colouring hair with permanent/oxidative hair colour using 6-12% hydrogen peroxide (full head) (H and S)	30.6 - 76.6 times/month ^{10,17,21}	95.2	0.247 - 1.55	1 time/month	0.00039	32 - 78
Colouring hair with semi-permanent oxidative hair colour using 2-3% hydrogen peroxide or non-oxidative hair colour (full head) (H and S)	3 times/week ¹⁷	95.2§	0.0147	1 time/week§	0.00241	4
Colouring hair (root/regrowth only) using oxidative/non-oxidative hair colours according to previous treatment (H and S)	11.5 times/month ¹⁷	95.2§	0.0122	1 time/month¶	0.00014	13
Bleaching the hair with bleach using mostly using 6-9% hydrogen peroxide (full head) (H)	7.6 - 47.9 times/month ^{10,17,21}	77.9	0.0152 - 0.0960	--	--	--
Bleaching the hair with bleach using mostly using 6-9% hydrogen peroxide (full head) (S)	1 time/month¶	--	0.00039	1 time/month¶	0.00039	9 - 49

† data taken from Uter *et al.* (1998)¹⁰; ‡ calculation formula: (amount / skin surface area) x daily exposure frequency, the amount is taken from the SCCS Notes of Guidance (NoG) for the testing of cosmetic ingredients and their safety, 11th revision⁷ which refer back to Hall *et al.* (2007)⁹, Hall *et al.* (2011)⁸, Colipa 16.01.97 BB-97/007¹¹, and the Scientific Committee on Cosmetic products and Non-Food Products intended for consumers (SCCNFP) SCCNFP/0321/00¹², data on the skin surface area (SSA) is taken from the NoG⁷ which refer back to Bremmer *et al.* (2006)¹³ and Bremmer

et al. (2006)¹⁴, for hairdressers the SSA of the hands (860cm²) and for consumers the SSA of ½ head (580cm²) was considered; § data taken from the NoG⁷; ¶ factor by which hairdressers are higher exposed as consumers, calculation formula: (frequency of exposure for hairdressers + frequency of exposure for consumers) / frequency of exposure for consumers; day, 8 working hours; month, 21 working days; week, 5 working days

Table 3: Exposure to wet work according to epidemiological studies involving hairdressers

Study on hairdressers' exposure	Hairdressers' exposure according to the respective study (mean values)	Consumers' exposure according to the respective study (mean values)
Wet work (h/day)		
Kralj <i>et al.</i> (2011) ^{15†} , n=106	8234±3826s (for 8h shifts)	---
Lysdal <i>et al.</i> (2012) ^{17†} , n=2896	never: 0.1% <1/2h/day: 2.2% 1/2h-1h/day: 4.1 >1-<2h/day: 7.0% 2-3h/day: 16.8% >3-<4h/day: 15.8% ≥4h/day: 54.0%	---
Meding <i>et al.</i> (2017) ^{23‡} , n=3091§	---	0–10 times/day: 71.4% >10 times/day: 28.7% >20 times/day: 3.1%
Lund <i>et al.</i> (2019) ^{22†} , n=74	4.75±2.63	---
Glove wearing (h/day)		
Lysdal <i>et al.</i> (2012) ^{17†} , n=2887	<1/2h/day: 5.8% 1/2h/day: 19.6% >1-<2h/day: 33.7% 2-3h/day: 31.7% >3-<4h/day: 6.8% ≥4h/day: 2.4%	---
Hand washing (times/day)		
Lysdal <i>et al.</i> (2012) ^{17†} , n=2911	0-5 times/day: 22.0% 6-10 times/day: 41.1% 11-20 times/day: 29.9% >20 times/day: 7.0%	---

† the studied cohort consists of hairdressers; ‡ the study cohort consists of adolescents; § water exposure is studied rather than wet work; h, hour; s, seconds

Table 4: Additional sources of exposure (extract) to potentially harmful substances in the hairdressing trade alongside corresponding tasks, also involving cosmetic product categories not for use on hair

