ORIGINAL ARTICLE

Patch test sensitization and permanent tattoos: epidemiological data from two referral centers

Alessandra Chiei Gallo[1], Francesca Barei[2], Christian Paolo Ratti[1], Eleonora Bono[1], Alice Botta[1], Matteo Cavara[1], Paolo Calzari[3], Elisa Rusconi[3], Lea Caron[1], Angelo Valerio Marzano[2,3], Valeria Giuseppina Rita Ortolani[1], Enrico Iemoli[1], Silvia Mariel Ferrucci[2]

[1]Allergy and Clinical Immunology Unit, Sacco Hospital, Milan, Italy
[2]Dermatology Unit, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy
[3]Department of Pathophysiology and Transplantation, Università degli Studi Di Milano, Milan, Italy

Summary

Background. Permanent tattoos introduce pigments and metal contaminants into the dermis, potentially triggering allergic contact dermatitis (ACD). However, comparative analyses between tattooed and non-tattooed individuals remain limited. This study aimed to assess the impact of tattoos on allergic sensitization and patch test (PT) reactivity. **Methods**. Retrospective observational analysis of 485 adults undergoing PT at two referral centers in Milan (December 2024-June 2025) was included in this study. Patients were classified as tattooed (n = 107) or non-tattooed (n = 378). Patch testing was performed according to the 2024 Italian Baseline Series; reactions were graded following International Contact Dermatitis Research Group guidelines. Logistic regression was performed to identify factors associated with positive reactions, adjusting for MOAHLFA characteristics (male sex, occupational dermatitis, atopic dermatitis, hand/leg/face dermatitis, age > 40 years). Given the retrospective design, the analyses are subject to potential selection bias and unmeasured confounding. **Results.** Sensitization rates to standard allergens did not differ between the two groups analyzed. However, receiving the first tattoo > 5 years prior 2025 was associated with a 4.4-fold higher risk of nickel sensitization (p = 0.029, OR = 4.407, 95%CI 1.166-16.656). **Conclusions.** Tattoos do not appear to significantly influence sensitization to standard allergens; however, long-term tattoo exposure is associated with an increased rate of nickel sensitization. These findings may reflect differences in cumulative nickel exposure over time, potentially related to the timing of tattooing and regulatory changes. Consideration of tattoo history and temporal exposure is recommended when assessing ACD risk.

Introduction

Permanent tattooing, including cosmetic tattooing, involves the intradermal injection of pigment mixtures and soluble compounds – such as preservatives and metal contaminants – through repeated disruption of the basement membrane using metallic needles. This procedure inevitably induces local inflammation, a key driver of allergic sensitization (1,2). Additional exposures occur through aftercare products, which may contain sensitizing agents such as preservatives or fragrances, and through pre-procedural topical anesthetics, further increasing the risk of cutaneous sensitization (3,4).

Tattooed individuals may therefore have an elevated risk of developing allergic contact dermatitis (ACD), particularly when co-exposures such as hair dyes or body piercings are present (1). ACD is common in the general population, with approximately 20% of patch-tested individuals exhibiting at least one positive reaction (5). ACD is mediated by a delayed-type (type IV) hypersensitivity reaction: following skin penetration, small reactive chemicals (haptens) bind to endogenous proteins, form immunogenic complexes, and are processed by antigen-presenting cells. Upon re-exposure, memory T cells trigger a delayed inflammatory cascade that produces the clinical manifestations of dermatitis (6–9). Although several epidemiological studies have described the characteristics of tattooed populations, direct comparisons between tattooed and non-tattooed individuals remain limited (10–14). This gap is particularly relevant in light of recent regulatory changes. Since 2020, the European Union has implemented Regulation (EU) 2020/2081 under the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) framework (Annex XVII), which restricts the presence of potentially sensitizing metals – including nickel – in tattoo inks. These regulatory measures introduced new maximum allowable concentrations for numerous substances, including metal contaminants, with the aim of reducing pigment- and metal-induced sensitization in the population. This regulatory transition is expected to modify exposure profiles and may influence sensitization patterns in the years following implementation (15,16). Given these considerations, comparative clinical data assessing patch

test responses in tattooed versus non-tattooed individuals are needed to clarify the potential impact of tattoo exposure on allergic sensitization. Therefore, the aim of this study was to evaluate differences in patch test reactivity between these two groups and to explore the relationship between tattoo characteristics and sensitization patterns before and after the 2020 regulatory changes, using a retrospective cohort of patients patch-tested in two referral centers.

