Epidemiology of patch tested patients with permanent tattoos—A comparative analysis of 9693 IVDK patients (2020–2022)

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Abstract

Background: Permanent tattooing is the invasive introduction of tattoo ink (pigments) into the dermis. The ink and aftercare cosmetics applied on pre-damaged skin may contain skin sensitisers.

Objectives: To identify patient characteristics and the pattern of sensitisation in tattooed patients patch tested within the Information Network of Departments of Dermatology (IVDK).

Patients and Methods: Comparative analysis of patient characteristics and reaction frequencies to baseline series allergens in 1648 consecutive patients with and 8045 consecutive patients without permanent tattoos. Non-overlapping 95%-confidence intervals were considered as significant.

Results: Having permanent tattoos was related with female sex, age <40 years, tobacco smoking, atopic dermatitis, (occupational) hand dermatitis and being employed in particular occupational groups (e.g., healthcare workers, mechanics, hairdressers). Sensitisation to nickel was increased in tattooed patients and associated

See Appendix S1 for the IVDK.

with female sex (OR 4.23 [95%-CI, 3.48–5.18]), age ≥40 years (OR 1.26 [95%-CI, 1.08–1.49]), tobacco smoking (OR 1.19 [95%-CI, 1.01–1.40]) and having permanent tattoos (OR 1.27 [95%-CI, 1.05–1.53]).

Conclusions: The association between nickel sensitisation and permanent tattoos is probably confounded by past reactions to pierced costume jewellery. Socio-economic factors most probably contribute to the connection between tattoos, tobacco smoking, occupational or hand dermatitis, and being employed in particular occupational groups.

KEYWORDS

allergic contact dermatitis, nickel, patch test, permanent make-up, tattoo, tattoo aftercare cosmetics

1 | INTRODUCTION

During permanent tattooing (including permanent make-up), mixtures of pigments and soluble substances (e.g., preservatives, metal contaminants) are deposited into the dermis by a thousand-fold disruption of the basement membrane with metallic needles.[1] This process obligatorily involves inflammation – a driving force of sensitisation.[2] The use of tattoo aftercare cosmetics following the tattoo procedure is frequently recommended, which leads to additional application of products which may contain sensitisers (mainly preservatives, fragrances) on pre-damaged skin.[3] Numbing creams containing local anaesthetics may be also used prior to tattoo application. Hence, permanent tattoos may constitute an infrequent (partly nonrecurring), but risky skin exposure to these sensitisers which may facilitate sensitisation. Therefore, tattooed individuals might be more prone to acquire a contact dermatitis to certain allergens. The population of tattooed individuals may additionally be exposed to other special allergen sources, e.g., due to a higher affinity to body art (piercing or hair dye), influencing the overall sensitisation pattern.[1]

In a specialised tattoo clinic, 50.2% and 1.3% of the patients were diagnosed with allergic reactions to red tattoo pigment or tattoo after care products, respectively.[4] While the diagnosis of pigment allergy is hampered, among other things, by the lack of commercially available patch test (PT) preparations, sensitisation to soluble ink components or ingredients of aftercare products can be diagnosed more easily.[1,5]

In order to characterise tattooed PT patients, we have conducted a retrospective comparative analysis of patients' clinical data and PT results obtained with the baseline series of the German Contact Dermatitis Research Group (DKG) stratified for the prevalence and absence of permanent tattoos in a population of patients consecutively patch tested within the Information Network of Departments of Dermatology (IVDK).

2 | METHODS

As a follow-up to an earlier data analysis,[6] 19.797 patients were patch tested in 56 departments of dermatology joining the IVDK between 08/2020 and 12/2022. The IVDK's structure and routine operating procedures are described in detail elsewhere.[7] Basic data on permanent tattoos were obtained in a sub-set of 9693 (49.0%) patients aged 18 years or older from 44 departments via IVDK routine questionnaire. During medical consultation, tattooed patients were asked for past non-infectious ('inflammatory') tattoo reactions (i.e., lichenoid reaction, eczema, granuloma and hyperkeratosis; but exclusive infections or wound healing disorders). A total of 1648 patients (17.0%) stated to have permanent tattoos or permanent make-up (study group), 8045 were not tattooed (control group). Patch testing was performed according to DKG guidelines.[8,9] PTs were read at least twice, namely on the day (D) of patch removal (D2 in 93.8% of the patients; D1 in the remainder) and on D3. In a few exceptional cases, PTs were read on D4 instead of D3. Reactions on D3 or D4 were assessed for the analysis. PT reactions coded as +, ++ or +++, thus with erythema, infiltration, papules and/or (coalescing) vesicles were judged as positive. Most PT preparations were purchased from SmartPractice Europe (Greven, Germany) and few from Chemotechnique (Vellinge, Sweden). In the large majority of the patients (84.3%), Finn-Chambers on Scanpor (SmartPractice Europe) were used as test system. Statistical significance of differences in proportions of positive PT reactions and anamnestic items in disjunct groups of patients was concluded from non-overlapping 95% confidence intervals (95%-CIs).[10] Data was managed and analysed with the statistical analysis software SAS© version 9.4 (SAS Institute, Cary, NC, USA).

