Journal of Elementology ISSN 1644-2296

Chmielewski, J., Żeber-Dzikowska, I., Wójtowicz, B., Dziewięcka, E., Wilczkowska, A. and Miracka, I. (2025)
'Tattooing – hazardous chemicals – an underestimated health risk',
Journal of Elementology, 30(4), 631-642,
available: https://doi.org/10.5601/jelem.2025.30.2.3568

RECEIVED: 30 April 2025
ACCEPTED: 29 September 2025

ORIGINAL PAPER

Tattooing – hazardous chemicals – an underestimated health risk*

Jarosław Chmielewski[1], Ilona Żeber-Dzikowska[2], Bożena Wójtowicz[3], Edyta Dziewięcka[4], Anna Wilczkowska[4], Izabela Miracka[5]

[1] Department of Public Health
Academy of Medical Sciences of Applied and Holistic Sciences in Warsaw, Poland
[2] Faculty of Pedagogy and Psychology
The Jan Kochanowski University in Kielce, Poland
[3] Faculty of Humanities and Social Sciences
Academy of Applied Sciences in Konin, Poland
[4] Collegium Medicum
The Jan Kochanowski University in Kielce, Poland
[5] Department of Psychology
Academy of Medical Sciences of Applied and Holistic Sciences in Warsaw, Poland

Abstract

The observed increase in the number of people deciding to have a tattoo has caused skin pigmentation treatments to become increasingly popular. It is widely known that tattoo inks remain in the skin for a lifetime. It is also a known fact that chemicals used in tattoo pigments can remain in the body for a long time, which results in a significant long-term risk of harmful ingredients being placed in the body. Tattoo dyes contain various substances and their main decomposition components can cause health risks and undesirable side effects. Objective of the study: The objective of this study is to present, analyse and identify the causes of the most common complications after tattooing procedures based on the available literature as well as to draw attention to the necessity of changing the regulations concerning the use of tattoo ink and its manufacturers to ensure that tattooing does not cause adverse systemic effects. Research methods: Epidemiological studies demonstrating adverse health effects have been reviewed. Bibliometrics from the period 2020-2024 have been applied in this review. The literature was searched through PubMed, Scopus, and Google Scholar. The bibliographic data has been analysed using selected subject classification entries as a criterion. Results: All skin pigmentation procedures, whether they are decorative tattoos or permanent make-up, carry a risk of complications. Therefore, ink compositions should be strictly regulated. Conclusions: The complexity of tattoo ink compounds includes organic dyes, metals and solvents that may have dangerous effects on the human body. Further scientific research on the issue of tattooing should be conducted. There is a need to investigate the unknown long-term side effects of various inks and dyes is important in terms of wider public health. Activities within the scope of legal regulations concerning production dyes, which are essential elements of tattooing, should be undertaken.

Keywords: tattoo, heavy metals, health, complications, adverse effects

Jarosław Chmielewski, Ph.D., Academy of Medical Sciences of Applied and Holistic Sciences, St. Kasprzaka 49, 01-234 Warsaw, Poland, e-mail: jaroslaw.chmielewski@amh.edu.pl

* Source of financing: The project is financed from the Research Fund of the Jan Kochanowski University in Kielce, which is intended to support the continuity and development of the university's scientific research.

INTRODUCTION

Since time immemorial, people have been interested in decorating their bodies. Tattooing is one of the forms of body decoration that has been known for a long time. A tattoo is a graphic mark obtained on the skin by inserting pigment into the skin tissue. Currently, having a tattoo is becoming increasingly popular among adolescents and young adults (Kluger et al. 2019).

Throughout history, tattoos have held symbolic meanings. They have been used to signify membership in social groups, designate kinship relations, indicate social status and even commemorate heroic or, on the contrary, dishonorable acts. In modern times, tattoos serve a variety of purposes, including religious, cosmetic, erotic, and rebellious expressions. They also serve as evidence of undergoing various initiation rites (Cárdenas, Torres 2024).