Product	Potentially harmful substances (extract)	Exposure route	Are gloves usually worn?	Comment
eyelash glue	acrylates	dermal, respiratory	no	For some make-up services eyelash extensions are used. The eyelash glue is placed on the back of the hand and the eyelash extension is dipped into the glue. The remaining eyelash glue (dried residue) may only be removed at the end of the working day. Dermal and respiratory effects of eyelash glues have already been reported. ^{35,36}
nail glue	acrylates	dermal, respiratory	no	Press-on-nails or nail art decorations (e.g. rhinestones) are applied with nail glue within the course of conducting manicures. The nail glue may get on the fingers of the hairdresser and only be removed at the end of the working day. Dermal and respiratory effects of nail glues have already been reported. ³⁷⁻³⁹
hair extension glue	acrylates, latex	dermal, respiratory	no	A variation of hair extension glues is used to install hair extensions. Allergic reactions against hair extension glues have already been reported. ⁴⁰⁻⁴² The mentioned glues range from liquid delivery forms to adhesive strips (so-called tapes). Whilst installing hair extensions, gloves are regularly not worn exposing the hairdressers to the glues for a considerable amount of time during conducting the service on the client. Glue residue might remain on the hands until they are thoroughly cleaned off at the end of the working day.
hot wax, sugaring paste	colophony, cera alba, fragrances	dermal	no	Depilation of undesired body hair (e.g. facial hair in women) may be removed by hairdressers using hot wax or sugaring paste. Whilst depilating the hair, the hot wax/sugaring paste can get on the hands of the hairdresser and needs to dry before it can be removed. Dermal effects of hot wax/sugaring paste have already been reported. ⁴³⁻⁴⁵
hair styling and setting products (e.g. hairspray)	aerosols, resins, fragrances	dermal, respiratory	no	Styling products (e.g. hair gels) are applied by the hairdresser without gloves and the hands are usually not washed until the service is finished. In order not to get setting products (e.g. hairspray) into the customers' face, the hairdresser protects it using their own hand whilst spraying with the other getting the hairspray on the protecting hand. Dermal and respiratory effects of hairsprays have already been reported. ^{46,47}

metal tools/objects (e.g. tweezers, crochet hooks)	nickel and/or cobalt	dermal	no	Tweezers are used to pluck eyebrows and to remove undesired facial hair. A nickel and cobalt release (and also a co-release of both) from tweezers has already been reported. ^{26,27} Crochet hooks are used for highlighting/lowlighting the hair using a cap. A nickel release from tweezers in the hairdressing trade has already been reported. ^{27,48}
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8 Figures