Materials and methods

Patients and data collection

We conducted a retrospective study on 485 adult (≥18-year-old) patients who underwent PT for a suspected ACD between December 2024 and June 2025 at two referral centers in Milan (Italy): Dermatology Unit of Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico and Allergy and Clinical Immunology Unit of L. Sacco Hospital. All patient data were obtained from medical records and analyzed in anonymized form. Participants were divided into two groups based on documented tattoo history: individuals with at least one permanent tattoo or permanent make-up (tattooed group) and individuals with no tattoos (non-tattooed group). No active selection, matching, or stratification was performed; instead, all consecutive patients meeting inclusion criteria during the study period were enrolled. To ensure comparability between groups, demographic and clinical characteristics were systematically collected and subsequently adjusted for in multivariable analyses using MOAHLFA (male, occupational dermatitis, atopic dermatitis, hand dermatitis, leg dermatitis, facial dermatitis, age > 40 years) variables. The objective of the study was to assess potential differences in PT results between the two groups. Patients who did not complete the test (for example, they did not attend the follow-up readings, or the test was uninterpretable) or had missing tattoo history were excluded. Tattoo removal due to suspected or confirmed tattoo-related dermatitis was not used as an exclusion criterion; however, none of the individuals included in the present cohort reported having undergone tattoo removal. At the time of PT application (Day 0), baseline clinical and epidemiological characteristics were recorded. Regarding tattoos, data were collected on tattoo color, number of tattoos, and the dates of the first and most recent tattoos.

Patch testing

All patients were tested using the 2024 Italian Baseline Series (AIFA Technical Committee) and, when appropriate, additional series (eyelid, lip, dental, orthopedic, cosmetic, hairdresser), all provided by SmartPractice (Rome, Italy). PT were applied using allergEAZE Chambers and fixed with Eurofix tape (Fastening Systems, Seregno, Italy) on the upper back. Readings were performed on Day 2 (D2) and Day 4 (D4), following Società Italiana di Dermatologia Allergologica Professionale e Ambientale (SIDAPA) guidelines and International Contact Dermatitis Research Group (ICDRG) criteria (17,18). Reactions graded as +, ++, or +++ were considered positive. The clinical relevance of positive reactions was assessed as definite, probable, possible, or absent/unknown, based on the presence of the allergen in the patient's environment and the consistency of clinical features (18).

Statistical analysis

Descriptive statistics are reported as mean and standard deviation (SD) or median and quartiles (Q1-Q3) for quantitative variables based on the distribution of the population. Absolute numbers (n) and frequencies (%) are used for categorical variables. Categorical variables were analyzed using a chi-square test or Fisher's exact test as appropriate. Continuous variables were analyzed using the Mann-Whitney U test or T-test for unpaired data as appropriate. The variables included in the MOAHLFA index (male, occupational dermatitis, atopic dermatitis, hand dermatitis, leg dermatitis, facial dermatitis, age > 40 years) were analyzed using a chi-square test or Fisher's exact test as appropriate (19). We performed a logistic regression analysis to evaluate a potential predominant factor affecting the determination of a positive PT for nickel. As covariates we considered: the number of years between 2025 and the first tattoo and the MOAHLFA characteristics. Multicollinearity was assessed using the Variance Inflation Factor (VIF), variance proportions, and the condition index in SPSS. Thresholds of VIF < 10, condition index < 30, and absence of high shared variance proportions were considered acceptable. Sample size was calculated based on the primary endpoint, if there was any difference in the results of the patch test between tattooed and non-tattooed patients. This potential difference was studied using a Chi-squared test. As for sample size, considering a chi-square test, with a significance level of 0.05 and 80% power, a degree of freedom of 1, and assuming an effect size of 0.5, we determined that a minimum sample size of 32 patients was necessary. All statistical analyses were two-tailed with an alpha error set at 0.05, considering a P-value < 0.05 as significant. For **Tables I-III**, Bonferroni-adjusted p-values were

calculated to account for multiple comparisons within each set of related analyses. Statistical analyses were carried out using SPSS-IBM software (version 29.0). To calculate the sample size, power*G software (version 3.1, Heinrich Heine University Düsseldorf, Düsseldorf, Germany) was used.

Results

Population characteristics

The overall population included 485 adult patients, of whom 107 (22.1%) had permanent tattoos or permanent make-up (tattooed group), and 378 (77.9%) had no tattoos (non-tattooed group).

The baseline characteristics of these two population are reported in **Table I**. The tattooed group was significantly younger, with a median age of 40.0 years compared to 54.5 years in the non-tattooed group ($p<0.001$). There were no significant differences for the other baseline characteristics between the tattooed group and the non-tattooed group. Females predominated in both groups, particularly among tattooed patients (80.4% females vs. 19.6% males) compared to the non-tattooed group (73.3% females vs. 26.7% males). Ethnicity was similar across groups, with Caucasians representing the majority. Atopic comorbidities such as rhino-conjunctivitis and asthma were more frequent in tattooed patients (57.0% and 49.5%, respectively) than in non-tattooed individuals (48.7% and 40.5%), although differences were not statistically significant. Anatomical involvement patterns, referring to the sites of dermatitis reported in **Table I**, were broadly similar between groups, with face, hands, and limbs being the most commonly affected sites. Previous positive PT results, performed prior to the current evaluation, were slightly more common in non-tattooed patients (64.7%) compared to tattooed (55.6%); however, detailed information regarding timing and specific allergen positivity (including nickel) was not consistently available. Among the tattooed group (n=107), 35 individuals (32.7%) had a single tattoo, 41 (38.3%) had between two and five tattoos, and the remaining 31 (29.0%) had more than five tattoos, with a median (Q1-Q3) of 2 (1-7) tattoos. Regarding tattoo pigment colors, 69 patients (64.5%) had only one color. Almost all patients (106, 99.1%) had black ink among their tattoo colors, followed in frequency by red (30, 29.0%), blue (13, 12.1%), green (11, 10.3%), white (7, 6.5%), yellow (6, 5.6%), orange (4, 3.7%), and brown (1, 0.9%).