Although the art of tattooing has a history of over five thousand years, the popularity of tattoos has increased in recent decades, not only through a greater number of procedures being performed, but also by extending its influence to a wider spectrum of social classes. The main reason for this is probably the cultural commercialisation promoted by the media as well as the fact that tattoos produce a sense of power and control over the self and are a reflection of the concept of self (Frankel et al. 2022).

Tattooing can pose health risks, not only due to potential infections, but also because of the toxic components found in the ink that is injected under the skin. It is important to consider the potential for complications, such as bacterial infections of the skin and subcutaneous tissue, allergic reactions or the formation of granulomas. Therefore, it is crucial to have a qualified tattoo artist perform the procedure in a studio that follows strict principles of aseptic and antiseptic techniques, maintains proper hygiene and uses certified equipment and dyes. It should be noted that the industrial organic pigments commonly used in modern tattoo inks have not been officially approved by any regulatory body and manufacturers are not required to disclose the chemical ingredients of their products.

Tattoo pigments can contain a variety of chemicals, including nitrogenous and polycyclic compounds as well as aluminum, cadmium, calcium, copper, iron, phosphorus, silica, sulfur, titanium dioxide and barium sulfate. These chemicals have the potential to cause skin reactions, such as rash and can even be toxic. It is important to note that allergic reactions and irritation from tattoo inks can occur many years after the initial treatment. Additionally, the ink used for a tattoo can cause inflammation of the lymph nodes after several years. Studies have shown that the pigment from the tattoo can accumulate in the lymph cells of the nodes. Furthermore, it has been found that pigment components can break down when exposed to the sun, ultraviolet radiation, or laser light (Andreou et al. 2021, Al-Qaysi et al. 2022, Negi et al. 2022).

One potential source of health hazards is the use of dyes and chemical compounds they contain. As a result, it is crucial for them to be closely regulated and become the subject to the research and interest of public health institutions.

MATERIAL AND METHODS

The scope of scientific content from PubMed, the English-language online database of the National Library of Medicine, National Institutes of Health, Bethesda, MD, USA (http://www.ncbi.nlm.nih.gov/PubMed), SCOPUS, Google Scholar has been analyzed. The literature published in available scientific information databases in the years 2020-2025 has been reviewed, with the assumption that this time frame includes the most recent scientific reports on the subject matter. The process of searching for scientific articles used search options based on keywords or their combinations (step 1, Table 1). Reviews, conference proceedings, letters to the editors, book chapters as well as conference and training notes were not included in the review and were excluded from the analysis. The search was limited to literature written in English.

Table 1

Step one of the analysis of the literature trends on the basis of key words

Key words	The used search terms include: – composition of tattoo ink, tattoo dyes, tattoo pigments – side effects, risks, complications

Two different keyword-based search groups have been applied. Published material found in databases on tattoo ink chemicals, tattoo dyes, tattoo pigments that may cause adverse health effects and adverse reactions, risks, health complications associated with tattooing has been analysed. The above-mentioned data has been reviewed and the results are discussed below. In the section regarding ink composition and health risks, information is given on the chemical composition and the potential risks associated with the use of tattoo inks in the human body, as illustrated in Tables 2 and 3.

COMPOSITION OF INK, DYES, PIGMENTS USED FOR TATTOOING

Historically, pigments of natural origin were used for tattooing; today, pigments contain a conglomerate of metallic salts, organic dyes or plastics suspended in a carrier solution for consistency of application. The carrier can be a single substance or a mixture. The purpose of the carrier is to distribute the pigment throughout the ink evenly and to prevent the pigment from clumping together to facilitate its application under the skin (Rigali et al. 2024).