3 | RESULTS

3.1 | Population characteristics

Overall tattoo prevalence was 17.0% [95% CI, 16.3–17.8]. A higher prevalence of permanent tattoos was found in younger age groups and, with the exception of patients aged 60 to 69 years, among women (Figure 1).

Non-infectious tattoo reactions were stated by 85 (5.2%) of the tattooed patients, in fact significantly more often by tattooed patients between 18 and 39 years of age (6.8% [95% CI, 5.3–8.8]) compared to patients aged ≥40 years (3.6% [95% CI, 2.6–5.1]) (Figure 2).

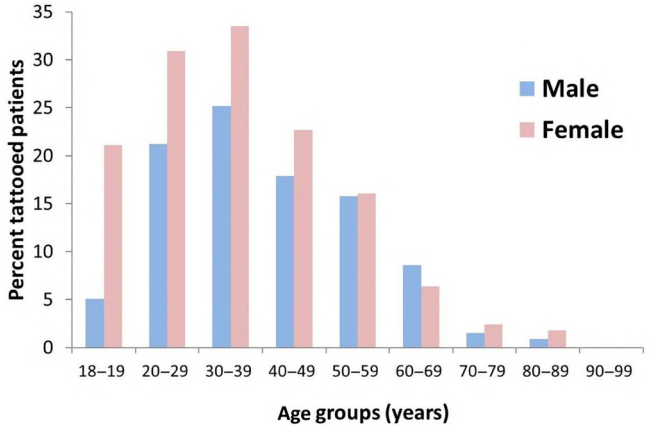

FIGURE 1 Prevalence of permanent tattoos in the study group (3.287 male (blue) and 6.406 female patients), stratified by sex and age.

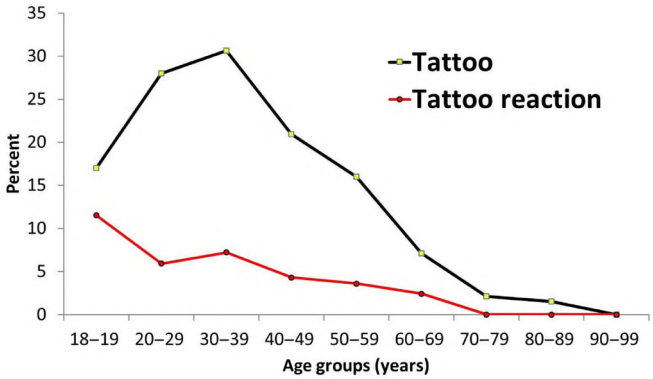

FIGURE 2 Proportions of patients with permanent tattoos in different age groups (black line) and corresponding proportions of self-reported adverse tattoo reactions (red line).

However, due to the small sample size, we did not analyse this subgroup separately.

A description of the study and the control group is given in Table 1. Apart from younger age and a higher number of women, PT patients with tattoos were characterised by an increased share of hand and occupational dermatitis as well as (past or present) atopic dermatitis. Health care workers, mechanics, hairdressers, geriatric nurses and storekeepers were over-represented. The same applies to the corresponding allergen sources suspected to be causative for the dermatitis leading to patch testing, such as protective (rubber) gloves, disinfectants and hair cosmetics. There were no significant differences as far as cosmetics as suspected allergen source are concerned (permanent tattoo: 32.0%; no permanent tattoo: 32.4%).

In a sub-set of 6951 (71.7%) patients, data on patients' smoking habits were available. Tattooed patients (49.6% [95% CI, 46.7–52.5]) had a significantly higher share of (past or present) tobacco smokers compared to patients without tattoos (22.8% [95% CI, 21.8–23.9]).