Patch test positivity

In the overall population, 246 (50.7%) patients had a positive PT result. The results of the PT are shown in **Table II**. In the overall population, nickel sulfate (5% in petrolatum) was the most frequently detected allergen, with a higher, though not statistically significant, prevalence in the non-tattooed group (29.0%) compared to the tattooed group (23.5%). Other common allergens included Textile dye mix, Cobalt chloride hexahydrate and Fragrance mix I + Sorbitan sesquioleate (**Figure 1**).

No statistically significant differences in sensitization rates to any specific allergen were observed between tattooed and non-tattooed individuals across the 2024 Italian Baseline Series (**Table II**).

We analyzed the distribution of patients with positive and negative PT results according to the MOAHLFA index characteristics (male sex, occupational dermatitis, atopic dermatitis, hand dermatitis, leg dermatitis, facial dermatitis, and age > 40 years) in both the tattooed and non-tattooed groups and no significant differences were detected (**Figure 2**, **Table III**). In the tattooed group, when considering the time elapsed since the first tattoo, no significant differences emerged regarding the baseline allergens, except for nickel, which is described in the next paragraph. Given the small sample size for several haptens that tested positive, the sub-analysis was restricted to the most frequently identified haptens. The number of tattoos was not significantly associated with a higher risk of having a positive patch test to nickel, textile dye mix, cobalt chloride and fragrance mix I + sorbitan sesquioleate. Similarly, the analysis related to ink color was restricted to red, blue, and green, as these were the best represented colors in the sample. Black ink was excluded because 99.1% of patients had it, making any meaningful comparison impossible. No association was found between the analyzed ink colors and positivity to the four aforementioned haptens.

Nickel sensitivity in the tattooed group

A significant association was found between nickel sensitization and the time elapsed since the first tattoo, considering the year 2025 as reference. In the tattooed group, among patients with a negative result for nickel (n=76), 52 (68.4%) had their first tattoo more than 5 years ago, while 24 (31.6%) had their first tattoo less than 5 years. Among patients who tested positive for nickel on patch testing (n=31), 28 (90.3%) had received their first tattoo more than 5 years ago, while only 3 (9.7%) received it in the last 5 years ($p=0.018$, χ^2 [Chi-squared]=5.598). Interestingly, this difference remained significant when comparing patients who had their first tattoo more than 5 years ago with the remaining patients, including those without tattoos ($p = 0.020$, χ^2 =

5.414). No significant differences were detected when considering patients with 1-2 tattoos and patients with more than 2 tattoos (p=0.483, χ^2=0.492). These findings were confirmed in the univariate logistic regression analysis: patients who had received their first tattoo more than 5 years earlier had a higher risk of a positive PT for nickel (p=0.026, OR [odds radio] =4.308, 95% C.I. [confidence interval] 1.192-15.573) (**Table IV**). We performed univariate regression and multivariate regression analyses to evaluate a potential predominant factor affecting the determination of a positive PT for nickel. No MOAHLFA characteristics had a significant result in the univariate analysis. On the contrary, the time interval remained significant in the multivariate analysis (p=0.029, OR= 4.407, 95% C.I. 1.166-16.656) (**Table IV**).