Table 2

Selected metals with concentration range detected in all measured tattoo inks sorted by tattoo ink colour (modified)

Tattoo ink colour	Substance	Concentration range# (mg kg^{-1})
Black	Cd	0.001-0.14
	Co	0.01-0.07
	Cr	0.87-3.06
	Hg	0.01-0.20
	Pb	0.007-1.45
Green	Cd	0.03-0.5
	Co	0.02-0.1
	Cr	0.10-22.00
	Hg	0.01-0.2
	Pb	0.07-0.80
Blue	Cd	0.02-1.15
	Co	0.01-0.18
	Cr	0.52-3.34
	Hg	0.01-0.14
	Pb	0.01-0.87
Brown	Cd	0.008-0.35
	Co	0.003-6.44
	Cr	0.45-147.23
	Hg	0.04-0.15
	Pb	0.03-8.13
Orange	Cd	0.01-2.99
	Co	0.02-0.13
	Cr	0.43-4.72
	Hg	0.02-0.15
	Pb	0.10-14.80
Red	Cd	0.007-0.04
	Co	0.009-0.03
	Cr	1.07-4.67
	Hg	0.007-0.17
	Pb	0.05-0.42
Violet	Cd	0.003-0.92
	Co	0.01-0.04
	Cr	0.50-4.99
	Hg	0.02-0.07
	Pb	0.03-0.12

Yellow	Cd	0.05-0.25
	Co	0.003-0.02
	Cr	0.36-1.90
	Hg	0.01-0.13
	Pb	0.02-0.11
White	Cd	0.47-0.56
	Co	0.01-0.04
	Cr	0.32-0.84
	Pb	0.03-0.07
Gray	Cd	0.01-0.52
	Co	0.02-0.04
	Cr	0.37-2.05
	Hg	0.09-0.13
	Pb	0.06-0.50

The source: Fels et al. 2023, # substances with only one concentration shown were observed in only one sample.

Table 3

Characteristics of health consequences associated with tattooing in the years from 2020 to 2025

Author of the study	Health consequences
Theune et al. 2025	Of the 4,248 participants, 7.4% (n=320) reported having either a tattoo (4.7%; n=199), permanent make-up (3.1%; n=135), or both (n=14). Out of these, 5% (16/320) reported experiencing medical complications related to their tattoos. The study also found that the tattooed population had increased odds ratios for cardiologic diseases and liver toxicity in terms of systemic chronic health effects. However, the results from the tattoo questionnaire did not show any indication of non-melanoma skin cancer developing at the site of the tattoo.
Nielsen et al. 2024	The study included a total of 11,905 participants, with a response rate of 54% among cases (n=1398) and 47% among controls (n=4193). The prevalence of tattoos was found to be 21% among cases and 18% among controls. Tattooed individuals had a higher adjusted risk of overall lymphoma (IRR = 1.21; 95% CI 0.99-1.48). The risk of lymphoma was highest in individuals with less than two years between their first tattoo and the index year (IRR = 1.81; 95% CI 1.03-3.20). However, the risk decreased for those with intermediate exposure duration (three to ten years), but increased again for those who had their first tattoo ≥11 years before the index year (IRR = 1.19; 95% CI 0.94-1.50).
Chalarca-Cañas et al. 2024	Reactions to tattoos are reported in up to 67% of people who get tattooed, with papulonodular and granulomatous reactions being the most common. Some neoplastic complications have been described, however, their causality is still debated. Any pigment can cause adverse reactions, although red ink is more frequently associated with them. Patients with pre-existing dermatoses may experience exacerbation or complications of their diseases while getting tattoos; therefore, this procedure is not recommended for this patient group.