3.2 | Patch test results

Table 2 gives an overview on age- and sex-standardised[11] proportions of positive reactions to allergens of the (German) DKG baseline series. Overall, most reaction frequencies were lower in the study group. The only significant difference was observed with nickel sulphate, to which more patients with permanent tattoos reacted positive (18.8% [95%-CI, 16.8–20.8] vs.14.9% [95%-CI, 14.0–15.9]). Data on clinical relevance were available for 255 positive reactions to nickel and 137 (53.7%) were found to be clinically relevant. Culprit products were documented for 37 (27.0%) of these cases. In contrast to tattoos, which were not named at all, or non-metal jewellery ($n = 4$, 10.8%), predominantly metal jewellery ($n = 14$, 37.8%), metal processing ($n = 3$, 8.1%), and other metal sources (e.g., coins, tools, medical suture material; $n = 16$, 43.2%) were mentioned. Nickel sensitisation is known to be not equally distributed in all age groups and genders.[12] Thus, we performed a multivariate logistic regression analysis to quantify the impact of sex, age (younger than 40 years or 40 years and older), (past or present) tobacco smoking and being tattooed, using these four factors as independent (explanatory) variables, and a positive PT to nickel sulphate 5% in petrolatum as dependent (target) variable in a subset of 5731 patients patch tested with nickel. Nickel sensitisation was significantly associated with female sex (OR 4.23 [95%-CI, 3.48–5.18]), age ≥40 years (OR 1.26 [95%-CI, 1.08–1.49]), (past or present) tobacco smoking (OR 1.19 [95%-CI, 1.01–1.40]) and being tattooed (OR 1.27 [95%-CI, 1.05–1.53]).

The two DKG test series 'preservatives in' and 'ingredients of' topical preparations were both tested in the majority of the tattooed patients and results showed throughout low proportions of positive reactions (Tables S1 and S2).

4 | DISCUSSION

Tattoo prevalence (17.0% [95% CI, 16.3–17.8]) shows an increasing trend in comparison to the last IVDK data assessment 09/2016–07/2020 (13.5% [95% CI, 12.9–14.0]).[6] The study confirms that permanent tattoos are prevalent especially in young women. With the exception of nickel allergy, which was predominantly associated with female sex and to a lower extend also with being tattooed, age (40 years or older) and (past or present) tobacco smoking, no specific sensitisation pattern associated with permanent tattoos was identified.

Permanent tattoos were noted as suspected allergen sources in 2.4% and inflammatory reactions to permanent tattoos in the past were self-reported by 5.2% of the tattooed patients. In particular patients younger than 40 years stated past tattoo reactions more frequently, perhaps simply as they remember complaints with more recent tattoos more easily. However, the true frequency of inflammatory tattoo reactions remains unknown. Self-assessments may also comprise other complaints which lead to a possible over-estimation of the size of the problem and individuals with adverse tattoo reactions

TABLE 1 MOAHLFA-Index and population characteristics of patch tested patients with ($n = 1648$) and without ($n = 8045$) permanent tattoos.

		Tattoo % [95%-CI]	No tattoo % [95%-CI]
MOAHLFA-Index			
Male	M	30.1 [27.9–32.4]	34.7 [33.7–35.7]
Occupational dermatitis	O	33.1 [30.8–35.4]	23.7 [22.8–24.7]
(past or present) Atopic dermatitis	A	31.8 [29.6–34.1]	25.7 [24.7–26.7]
Hand dermatitis	H	47.5 [45.1–50.0]	36.1 [35.1–37.2]
Leg dermatitis	L	5.2 [4.2–6.4]	7.3 [6.8–7.9]
Face dermatitis	F	12.6 [11.0–14.3]	14.4 [13.6–15.2]
Age ≥40 years	A	52.0 [49.6–54.4]	75.6 [74.6–76.5]
Groups of occupation			
Health-care professionals		12.4 [10.8–14.1]	8.1 [7.5–8.7]
Mechanics, metal-, machinery and related trades workers		7.0 [5.9–8.4]	4.6 [4.2–5.1]
Hairdressers, barbers, beauticians, wigmakers		3.5 [2.7–4.5]	1.1 [0.9–1.4]
Geriatric nurse, social work associate professionals		3.2 [2.4–4.2]	1.7 [1.4–2.0]
Storekeeper, transport labourers and freight handlers		2.1 [1.5–2.9]	1.1 [0.9–1.4]
Suspected allergen sources (up to 3 per patient)			
Gloves (all materials)		18.8 [16.9–20.7]	14.4 [13.6–15.2]
Disinfectants		17.2 [15.4–19.1]	12.9 [12.2–13.6]
Hair cosmetics		6.6 [5.4–7.9]	2.9 [2.5–3.3]
Permanent tattoos		2.4 [1.7–3.2]	0.0 [0.0–0.1][a]
Laser removal of tattoos		0.5 [0.2–1.0]	0.0 [0.0–0.0]