Discussion and conclusions

This study provides novel insights into the relationship between permanent tattoos and ACD. Although previous studies have explored a potential link between tattoos and ACD, the literature remains inconclusive regarding the impact of tattooing on sensitization to standard allergens. Our findings indicate that the presence of tattoos does not significantly alter the overall sensitization rates to standard allergens. Indeed, in our cohort, no specific allergen demonstrated a significantly increased frequency in tattooed patients, suggesting that the act of tattooing itself may not inherently predispose individuals to ACD. These results are consistent with the observations of Serup et al. and Liszewski et al., who reported negative outcomes in baseline PT despite clinical reactions to tattoo inks, suggesting that allergen formation may occur in situ via haptenization rather than being present in the inks themselves (20,21). When considering the tattooed group alone, our study identified a significant association between the time elapsed since the first tattoo and nickel sensitization. In fact, patients who had received their first tattoo more than five years (prior 2025) exhibited a 4.4-fold higher risk of a positive PT for nickel, even after adjusting for potential confounders such as MOAHLFA characteristics, compared to the other tattooed group. This difference remained significant when comparing patients who had received their first tattoo more than five years prior 2025 to the rest of the population. This result may reflect cumulative exposure over time, potentially influenced by changes in regulatory frameworks such as the 2020 European Union Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) regulation, which introduced restrictions on a broad range of substances in tattoo inks (15,16). However, the specific contribution of nickel from inks remains uncertain, and alternative mechanisms should be considered, including exposure to metal particles released during tattooing procedures, such as needle wear, as suggested by Schreiver et al. as well as other environmental sources (3). This finding is in line with observations by Schubert et al., who reported increased nickel sensitization in tattooed individuals, especially those with long-standing or multiple tattoos, and with Liszewski et al., who discussed the potential role of metallic contaminants in tattoo-related sensitization, although the specific contribution of nickel remains uncertain (10,21). The pathogenesis of ACD involves a delayed-type hypersensitivity reaction, in which haptens bind to endogenous proteins and are processed by antigen-presenting cells to activate memory T cells upon re-exposure. In the context of tattoos, factors such as ink composition, needle-derived metal contaminants, the body's immune response, and duration of exposure may all contribute to sensitization. Modern tattoo and inks are complex mixtures of pigments, solvents, preservatives, and additives, and allergic reactions are difficult to diagnose reliably with patch testing due to limited pigment penetration, slow haptenization, and the unavailability of relevant pigments or breakdown products as test allergens (10). In this context, needle-derived metal particles have been proposed as a potential source of sensitization, particularly for nickel and chromium (3). This suggests that the increased risk of nickel sensitization may be related not only to ink composition itself, but also to procedural factors associated with tattooing. The study has limitations, including its retrospective design and the lack of systematic data on other potential sources of nickel exposure, such as piercings, jewelry, or occupational contact, as well as incomplete information on prior PT results, particularly regarding nickel sensitization before tattooing. In addition, information on tattoo characteristics and the overall extent of tattooed skin was not consistently available, which may have influenced the evaluation of exposure–sensitization patterns. In conclusion, tattoos do not appear to substantially influence sensitization to standard allergens; however, individuals whose first tattoo was performed more than five years before 2025 show a significantly increased risk of nickel sensitization; however, the clinical relevance of this finding remains to be established. This suggests that the timing of tattoo exposure – rather than the mere presence of tattoos could influence sensitization patterns. To our knowledge, this is one of the few studies to directly compare PT outcomes between tattooed and non-tattooed individuals within the same clinical population, using standardized allergen panels and adjusting for MOAHLFA variables. Our data underscore the importance of considering both the temporal dimension of tattoo history and individual susceptibility when assessing the risk of nickel allergy, thereby adding a nuanced perspective

to the current understanding of tattoo-related sensitization. Although no direct association was found between tattooing and sensitization to baseline allergens, the observed link with long-standing tattoos highlights a potential exposure-related risk that merits further investigation. Taken together, our results are also consistent with the possibility that the regulatory restrictions introduced in 2020 under REACH may be contributing to a gradual reduction in nickel sensitization associated with tattoo inks. At the same time, the observed association may reflect not only ink composition, but also procedural factors related to tattooing. While causal inference cannot be established, this pattern reinforces the potential public health relevance of continued regulation of sensitizing metals in tattoo products. Given the growing popularity of tattoos, clinicians should remain vigilant in evaluating ACD risk, particularly in individuals with long-standing tattoo exposure. Future studies should aim to characterize the specific chemical components of tattoo inks that may contribute to sensitization and to clarify the long-term implications of evolving regulatory frameworks.

Fundings: The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Author Contributions: A.C.G.: Conceptualization; methodology; data curation; visualization; project administration; writing – original draft. Francesca Barei: formal analysis; writing – review and editing. E.B., A.B., M.C., C.P.R., P.C., E.R., L.C.: data collecting, visualization. A.V.G, V.G.R.O., E.I., S.M.F.; data curation; validation; supervision; writing – review and editing.

Conflict of Interests: S.M.F. has served as advisory board member, speaker or principal investigator in clinical trials for: Abbvie, Almirall, Amgen, Bayer, Incyte, Galderma, Eli Lilly, Novartis, Sanofi, Pfizer, Leo Pharma.

Ethics Statement: The study was conducted in accordance with the ethical principles for medical research involving human subjects (WMA declaration of Helsinki and its later amendments). Informed consent was obtained from all individual participants included in the study.