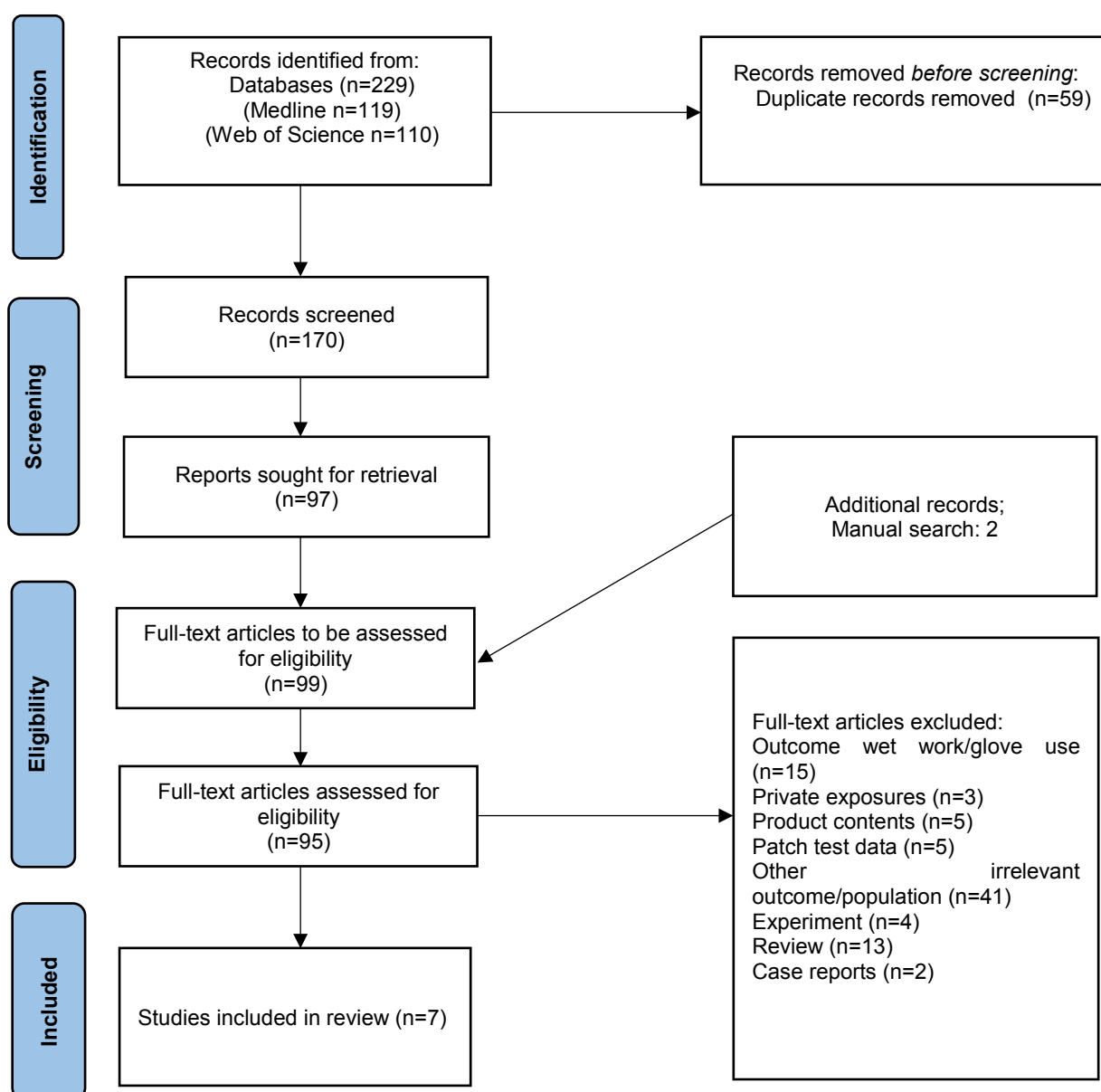


Figure 1: Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 flow diagram of literature search according to Page *et al.* (2021)⁴⁹

9 Appendices

Table A1: Publication record form (PRF) for included studies

Study	Time of investigation	Country	Study design/methods	Study population	Age range (years)	Sex (% female)
Uter <i>et al.</i> (1998) ¹⁰	Summer 1992, 1993, 1994	Germany	Prospective population-based cohort study	Hairdressing apprentices	-	-
Leino <i>et al.</i> (1998) ²¹	-	Finland	Survey by computer-aided telephone interviews on exposure and health and clinical examination	Hairdressers	15-54	100
Lind <i>et al.</i> (2007) ¹⁶	December 1996	Sweden	Survey by questionnaire	Hairdressers	19-50, median: 29	100
Kralj <i>et al.</i> (2011) ¹⁵	April to November 2008	Germany	Direct observation of activities by trained observers	Hairdressers	-	-
Lysdal <i>et al.</i> (2012) ¹⁷	May 2009	Denmark	Survey by questionnaire about hairdressing tasks within the last week	Hairdressers	22-65, median: 36.5	95.7
Ramirez-Martinez <i>et al.</i> (2016) ¹⁸	-	France	Survey by questionnaire and direct observation	Hairdressers	16-58	89.0
Samardžić <i>et al.</i> (2016) ¹⁹	-	Croatia	Survey by questionnaire and clinical examination	Hairdressing apprentices	-	100

Study on hairdressers' exposure	Hairdressers' exposure according to the respective study				Consumers' exposure [‡]		
	Frequency of procedures using corresponding products	Mean duration (min) [†]	Done by (%) [†]	Regular glove wearing (%) [†]	Frequency of procedures using corresponding products	Mean duration (min)	Done by (%)
Shampooing/washing the hair with shampoo							
Uter <i>et al.</i> (1998) ^{10§} , n=2352	12 times/day (median)	7.5	99.8	23.9	1 time/day (median) as consumer and/or self-user	nda, 7.5	nda, 100
Lind <i>et al.</i> (2007) ^{16¶} , n=3665	times/week: 0-30: 43%, 31-50: 39%, 51-70: 14%, 71+: 5%						
Kralj <i>et al.</i> (2011) ^{15¶} , n=106	6.6 times/day (mean)						
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	25 times/week (median), range: 1-99 times						
Ramirez-Martinez <i>et al.</i> (2016) ^{18¶} , n=28	6.02 times/day (mean)						
Samardžić <i>et al.</i> (2016) ^{19§} , n=101	88% ≥30 min/day (without gloves)						
Deep conditioning the hair with hair conditioner							
Uter <i>et al.</i> (1998) ^{10§} , n=2352	5 times/day (median)	10.0 (+12.5	90.5 (+head	11.5 (+head	0.28/day (median) as consumer and/or self-user	nda, 10.0	nda, 30.0
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	5 times/week (median), range: 1-99 times	due to a potentially following head massage)	massage: 91.7)	massage: 8.4)			
Cutting wet hair (without previous colouring)							
Uter <i>et al.</i> (1998) ^{10§} , n=2352‡‡	5 times/day (median)	25.0	93.5	1.3	n/a, not conducted as consumer and/or self-user	n/a	n/a
Leino <i>et al.</i> (1998) ^{21¶} , n=355‡‡	6 times/day (median), range: 2-15 times						
Kralj <i>et al.</i> (2011) ^{15¶} , n=106	9.9 times/day (mean)						
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	25 times/week (median), range: 1-99 times						
Ramirez-Martinez <i>et al.</i> (2016) ^{18¶} , n=28	4.62 times/day (mean)						
Samardžić <i>et al.</i> (2016) ^{19§} , n=101	32% ≥30 min per day (without gloves)						
Cutting wet hair (after colouring)							
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	10 times/week (median), range: 1-99 times	see <i>cutting wet hair (without previous colouring)</i>	see <i>cutting wet hair (without previous colouring)</i>	see <i>cutting wet hair (without previous colouring)</i>	n/a, not conducted as consumer and/or self-user	n/a	n/a
Ramirez-Martinez <i>et al.</i> (2016) ^{18¶} , n=28	0.42 times/day (mean)						
Colouring hair with permanent/oxidative hair colour using 6-12% hydrogen peroxide (full head)							