Note: Only those occupational groups and suspected allergen sources are listed, which were found significantly more often among tattooed patients.
Abbreviation: 95% CI, 95% confidence interval.
[a]One patient tested prior to tattoo application.

frequently rather consult their tattooists than dermatologists, which may lead to an under-estimation.[1]

Occupational and hand dermatitis were associated with having permanent tattoos. The study group contained no tattooist and therefore a direct connection cannot be deduced. Notably, a high share of patients with tattoos worked in occupational groups known for a high prevalence of occupational hand dermatitis (e.g., health care workers, hairdressers). The most common suspected allergen sources in patients with permanent tattoos corresponded well with these occupations but in part also with exposures during the tattooing procedure (e.g., rubber gloves, disinfectants).

Interestingly, the increased share of (past or present) tobacco smokers or (past or present) atopic dermatitis sufferers among tattooed patients is in line with published epidemiological data.[13] Both, tobacco smoking[14] and tattoos,[15] have been positively associated with lower socio-economic status and education level. In a German representative survey from 2016,[16] 76.1% of the tattooed respondents had basic or secondary school qualification. This may explain the higher prevalence of tattoos in occupational groups associated with a high risk for occupational (hand) dermatitis. Tobacco smoking[17] and atopic dermatitis[18] may additionally facilitate the severity of (occupational) hand dermatoses.

Although occupational dermatitis and being employed in certain high-risk professions was associated with being tattooed, an increased frequency of corresponding sensitisations was not evident from our data. With the exception of nickel sensitisation, we found no specific sensitisation pattern characterising the tattooed PT population. Despite nickel may be contained as a pigment-derived impurity in tattoo inks[19] or deposited as tattoo needle wear in TiO_2-dependent manner into the dermis during the tattoo procedure,[20] our study confirmed the well-established association between female sex and nickel sensitisation (OR 4.18 [95%-CI, 3.56–4.95]). In other PT studies, nickel sensitisation was no indicator for tattoo allergy[1,21] and the increased prevalence of nickel sensitisation in the study group may rather be a socio-demographic finding for three reasons. First, nickel levels in tattoo ink are usually too low to sensitise a significant number of individuals.[1] Second, metal jewellery and other metal sources were frequently documented as clinically relevant exposures in sensitised patients of the tattoo group and are well-known sources of nickel sensitisation.[12,22] Third, in other studies, the prevalence of both, (ear lobe) piercings and nickel allergy, were increased among females[23] and particularly young tattooed females were very often pierced as well.[24] In two Danish studies, sensitisation to nickel was associated with tobacco smoking, a lower education level, piercings and hand dermatitis in women.[25,26]

TABLE 2 Proportions of positive reactions to allergens of the (German) DKG baseline series presented as age- and sex standardised reaction frequencies (9) with 95%-confidence intervals (95%-CIs) in patients with or without permanent tattoos.

Test preparation		Tattoo ($n = 1464$) % pos. [95%-CI]	No tattoo ($n = 6904$) % pos. [95%-CI]
Nickel sulphate	**5%**	**18.8 [16.8–20.8]**	**14.9 [14.0–15.9]**
Cobalt chloride	1%	8.2 [6.8–9.6]	7.0 [6.3–7.7]
Potassium dichromate	0.5%	5.5 [4.3–6.7]	5.4 [4.8–6.0]
Balsam of Peru (*Myroxylon pereirae*)	25%	4.9 [3.8–6.0]	5.7 [5.1–6.3]
Fragrance mix	8%	4.1 [3.1–5.1]	5.0 [4.4–5.6]
Colophony (Rosin)	20%	3.3 [2.4–4.2]	3.3 [2.8–3.7]
Propolis	10%	3.0 [2.1–3.9]	3.3 [2.8–3.8]
Fragrance mix II	14%	2.6 [1.7–3.4]	3.0 [2.6–3.4]
Thiuram mix	1%	2.3 [1.5–3.1]	2.3 [1.9–2.7]
Ylang ylang oil	10%	2.2 [1.4–3.0]	2.5 [2.0–3.0]
2-Hydroxyethyl methacrylate (HEMA)	1%	2.1 [1.3–2.8]	1.3 [1.0–1.6]
Methyl isothiazolinone (MI, aq)	0.05%	1.7 [1.0–2.5]	2.5 [2.0–2.9]
Methylchloroisothiazolinone (MCI/MI, aq)	0.01%	1.6 [1.0–2.3]	2.6 [2.1–3.0]
Epoxy resin	1%	1.4 [0.7–2.0]	1.7 [1.3–2.0]
Compositae mix II	5%	1.0 [0.5–1.5]	1.3 [1.0–1.6]
Sandalwood oil	10%	1.0 [0.5–1.5]	0.7 [0.5–0.9]
Lanolin alcohols	30%	0.9 [0.4–1.4]	1.3 [1.0–1.6]
Hydroxyisohexyl 3-cyclohexene carboxaldehyde (HICC)	5%	0.9 [0.4–1.4]	1.1 [0.8–1.3]
Mercapto mix (CBS, MBTS, MOR)	1%	0.9 [0.3–1.4]	0.4 [0.2–0.6]
Formaldehyde (aq)	1%	0.8 [0.4–1.3]	0.8 [0.6–1.1]
Mercaptobenzothiazole	2%	0.8 [0.3–1.2]	0.6 [0.4–0.8]
Iodopropynylbutyl carbamate (IPBC)	0.2%	0.8 [0.3–1.3]	0.9 [0.6–1.1]
Jasmine absolute	5%	0.8 [0.3–1.3]	0.9 [0.7–1.2]
N-Isopropyl-N′-phenyl-p-phenylene diamine (IPPD)	0.1%	0.7 [0.3–1.2]	0.6 [0.4–0.8]
Sorbitan sesquioleate	20%	0.6 [0.2–1.0]	0.6 [0.4–0.8]
Oil of turpentine	10%	0.1 [0.0–0.3]	0.2 [0.1–0.3]