References

1. Schubert S, Oppel E, Bauer A, Schröder-Kraft C, Löffler H, Strom K, et al. Epidemiology of patch tested patients with permanent tattoos-A comparative analysis of 9693 IVDK patients (2020-2022). Contact Dermatitis. 2024;91(4):278-284. doi: 10.1111/cod.14632.
2. Martin SF, Esser PR, Weber FC, Jakob T, Freudenberg MA, Schmidt M, et al. Mechanisms of chemical-induced innate immunity in allergic contact dermatitis. Allergy. 2011;66(9):1152-63. doi: 10.1111/j.1398-9995.2011.02652.x.
3. Schreiver I, Hesse B, Seim C, Castillo-Michel H, Anklamm L, Villanova J, et al. Distribution of nickel and chromium containing particles from tattoo needle wear in humans and its possible impact on allergic reactions. Part Fibre Toxicol. 2019;16(1):33. doi: 10.1186/s12989-019-0317-1.
4. Warshaw EM, Schram SE, Belsito DV, DeLeo VA, Fowler JF Jr, Maibach HI, et al. Patch-test reactions to topical anesthetics: retrospective analysis of cross-sectional data, 2001 to 2004. Dermatitis. 2008;19(2):81-5. doi: 10.2310/6620.2007.06072.
5. Alinaghi F, Bennike NH, Egeberg A, Thyssen JP, Johansen JD. Prevalence of contact allergy in the general population: A systematic review and meta-analysis. Contact Dermatitis. 2019;80(2):77-85. doi: 10.1111/cod.13119.
6. Tramontana M, Hansel K, Bianchi L, Sensini C, Malatesta N, Stingeni L. Advancing the understanding of allergic contact dermatitis: from pathophysiology to novel therapeutic approaches. Front Med (Lausanne). 2023;10:1184289. doi: 10.3389/fmed.2023.1184289.
7. Martin SF. Immunological mechanisms in allergic contact dermatitis. Curr Opin Allergy Clin Immunol. 2015;15(2):124-30. doi: 10.1097/ACI.0000000000000142.
8. Vocanson M, Hennino A, Rozières A, Poyet G, Nicolas JF. Effector and regulatory mechanisms in allergic contact dermatitis. Allergy. 2009;64(12):1699-714. doi: 10.1111/j.1398-9995.2009.02082.x.

9. Kaplan DH, Igyártó BZ, Gaspari AA. Early immune events in the induction of allergic contact dermatitis. Nat Rev Immunol. 2012;12(2):114-24. doi: 10.1038/nri3150.
10. Schubert S, Kluger N, Schreiver I. Hypersensitivity to permanent tattoos: Literature summary and comprehensive review of patch tested tattoo patients 1997-2022. Contact Dermatitis. 2023;88(5):331-350. doi: 10.1111/cod.14291.
11. Kluger N. Nickel and tattoos: Where are we? Contact Dermatitis. 2021. doi: 10.1111/cod.13869.
12. Wang X, Josefsson L, Meschnark S, Lind ML, Emmer Å, Goessler W, et al. Analytical survey of tattoo inks-A chemical and legal perspective with focus on sensitizing substances. Contact Dermatitis. 2021;85(3):340-353. doi: 10.1111/cod.13913.
13. Uter W, Schnuch A, Gefeller O; ESCD working group: European Surveillance System on Contact Allergies. Guidelines for the descriptive presentation and statistical analysis of contact allergy data. Contact Dermatitis. 2004;51(2):47-56. doi: 10.1111/j.0105-1873.2004.00406.x.
14. Kluger N. Epidemiology of tattoos in industrialized countries. Curr Probl Dermatol. 2015;48:6-20. doi: 10.1159/000369175.
15. THE EUROPEAN COMMISSION. Commission Regulation (EU) 2020/2081 of December 14, 2020 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards substances in tattoo inks or permanent make-up. 2020. [available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32020R2081]. Accessed on November 29, 2025.
16. Famele M, Lavalle R, Leoni C, Majorani C, Ferranti C, Palleschi L, et al. Quantification of preservatives in tattoo and permanent make-up inks in the frame of the new requirements under the REACH Regulation. Contact Dermatitis. 2022;87(3):233-240. doi: 10.1111/cod.14105.
17. Stingeni L, Bianchi L, Caroppo ES, Belloni Fortina A, Caroppo F, Corazza M, et al. The new Italian SIDAPA Baseline Series for patch testing (2023): an update according to the new regulatory pathway for contact allergens. Ital J Dermatol Venerol. 2024;159(2):83-104. doi: 10.23736/S2784-8671.24.07733-8.
18. Johansen JD, Aalto-Korte K, Agner T, Andersen KE, Bircher A, Bruze M, et al. European Society of Contact Dermatitis guideline for diagnostic patch testing - recommendations on best practice. Contact Dermatitis. 2015;73(4):195-221. doi: 10.1111/cod.12432.
19. Uter W, Andersen KE, Brans R, Bruze M, Schubert S, Gonçalo M. The 'MOAHLFA(P) Index': An Attempt to Standardise a Widely Used Array of Descriptors of Patch-Tested Patients. Contact Dermatitis. 2025;92(4):251-260. doi: 10.1111/cod.14750.
20. Serup J, Hutton Carlsen K. Patch test study of 90 patients with tattoo reactions: negative outcome of allergy patch test to baseline batteries and culprit inks suggests allergen(s) are generated in the skin through haptenization. Contact Dermatitis. 2014;71(5):255-63. doi: 10.1111/cod.12271.
21. Liszewski W, Warshaw EM. Pigments in American tattoo inks and their propensity to elicit allergic contact dermatitis. J Am Acad Dermatol. 2019;81(2):379-385. doi: 10.1016/j.jaad.2019.01.078.