McCarty et al. 2024	The prevalence of tattooing was found to be 22% among Hodgkin lymphoma (HL) cases, 11% among non-Hodgkin lymphoma (NHL) cases, 16% among myeloid neoplasm cases and 15% among controls. While there were no clear patterns of associations between ever receiving a tattoo and the risk of HL, NHL or myeloid neoplasms overall, further analysis restricted to ages 20-60 years revealed that ever receiving a tattoo (OR 2.06; 95% CI 1.01, 4.20) and receiving a tattoo 10+ years prior (OR 2.64; 95% CI 1.23, 5.68) were associated with an aggregated group of rarer mature B-cell NHLs. Additionally, elevated risks were observed for a 10+ year latency for myelodysplastic syndromes and chronic myeloid leukemia (OR 1.48; 95% CI 0.40, 5.41, and OR 1.24, 95% CI 0.45, 3.43, respectively).
Kerna et al. 2024	Research indicates that up to 67% of individuals with tattoos experience complications, with infections, allergic reactions and scarring being common concerns. Moreover, tattoos can exacerbate existing medical conditions, particularly in individuals with diabetes, heart conditions or immunosuppressive disorders. Individuals who are pregnant or breastfeeding face additional risks due to physiological changes affecting wound healing and immune response.
Friis et al. 2024	Overall, 21.1% of participants reported having at least one tattoo. Of those, 10.2% reported experiencing skin reactions, such as itching, pain, inflammation and swelling beyond the first three weeks after getting the tattoo. The likelihood of experiencing these reactions was higher for individuals between the ages of 16 and 44 (adjusted odds ratio (AOR) ≥1.75), those with larger tattoos (AOR ≥1.61), and those who had had tattoos for more than 10 years (AOR = 2.92, 95% confidence interval 1.45-5.88). Additionally, individuals with tattoos in colours other than black were more likely to experience skin reactions.
Kinkar et al. 2023	The most commonly reported health effects and infections were bacterial infections at the site of body modification (479; 56.5%), purpura (380, 44.9%), cutaneous abscesses (380, 44%), melanoma (338, 39.9%), hepatitis B virus (321, 37.9%), HIV (311, 36.7%), sepsis (306, 36.2%), allergic contact dermatitis (296, 35%), and hepatitis C virus (279, 33.1%).
Ricci et al. 2022	In total, 35 cases of melanoma arising on tattoos on the skin were identified, with 32 males and 3 females. Interestingly, the majority of these melanomas occurred on dark blue (10/35), black (12/35) or blue (3/35) tattoos.
Rogowska et al. 2022	Twenty-one patients (40%) experienced hypersensitivity reactions to tattoo ink, with the majority (18) being triggered by red ink. In 11 cases (21%), contact dermatitis developed after tattooing, while 9 patients (17%) experienced infectious complications, such as bacterial infections, common warts, molluscum contagiosum and demodicosis. Eight cases (15%) involved papulonodular reactions in black tattoos, with histology revealing granuloma formation in 6 of these cases. In 2 cases (4%), symptoms of anaphylaxis were observed after the tattooing procedure and in another 2 cases (4%), Koebner phenomenon was diagnosed in the tattooed area.
Kluger et al. 2020	Nowadays, the majority of infections resulting from tattoos are superficial and caused by bacteria. These infections typically occur within a few days after getting a tattoo. However, there is a risk of more serious systemic infections, such as cellulitis, erysipelas, necrotizing fasciitis or bacterial endocarditis.

Barton et al. 2020	One hundred fifty-six cases (17%) with early onset basal cell carcinoma and 213 controls (26%) reported cosmetic tattoos. Among those with tattoos, the adjusted odds ratio of basal cell carcinoma at the tattoo site compared to another site was 1.8 (95% confidence interval = 1.0, 3.2). The strongest associations for yellow and green tattoo colours were observed.
Cohen et al. 2020	Tattoos have been linked to medical complications, including rare cases of skin cancer. The case of a 46-year-old man who developed a basal cell carcinoma within a tattoo on his left scapula is described, and the features of 13 other patients (7 men and 6 women) who have developed tattoo-associated basal cell carcinoma are reviewed. This type of tumour typically occurs on the sun-exposed skin of individuals aged 60 years and older and the tattoo in question has often been present for 20 years or more. The pathogenesis of a basal cell carcinoma developing within a tattoo may be merely a coincidence. However, there is supporting evidence that the tattoo and the subsequent basal cell carcinoma may be coincident events whereby either tattoo injection-associated trauma or the tattoo pigments and dyes (in their native state or after ultraviolet radiation alteration) or both have a carcinogenic impact on the development of the basal cell carcinoma at that location.