Note: Significant differences are marked in bold. All preparations in petrolatum unless aqua (aq) is indicated.
Abbreviations: CBS, N-Cyclohexyl-2-benzothiazylsulphenamide; MBTS, Dibenzothiazyl disulphide; MOR, Morpholinylmercapto-benzothiazole.

Therefore, the regression analysis and the relatively low OR of 1.35 [95%-CI, 1.16–1.58] for permanent tattoos were possibly confounded by missing data on past piercing reactions, which are not recorded with the IVDK routine anamnesis and therefore were not considered as explanatory variable. Thus, no final conclusions can be drawn and the role of nickel in allergic tattoo reactions remains disputed.[27]

5 | LIMITATIONS

Data on past piercing reactions were not available and therefore interpretation of PT results obtained with nickel sulphate was limited. In addition, data on the size and colours of permanent tattoos as well as information on the timely delay between application of a tattoo and occurrence of complaints or complications, potentially influencing the number of self-reported adverse reactions, were not available. Furthermore, tattoo pigments are not available as patch test material.

6 | CONCLUSIONS

Significant characteristics of tattooed PT patients were female sex, younger age, (past or present) tobacco smoking, (past or present) atopic dermatitis, occupational and hand dermatitis as well as being employed in particular occupational groups. These should be considered as confounders for sound interpretation of patch test results. Past reactions to (earlobe) piercings may explain the increased frequency of nickel sensitisation in the study group of PT patients with permanent tattoos. Unfortunately, no final conclusions can be drawn.

AUTHOR CONTRIBUTIONS

S. Schubert: Conceptualization; methodology; software; data curation; formal analysis; visualization; project administration; writing – original draft; writing – review and editing. **E. Oppel:** Investigation; writing – review and editing. **A. Bauer:** Investigation; writing – review and editing. **C. Schröder-Kraft:** Investigation; writing – review and

editing. **H. Löffler:** Investigation; writing – review and editing. **K. Strom:** Investigation; writing – review and editing. **M. Worm:** Investigation; writing – review and editing. **R. Brans:** Investigation; writing – review and editing. **N. Wagner:** Investigation; writing – review and editing. **Y. Angela:** Investigation; writing – review and editing. **J. Geier:** Methodology; data curation; validation; supervision; writing – review and editing.

FUNDING INFORMATION

None.

CONFLICT OF INTEREST STATEMENT

All authors except Y. Angela are members of the German Contact Dermatitis Research Group (DKG). The Information Network of Departments of Dermatology (IVDK), maintained by the IVDK e.V., of which S. Schubert is an employee, is sponsored by the cosmetic, fragrance and tattoo industry and associations as well as by public funds. He received honoraria for educational lectures for tattooists. The other authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Sharing of original data is not possible due to legal data protection restrictions.

ETHICS STATEMENT

The study was conducted in accordance with the ethical principles for medical research involving human subjects (WMA declaration of Helsinki). Written informed consent was obtained from all patients.

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SUPPORTING INFORMATION

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

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