Table I - *Baseline characteristics of overall population and in the two subgroups (patients with and without permanent tattoo).*

Baseline characteristics	**Overall population**	**Valid N**	**Tattoo**	**Valid N**	**No Tattoo**	**Valid N**	**p-value**
Sex, *n* (%) - F - M	 363 (74.8) 122 (25.2)	485	 86 (80.4) 21 (19.6)	107	 277 (73.3) 101 (26.7)	378	0.135
Age (years), median (Q1-Q3)	50.0 (31.0-64.5)	485	40.0 (27.0-55.0)	107	54.5 (33.8-68.0)	378	<0.001
Ethnicity, *n* (%) - Caucasian - Black - Asian/Chinese - Hispanic/Latino - Indian - North African	 429 (88.5) 6 (1.2) 12 (2.5) 25 (5.2) 7 (1.4) 6 (1.2)	485	 98 (91.6) 1 (0.9) 0 (0.0) 4 (3.7) 3 (2.8) 1 (0.9)	 107	 331 (87.6) 5 (1.3) 12 (3.2) 21 (5.6) 4 (1.1) 5 (1.3)	378	0.289
Hobbies, *n* (%) - None / Not relevant - Painting - Gardening	 454 (94.2) 20 (4.1) 8 (1.6)	482	 99 (93.4) 6 (5.7) 1 (0.9)	106	 355 (94.4) 7 (1.9) 14 (3.7)	376	0.593
Autoimmune diseases, *n* (%)	53 (10.9)	485	8 (7.5)	107	45 (11.9)	378	0.195
Atopic comorbidities, *n* (%) - Rhinoconjunctivitis - Asthma - Food allergy - Drug allergy	245 (50.5) 206 (42.5) 72 (14.8) 47 (9.7) 52 (10.7)	485	61 (57.0) 53 (49.5) 17 (15.9) 12 (11.2) 10 (9.3)	107	184 (48.7) 153 (40.5) 55 (14.6) 35 (9.3) 42 (11.1)	378	 0.290 0.873 0.841 0.329
AD, *n* (%) - Active - In remission	111 (22.9) 64 (13.2) 47 (9.7)	485	27 (25.2) 12 (11.2) 15 (14.0)	107	84 (22.2) 52 (13.8) 32 (8.5)	378	0.110
Family history of atopy, *n* (%)	106 (21.9)	485	25 (23.4)	73	81 (21.4)	378	0.387
Dermatol. comorbidities, *n* (%) - Psoriasis - MF - NE - PN - CSU	 19 (3.9) 2 (0.4) 7 (1.4) 3 (0.6) 8 (1.6)	485	 5 (4.7) 0 (0.0) 2 (1.9) 0 (0.0) 1 (0.9)	107	 14 (3.7) 2 (0.5) 5 (1.3) 3 (0.8) 7 (1.6)	378	 0.777 1.000 1.000 0.597 0.684
Sites involved, *n* (%) - Face - Hands - Feet	 216 (44.5) 143 (29.5) 34 (7.0)	485	 50 (46.7) 34 (31.8) 10 (9.3)	107	 166 (43.9)	378	 0.605 0.556 0.284

- Abdomen	79 (16.3)		15 (14.0)		109		0.471
- Back	37 (7.6)		10 (9.3)		(28.8)		0.449
- Scalp	8 (1.6)		1 (0.9)		24 (6.3)		0.692
- Upper Limbs	99 (20.4)		27 (25.2)		64 (16.9)		0.161
- Lower Limbs	101 (20.8)		33 (30.8)		27 (7.1)		0.004
- Genitals	22 (4.5)		7 (6.5)		7 (1.9)		0.291
- Oral Mucosa	11 (2.3)		3 (2.8)		72 (19.0)		0.673
- No area involved	20 (4.1)		3 (2.8)		68 (18.0)		0.437
					15 (4.0)		
					8 (2.1)		
					17 (4.5)		
Previous PT, *n* (%)	69 (14.2)	485	18 (16.8)	107	51 (13.5)	378	
- Positive, *n* (%)	43 (62.3)	69	10 (55.6)	18	33 (64.7)	51	0.384

Note: the p-value refers to the differences between the two subgroups. Abbreviation: CSU, chronic spontaneous urticaria; AD, atopic dermatitis, PN, prurigo nodularis; NE, nummular eczema; MF, mycosis fungoides; F, female; M, male; PT, patch test.