Study on hairdressers' exposure	Hairdressers' exposure according to the respective study				Consumers' exposure [‡]		
	Frequency of procedures using corresponding products	Mean duration (min)†	Done by (%)†	Regular glove wearing (%)†	Frequency of procedures using corresponding products	Mean duration (min)	Done by (%)
Uter <i>et al.</i> (1998) ^{10§} , n=2352§§	4 times/day (median)	15.0	99.3	95.2	1 time/month (median), as consumer and/or self-user	nda, 15.0	nda, 33.3
Leino <i>et al.</i> (1998) ^{21¶} , n=355§§	8 times/week (median), range: 0-30 time(s)						
Lind <i>et al.</i> (2007) ^{16¶} , n=3665	times/week: 0-1: 44%, 2-7: 52%, 8-14: 3%, 15+: 0.3%						
Kralj <i>et al.</i> (2011) ^{15¶} , n=106	1.3 times/day (mean)						
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	8 times/week (median), range: 1-60 time(s)						
Ramirez-Martinez <i>et al.</i> (2016) ^{18¶} , n=28§§	1.04 times/day (mean)						
Samardžić <i>et al.</i> (2016) ^{19§} , n=101§§	72% ≥30 mins per day (with gloves)						
Colouring hair with semi-permanent oxidative hair colour using 2-3% hydrogen peroxide or non-oxidative hair colour (full head)							
Lind <i>et al.</i> (2007) ^{16¶} , n=3665	times/week: 0-1: 38%, 2-7: 55%, 8-14: 7%, 15+: 0.3 %	see <i>colouring hair with permanent / oxidative hair colour using 6-12% hydrogen peroxide (full head)</i>	see <i>colouring hair with permanent / oxidative hair colour using 6-12% hydrogen peroxide (full head)</i>	see <i>colouring hair with permanent / oxidative hair colour using 6-12% hydrogen peroxide (full head)</i>	1 time/week (median), counts for semi-permanent, non-oxidative hair colour, as consumer and/or self-user	nda, 15.0	nda, 33.3
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	3 times/week (median), range: 1-50 time(s)						
Colouring hair (root/regrowth only) using oxidative/non-oxidative hair colours according to previous treatment							
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	3 times/week (median), range: 1-60 time(s)	see <i>colouring hair with permanent / oxidative hair colour using 6-12% hydrogen peroxide (full head)</i>	see <i>colouring hair with permanent / oxidative hair colour using 6-12% hydrogen peroxide (full head)</i>	see <i>colouring hair with permanent / oxidative hair colour using 6-12% hydrogen peroxide (full head)</i>	1 time/month (median) corresponding to <i>colouring hair with permanent / oxidative hair colour using 6-12% hydrogen peroxide (full head)</i> and with semi-	nda, 15.0	nda, 33.3