Tattoos are made using a variety of inks, dyes, and pigments from different sources. Despite their widespread use and availability on the market, the exact composition of these substances remains largely unknown. Tattoo ink is a complex chemical mixture containing multiple ingredients. In recent years, there has been a growing number of scientific reports and publications examining the composition of inks and the potential health risks associated with their use (Andreou et al. 2021, Fels et al. 2023, Rigali et al. 2024).

Unlike cosmetics, tattoo inks are not officially controlled. The origin and chemical structures of these pigments are not sufficiently understood yet. The chemical content varies and depends on the manufacturer. The danger of using tattoos, due to the heavy metals contained in the inks, depends on the type of ink used (black, coloured), the manufacturer, the size of the design and the body surface covered with it (Di Gaudio et al. 2023).

Dembska et al. conducted the study whose objective was to analyse the content of heavy metals in tattoo inks and exposure of tattooed persons to heavy metals, depending on the applied colour of the drawing and the origin of the ink. The study confirmed a wide variation in the concentrations of heavy metals (Cd, Pb, Zn, Hg, As, Cr) in the tested samples of the tattoo inks. The highest concentrations of mercury and chromium were recorded in black ink, cadmium, lead and zinc in white ink and arsenic in green ink (Dembska et al. 2017).

In this study, Karadagli et al. determined the content of metals (Cd, Hg, Pb and Cr) in the tattoo inks available on the Turkish market. Nine tattoo inks (3 colours) from 3 different brands were analysed. Concentrations of trace elements in the inks were detected as follows: Cd 0.0641-1.3857, Hg 0.0204-0.2675, Pb 0.8527-6.5981, Cr 0.1731-45.3962 ($\mu g\ mL^{-1}$). It was

observed that the levels of Pb and, especially, Cr in the samples exceeded the limits (Karadagli et al. 2023).

Evgenakis et al. presented the determination and quantification of 8 elements (As, Cd, Co, Cr, Cu, Hg, Ni, Pb) in twenty colours of tattoo ink available on the Greek market, which were imported from the United States and China. All inks contained Cr, Cu, Ni and Pb, while the content of As, Cd and Co was below the detection limit in specific samples. Mercury was determined in three samples. The highest concentrations were observed for chromium, copper, and nickel, while cadmium and mercury levels were generally low. Interestingly, the majority of the elements reached their maximum levels in brown ink from the USA.

The selected identified chemical composition of tattoo inks, dyes and pigments has been presented in Table 2 (Fels et al. 2023). Additionally, Table 4 shows the maximum allowed concentrations of specific metals in tattoo inks (Di Gaudio et al. 2023).

Table 4

Maximum allowed concentrations of metals and metalloids recommended by the Council of Europe and the European Union

Maximum allowed concentrations ($\mu g g^{-1}$)	As	Ba	Cd	Co	Cr	Cu	Hg
ResAP (2008)1 MAC	2	50	0.2	25	0.2	25(a)	0.2
Commission Regulation 2020/2081 MAC	0.5	500(a)	0.5	0.5	0.5	250(a)	0.5
Maximum allowed concentrations ($\mu g g^{-1}$)	Ni	Pb	Sb	Sn	Sr	V	Zn
ResAP (2008)1 MAC	(b)	2	2	50	34	0.3	50
Commission Regulation 2020/2081 MAC	5	0.7	0.5	0.5(c)	1.8	3.5	2000(a)

The source: Di Gaudio et al. 2023, (a) soluble, (b) as low as technically achievable, also, the presence of trace amounts of nickel in tattoo products should be indicated on the packaging along with a warning (for example, Contains nickel. May cause allergic reactions), (c) organometallic.