Table II - *Frequency of positivity to allergens from the Italian Baseline Series 2024 in the overall population, in tattooed and non-tattooed patients undergoing patch testing.*

Compound	**Concentration %, vehicle**	**Overall population (N=485)**	**Tattoo (N=107)**	**No Tattoo (N=378)**	**p-value**
Balsam of Peru, *n* (%)	25, pet	15 (3.1)	2 (1.9)	13 (3.4)	0.539
1,2-Benzisothiazolin-3-one, *n* (%)	0.1, pet	3 (0.6)	0 (0.0)	3 (0.8)	0.597
Budesonide, *n* (%)	0.01, pet	4 (0.8)	1 (0.9)	3 (0.8)	1.000
Caine Mix, *n* (%)	10, pet	5 (1.0)	1 (0.9)	4 (1.1)	1.000
Cocamidopropyl betaine, *n* (%)	1, aq	5 (1.0)	2 (1.9)	3 (0.8)	0.591
Cobalt chloride hexahydrate, *n* (%)	1, pet	19 (3.9)	6 (5.6)	13 (3.4)	0.394
Colophony, *n* (%)	20, pet	5 (1.0)	0 (0.0)	5 (1.3)	0.360
2-Hydroxy ethyl methacrylate, *n* (%)	2, pet	2 (0.4)	1 (0.9)	1 (0.3)	0.393
Textile dye mix, *n* (%)	6.6, pet	20 (4.1)	7 (6.5)	13 (3.4)	0.169
3-Dimethylamino-1-propylamine, *n* (%)	1, aq	3 (0.6)	0 (0.0)	3 (0.8)	0.597
N-isopropyl-N'-phenyl-p-phenylenediamine, *n* (%)	0.1, pet	3 (0.6)	2 (1.9)	1 (0.3)	0.124
Compositae Mix II, *n* (%)	5, pet	1 (0.2)	0 (0.0)	1 (0.3)	1.000
Lanolin alcohols, *n* (%)	30, pet	7 (1.4)	1 (0.9)	6 (1.2)	0.704
Lyral, *n* (%)	5, pet	2 (0.4)	1 (0.9)	1 (0.3)	0.393
Formaldehyde, *n* (%)	2, aq	5 (1.0)	2 (1.9)	3 (0.8)	0.591
2-Mercaptobenzothiazole, *n* (%)	2, pet	1 (0.2)	0 (0.0)	1 (0.3)	1.000
Mercapto Mix, *n* (%)	2, pet	3 (0.6)	0 (0.0)	3 (0.8)	0.597
Fragrance mix I + Sorbitan sesquioleate, *n* (%)	8, pet	18 (3.7)	3 (2.8)	15 (4.0)	0.775
Neomycin sulfate, *n* (%)	20, pet	12 (2.5)	5 (4.7)	7 (1.9)	0.149
Kathon CG, *n* (%)	0.02, aq	11 (2.3)	1 (0.9)	10 (2.6)	0.469
Nickel sulfate, *n* (%)	5, pet	120 (24.7)	31 (29.0)	89 (23.5)	0.251
Paraben mix, *n* (%)	16, pet	2 (0.4)	0 (0.0)	2 (0.5)	1.000
p-Phenylendiamine, *n* (%)	1, pet	15 (3.1)	3 (2.8)	12 (3.2)	1.000
Potassium dichromate, *n* (%)	0.5, pet	10 (2.1)	3 (2.8)	7 (1.9)	0.699
2-Methyl-4-isothiazolin-3-one, *n* (%)	0.2, aq	16 (3.3)	1 (0.9)	15 (4.0)	0.140
Fragrance mix II, *n* (%)	14, pet	13 (2.7)	3 (2.8)	10 (2.6)	1.000
Bisphenol A epoxy resin, *n* (%)	1, pet	3 (0.6)	1 (0.9)	2 (0.5)	1.000
p-tert-Butylphenol formaldehyde resin, *n* (%)	1, pet	8 (1.6)	1 (0.9)	7 (1.9)	0.692
Sodium disulfite, *n* (%)	1, pet	4 (0.8)	1 (0.9)	3 (0.8)	1.000
Thiuram mix, *n* (%)	1, pet	4 (0.8)	2 (1.9)	2 (0.5)	0.213
Tixocortol 21-pivalate, *n* (%)	1, pet	0 (0.0)	0 (0.0)	0 (0.0)	--
Petrolatum, *n* (%)	100	0 (0.0)	0 (0.0)	0 (0.0)	--
Sorbitan sesquioleate, *n* (%)	20, pet	0 (0.0)	0 (0.0)	0 (0.0)	--

Note: the p-value refers to the differences between the two subgroups. Abbreviations: pet, petrolatum; aq, aqua.