Study on hairdressers' exposure	Hairdressers' exposure according to the respective study				Consumers' exposure [‡]		
	Frequency of procedures using corresponding products	Mean duration (min) [†]	Done by (%) [†]	Regular glove wearing (%) [†]	Frequency of procedures using corresponding products	Mean duration (min)	Done by (%)
					<i>permanent oxidative hair colour using 0-2% hydrogen peroxide or 1 time/week (median) corresponding to colouring hair with non-oxidative hair colour (full head), as consumer and/or self-user</i>		
Highlighting the hair (mostly using bleach with 6-9% hydrogen peroxide) and lowlighting (mostly using oxidative hair colour with 6% hydrogen peroxide) the hair using foil							
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	6 times/week (median), range: 1-60 time(s)	n/s	n/s	n/s	nda, 0.25-1 time(s)/month, only as consumer, not as self-user	nda, 15.0	nda, 33.3
Highlighting the hair (mostly using bleach with 6-9% hydrogen peroxide) and lowlighting (mostly using oxidative hair colour with 6% hydrogen peroxide) the hair using a cap							
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	3 times/week (median), range: 1-40 time(s)	n/s	n/s	n/s	nda, 0.25-1 time(s)/month, only as consumer, not as self-user	nda, 15.0	nda, 33.3
Kamirez-Martinez <i>et al.</i> (2016) ^{18¶} , n=28	0.84 times/day (mean)						
Bleaching the hair with bleach using mostly using 6-9% hydrogen peroxide (full head)							
Uter <i>et al.</i> (1998) ^{10§} , n=2352	2.5 times/day (median)	15.0	96.6	77.9	nda, 0.5-1 time(s)/month ^{¶¶}	nda, 15.0	nda, 33.3
Leino <i>et al.</i> (1998) ^{21¶} , n=355	3 times/week (median), range: 0-14 time(s)				as consumer and/or self-user		
Lind <i>et al.</i> (2007) ^{16¶} , n=3665	times/week: 0-1: 36%, 2-7: 58%, 8-14: 5%, 15+: 0.5%						
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	2 times/week (median), range: 1-50 time(s)						
Perming the hair using waving/perm lotion (acid, alkaline, and exothermic perms)							
Uter <i>et al.</i> (1998) ^{10§} , n=2352	3 times/day (putting in perm curlers) (median),					nda, 5.0	

Study on hairdressers' exposure	Hairdressers' exposure according to the respective study				Consumers' exposure [‡]		
	Frequency of procedures using corresponding products	Mean duration (min) [†]	Done by (%) [†]	Regular glove wearing (%) [†]	Frequency of procedures using corresponding products	Mean duration (min)	Done by (%)
Leino <i>et al.</i> (1998) ^{21¶} , n=355 Lind <i>et al.</i> (2007) ^{16¶} , n=3665	3 times/day (alkaline perm, appliance) (median), 3 times/day (alkaline perm, washing out) (median), 2 times/day (acid perm, appliance) (median), 2 times/day (acid perm, washing out) (median), 4 times/day (perm fixation with neutraliser) (median), 5 times/week (median), range: 0-23 time(s) times/week (alkaline perm): 0-1: 22%, 2-7: 64%, 8-14: 13%, 15+: 2% times/week (acid perm): 0-1: 65%, 2-7: 33%, 8-14: 2%, 15+: 1%	putting in perm curlers: 25.0, alkaline perm (appliance): 5.0, alkaline perm (washing out): 5.0, acid perm (appliance): 5.0, acid perm (washing out): 5.0, perm fixation: 7.5	putting in perm curlers: 92.6, alkaline perm (appliance): 97.5, alkaline perm (washing out): 98.1, acid perm (appliance): 44.3, acid perm (washing out): 44.4, perm fixation: 98.9	putting in perm curlers: 13.9, alkaline perm (appliance): 29.2, alkaline perm (washing out): 33.3, acid perm (appliance): 34.7, acid perm (washing out): 37.5, perm fixation: 38.1	nda, 0.25 times/month, only as consumer, not as self-user		nda, 10.0
Kralj <i>et al.</i> (2011) ^{15¶} , n=106 Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	0.7 times/day (mean) 2 times/week (median), range: 1-50 time(s)						
Colouring eyelashes and/or eyebrows with oxidative hair colour using mostly 3% hydrogen peroxide							
Lysdal <i>et al.</i> (2012) ^{17¶} , n=5239	4 times/week (median), range: 1-80 time(s)	n/s	n/s	n/s	nda, 0.5-1 time(s)/month, only as consumer, usually not as self-user	nda, 10.0	nda, 20.0

[†] data taken from Uter *et al.* (1998)¹⁰; [‡] data for consumer exposure is taken from the SCCS Notes of Guidance (NoG) for the testing of cosmetic ingredients and their safety, 11th revision⁷, as far as available; § the studied cohort consists of hairdressing apprentices; ¶ the studied cohort consists of hairdressers; ‡‡ previously conducted colouring treatments were not reported; §§ all types of colouring hair are considered together and cannot be further specified; ¶¶ for consumers the label *full head* only applies for first time bleaching, after that full head refers to root/regrowth only since

already bleached hair cannot be bleached as often as desired in contrast to colouring the hair with oxidative or non-oxidative hair colours; n/a, not applicable; nda, no data available from the SCCS Notes of Guidance (NoG) for the testing of cosmetic ingredients and their safety, 11th revision⁷, information was estimated by the authors of this paper; n/s, not stated in the paper