Health risks

Through the skin, substances contained in inks, dyes, pigments are absorbed into the body. The skin is one of the most important barriers that separates the body from the external environment. It provides a solid, flexible and self-repairing barrier to the external environment, protecting the body's internal organs and fluids from negative influences from the outside. Absorption through the skin depends on a number of factors, including skin condition, age, ambient temperature and humidity and chemical properties of the specific agents. Absorption of xenobiotics through the skin, including compounds contained in tattoo inks, can be divided into two types: through the epidermis (transepidermal transport) and through the hair and seba-

ceous system (transfollicular transport), through which electrolytes and heavy metals are absorbed, along with their organic compounds (Hofmann et al. 2023).

The introduction of tattoo ink into the body is a serious health concern, as evidenced by data from 2016 which shows that exposure to tattoo inks is widespread in the general population. According to estimates, approximately 24% of the United States (US) population and 12% of the European population have at least one tattoo, including adolescents (Piccinini et al. 2016). In Germany, a 2017 study found that 24% of people admitted to having at least one tattoo (Fels et al. 2023). Additionally, a 2018 study revealed that the prevalence of respondents with at least one tattoo ranged from 25% in Israel to 48% in Italy (Kluger et al. 2019).

In recent years, there has been a growing number of scientific reports and publications focusing on the composition of inks and their potential health effects.

Comparison of the levels of contaminants in tattoo inks with the permissible concentrations set out in REACH (Table 5) enables one to assess whether these compounds pose a potential risk to tattoo artists (Fels et al. 2023).

Health consequences associated with tattooing are shown in Table 3.

Table 5

Concentration limits of substances set by the European Parliament and the Council in relation to REACH for substances in tattoo inks and permanent makeup in Regulation (EU) No. 2020/2081

Substances	Concentration limit[a] (mg kg^{-1})
Classified as carcinogen or germ cell mutagen (group 1A, 1B or 2)	0.5
Classified as toxic to reproduction	10
Classified as skin sensitizers	10
Classified as skin corrosive or irritant or serious eye damaging/eye irritant	100
Prohibited for use in cosmetic products in Annex IV of Regulation (EC) 1223/2009, subject to any of the following conditions: rinse-off products, not to be used in products applied on mucous membranes, not to be used in eye products [b]	0.5
Listed in Appendix 13 of Regulation (EU) No. 2020/2081	specific concentration limits
Mercury [c]	0.5
Nickel [c]	5.0
Cadmium [c]	0.5
Chromium [c]	0.5
Cobalt [c]	0.5
Lead [c]	0.7
Benzo[a]pyrene [c]	0.005
PAH (classified as carcinogen or germ cell mutagen (category 1A, 1B or 2))[c]	0.5

The source: Fels et al. 2023, [a] – concentration limits converted from % (w/w) to mg kg^{-1}; [b] – REACH Regulation (EU) No. 2020/2081, cross-references Cosmetics Regulation (EC) No. 1223/2009, because the EU Commission considers that if a substance is restricted for use on the skin, it must also be restricted for use in products that penetrate the skin, c – the substances and concentration limits shown are taken from Annex 13 of REACH Regulation (EU) No. 2020/2081.

CONCLUSIONS

After our analysis of the literature, the following conclusions have been drawn:

1. In terms of prevention of tattooing complications, it is important to raise public awareness of the skin pigmentation process and its possible complications. Health alerts, educational programmes and warnings on product labels should be implemented to increase public awareness of the problem.

2. It is necessary to conduct studies to determine the extent of the problem, the sources of risk and the potential health risks associated with exposure.

3. Taking into account the increasing popularity of tattooing and the possible presence of harmful substances in tattoo products, there is a need for regulation to reduce the risks associated with their use.

4. An assessment of exposure from tattooing to chemicals that demonstrates any associated health risks is required.

Author contributions

J.C. – designed the research, J.C., I.Ż.D., B.W., E.D., A.W. – analyzed data and wrote the manuscript. All authors have read and approved the manuscript.

Conflicts of interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article. The present research did not receive any specific donation from any funding agency in the public, commercial or non-profit sector. Artificial intelligence (AI) was not used in the creation of the paper.