Table III - *The MOAHLFA index for patch tested patients with tattoos (tattooed group) and without (non-tattooed group) tattoos.*

	Total patch test patients	**Negative patch test patients**	**Positive patch test patients**	**Chi square test p-value**
Non-tattooed group	**N=378**	**N=197**	**N=181**	
M	101 (26.7)	58 (29.4)	43 (23.8)	0.212
O	38 (10.1)	17 (8.6)	21 (11.6)	0.337
A	84 (22.2)	43 (21.8)	41 (22.7)	0.847
H	109 (28.8)	54 (27.4)	55 (30.4)	0.523
L	80 (21.2)	40 (20.3)	40 (22.1)	0.670
F	166 (43.9)	90 (45.7)	76 (42.0)	0.469
A	254 (67.2)	125 (63.5)	129 (71.3)	0.106
Tattooed group	**N= 107**	**N=42**	**N=63**	
M	21 (19.6)	5 (11.9)	16 (24.6)	0.106
O	11 (10.3)	4 (9.5)	7 (10.8)	1.000
A	27 (25.2)	8 (19.0)	19 (29.2)	0.236
H	34 (31.8)	9 (21.4)	25 (38.5)	0.065
L	26 (24.3)	12 (28.6)	14 (21.5)	0.408
F	50 (46.7)	22 (52.4)	28 (43.1)	0.346
A	53 (49.5)	20 (47.6)	33 (50.8)	0.750

Note: the p-value refer to the differences between the negative and positive patch test patients (Chi square test). Abbreviations: A, atopic dermatitis; A, age > 40 years; F, face dermatitis; H, hand dermatitis; L, leg dermatitis; M, male; O, occupational dermatitis.

Table IV - *Univariate and multivariate regression analysis for nickel positivity in the tattoed group.*

	Univariate			**Multivariate**		
Covariates	**p-value**	**OR**	**95% C.I.**	**p-value**	**OR**	**95% C.I.**
>5 years	**0.026**	**4.308**	**1.192-15.573**	**0.029**	**4.407**	**1.166-16.656**
M	0.964	0.976	0.382-1.099	0.750	0.836	0.279-2.504
O	0.896	0.911	0.225-3.686	0.955	0.959	0.221-4.159
A	0.374	0.629	0.226-1.749	0.538	0.707	0.234-2.132
H	0.697	0.835	0.335-2.076	0.938	0.963	0.369-2.512
L	0.467	1.420	0.552-3.652	0.567	1.338	0.495-3.618
F	0.836	0.915	0.396-2.116	0.894	0.942	0.389-2.278
A	0.783	1.124	0.487-2.593	0.603	0.785	0.315-1.957

Note: Univariate and multivariate regression analysis considering nickel positivity as dependent variable in the tattooed group. As covariates were considered: having received the first tattoo more than 5 years before 2025 and the MOAHLFA characteristics. Abbreviation: OR, odd ratio; C.I., confidence interval; A, atopic dermatitis; A (second A), age > 40 years; F, face dermatitis; H, hand dermatitis; L, leg dermatitis; M, male; O, occupational dermatitis.

Figure 1 - *Prevalence of the four most frequent contact allergens in the overall population, in tattooed individuals, and in non-tattooed individuals.*

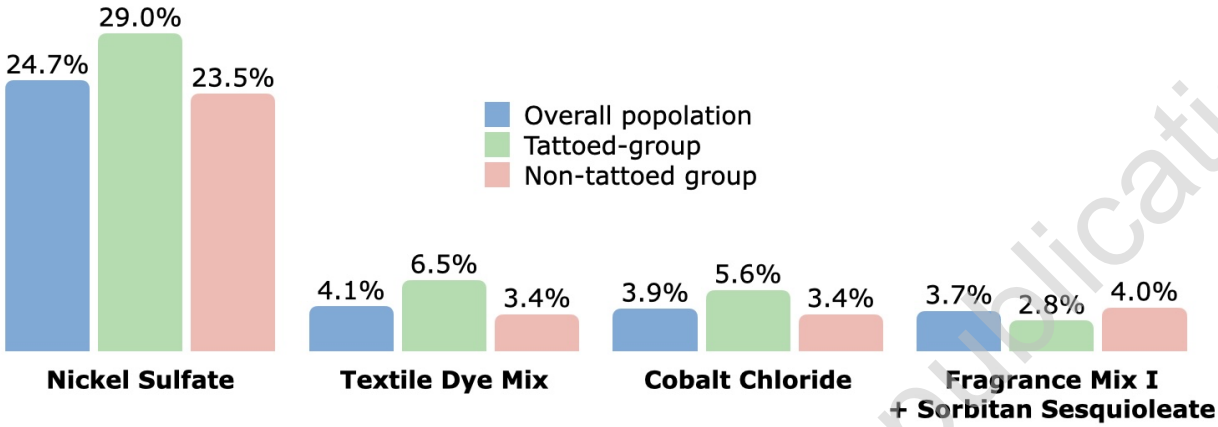

Figure 2 - *Percentage of patients in the different groups (tattooed vs. non-tattooed), based on the MOAHLFA index characteristics for patch-tested patients.*