REFERENCES

Andreou, E., Hatziantoniou, S., Rallis, E., Kefala, V. (2021) 'Safety of tattoos and permanent make up (PMU) Colorants', *Cosmetics*, 8(2),47, available: https://doi.org/10.3390/cosmetics 8020047

Al-Qaysi, W.W., Hammood, M.K., Tawfeeq, E.N. (2022) 'Analytical methods for the identification of pigments in tattoo inks and some of their physiological side effects: A review', *Current Pharmaceutical Analysis*, 18(2), 161-175, available: https://doi:10.2174/1573412917 666210303114759

Barton, D.T., Zens, M.S., Marmarelis, E.L., Gilbert-Diamond, D., Karagas, M.R. (2020) 'Cosmetic tattooing and early onset basal cell carcinoma: A population-based case-control study from New Hampshire', *Epidemiology*, 31(3), 448-450. available: https://doi.org/10.1097/ EDE.0000000000001179

Cárdenas, K.A., Torres, A.M. (2024) 'Tattoos and body modification: culture, therapy, and history', *Praxis and Saber*, 15(43), 1-21, available: https://doi.org/10.19053/uptc.22160159. v15.n43.2024.17472

Chalarca-Cañas, D., Caviedes-Cleves, M.A., Correa-Londoño, L.A., Ospina-Gómez J.P., Velásquez-Lopera, M.M. (2024) 'Tattoos: risks and complications, clinical and histopathological approach', *AnaIS Brasilieros de Dermatologia*, 99(4), 491-502. available: https://doi.org/10.1016/j.abd.2023.07.004

Cohen, P. R., Erickson, C. P., Uebelhoer, N. S., Calame, A. (2020) 'Tattoo-associated basal cell carcinoma: coincident or coincidence', *Biomedicine Hub*, 5(2), 1-8, available: https://doi.org/10.1159/000508208

Dembska, A., Rogala, D., Piekut, A., Spychała, A., Hajok, I. (2017) 'Content of heavy metals in tattoo ink – health risk', *Medycyna Og*ólna i *Nauki Zdrowia*, 23(3), 210-214. (in Polish) available:https://doi.org/10.26444/monz/76203

Di Gaudio, F., Amorello, D., Ferrara, M., Orecchio, S., Orecchio, S. (2023) 'Heavy metals in tattoo inks: developing an analytical methodology for accessing customer safety', *Chemistry Select*, 8(20), e202300986, available: https://doi.org/10.1002/slct.202300986

Evgenakis, E., Giouri, K., Bourliva, A., Christophoridis, C., Zacharis, C. K., Fytianos, K. (2023) 'Determination of Selected Elements in Commercially Available Tattoo Inks of the Greek Market Using Atomic Absorption Spectrometry', *Analytical Letters*, 57(7), 1038-1053, available: https://doi.org/10.1080/00032719.2023.2237141

Fels, P., Lachenmeier, D. W., Hindelang, P., Walch, S. G., Gutsche, B. (2023) 'Occurrence and regulatory evaluation of contaminants in tattoo inks', *Cosmetics*, 10(5), 141, available: https://doi.org/10.3390/cosmetics10050141

Frankel, S., Childs, M., & Kim, Y.K. (2022) 'Tattooed individuals in a community: Motivations and identities', *Deviant Behavior*, 44(4), 620-635. available: https://doi.org/10.1080/01639625.2022.2079442

Friis, K., Ladehoff Thomsen, A.M., Olsen, J., Rahbek Rørth, M., Serup, J. (2024) 'Tattoo – associated skin reactions: A danish population-based survey in 5,914 tattooed individuals', *Dermatology*, 240(2), 297-303, available: https://doi.org/10.1159/000535536

Hofmann, E., Schwarz, A., Fink, J., Kamolz, L.-P., Kotzbeck, P. (2023), 'Modelling the complexity of human skin in vitro', *Biomedicines*, 11(3), 794, available: https://doi.org/10.3390/biomedicines11030794

Karadagli, S.S., Kaftan, G., Cansever, I., Armagan, G. (2023), 'Tattoo inks: evaluation of cellular responses and analysis of some trace metals', *BioMetals*, 37(2), 495-505, available: https://doi.org/10.1007/s10534-023-00564-z

Kerna, N.A., Carsrud, N.V., Azi, C. I., Jeremiah, S.M., Anderson II, J., Ngwu, D.C., Akuma, O.M. (2024) 'Medical and societal implications of tattoos: from ancient traditions to modern risks and removal challenges', *European Journal of Arts, Humanities and Social Sciences*, 1(3), 45-59, available: https://doi.org/10.59324/ejahss.2024.1(3).04

Kinkar, L.I., Magboul, M.A., Alamri, G.E., Shaheen, E.A., Altalhi, E.R., Alharthi, A.M., Baabdullah, A. (2023) 'Knowledge and attitude towards cutaneous complications of tattoos and piercings among the general population in Saudi Arabia', *Cureus*, 15(12), available: https://doi.org/10.7759/cureus.49912

Kluger, N., Seite, S., Taieb, C. (2019) 'The prevalence of tattooing and motivations in five major countries over the world', *Journal of the European Academy of Dermatology and Venereology*, 33(12), e484-e486, available: https://doi.org/10.1111/jdv.15808

Kluger, N. (2020) 'Systemic diseases and infections, anecdotal complications and oddities associated with tattooing', *Presse Medicale*, 49(4), 104055, available: https://doi.org/10.1016/j.lpm.2020.104055

McCarty, R.D., Trabert, B., Kriebel, D., Millar, M.M., Birmann, B.M., Grieshober, L., Doherty, J.A. (2024) 'Tattoos and risk of hematologic cancer: A population-based case – control study in Utah', *Cancer Medicine*, 13(20), e70260, available: https://doi.org/10.1002/cam4.70260

Negi, S., Bala, L., Shukla, S., Chopra, D. (2022) 'Tattoo inks are toxicological risks to human health: A systematic review of their ingredients, fate inside skin, toxicity due to polycyclic

aromatic hydrocarbons, primary aromatic amines, metals, and overview of regulatory frameworks', *Toxicology and Industrial Health*, 38(7), 417-434, available: https://doi:10.1177/07482337221100870

Nielsen, C., Jerkeman, M., Jöud, A. S. (2024) 'Tattoos as a risk factor for malignant lymphoma: a population-based case – control study', *EClinicalMedicine*, 72, available: https://doi.org/10.1016/j.eclinm.2024.102649

Piccinini, P., Pakalin, S., Contor, L., Bianchi, I. (2016) 'Safety of tattoos and permanent make-up: adverse health effects and experience with the Council of Europe Resolution (2008) 1', *Report on Work Package, 3*, available: https://data.europa.eu/doi/10.2788/177900

Rigali, S., Cozzi, C., Liszewski, W. (2024) 'Identification of the pigments used in permanent makeup and their ability to elicit allergic contact dermatitis', *Journal of American Academy and Dermatology*, 91(3), 474-479. available: https://doi.org/10.1016/j.jaad.2024.05.067

Ricci, F., Fania, L., Antonelli, F., Ricci, F., Perino, F., Di Lella, G., Abeni, D. (2022) 'Melanoma on tattoos: a case study and review of the literature', *European Journal of Dermatology*, 32(6), 703-708, available: https://doi.org/10.1684/ejd.2022.4353

Rogowska, P., Sobjanek, M., Sławińska, M., Nowicki, R.J., Szczerkowska-Dobosz, A. (2022) 'Tattoos dermatological complications: analysis of 53 cases from northern Poland', *Dermatology*, 238(4), 799-806, available: https://doi.org/10.1159/000520752

Theune, L.E., Ghoreishi, N., Müller-Graf, C., Engel, C., Wirkner, K., Baber, R., Giulbudagian, M. (2025) 'Characteristics of a tattooed population and a possible role of tattoos as a risk factor for chronic diseases: Results from the LIFE-Adult-Study', *medRxiv*, 2025-01, available: https://doi.org/10.1101/2025.01.31.25321465