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Incidence of Tattoo-Associated Melanoma in the Netherlands (1991–2023): A Nationwide Registry Study

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Keywords
Tattoo · Melanoma · Retrospective cohort · Tattoo pigment · Dermato-oncology

Abstract
Introduction: Tattooing is an increasingly prevalent practice that is associated with various clinical complications. The carcinogenic potential of tattoo pigments remains unclear. While 45 case reports have described melanomas colocalizing with tattoos thus far, a pathogenetic link between tattoos and melanomas remains unproven. No nationwide epidemiological study has investigated the incidence of tattoo-associated melanoma (TAM). This study's objectives are to determine the incidence of TAM in the Netherlands from 1991 to 2023, analyse TAM characteristics and patient demographics, and compare these findings with melanoma data from the general Dutch population during the same period. ***Methods:*** Data were obtained from the nationwide network and registry of histo- and cytopathology in the Netherlands (PALGA). Malignant and benign melanocytic lesions on the tattooed skin were included. Patient demographics and melanoma characteristics were extracted and analysed. Data from the Netherlands Cancer Registry (NKR) were used for comparison. ***Results:*** From 1991 to 2023, 94 TAMs and 467 benign melanocytic lesions (BMLs) on tattoos were identified. The annual incidence of TAMs has increased over time. TAMs were diagnosed at an overall median age of 48.0 years, predominantly in males (64.9%). The median Breslow thickness was 0.9 mm, and most TAMs were TNM stage I (76.6%). The number needed to excise was 6.0. ***Conclusion:*** Ninety-four unique TAMs were identified in the Netherlands, which makes the largest case series to date. However, TAM incidence remained low (0.07%) compared to the total melanoma incidence, indicating that tattoos likely do not increase the risk of

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melanoma. A diagnostic delay from obscuring was considered unlikely based on the presented findings. This nationwide cohort study found no evidence supporting a causal relationship between tattoos and melanoma.

Plain Language Summary

The popularity of tattoos is on the rise: at least 12% of the European population has one or more tattoos, increasing up to 30% among younger generations. However, tattoos can lead to various clinical complications. Uncertainty exists whether tattoos could increase the risk of skin cancer, including melanoma – the most aggressive form of skin cancer, which can be fatal if not diagnosed early. While some cases of tattoo-associated melanoma (TAM) have been described in medical literature, it remains unclear if tattoos increase the risk of melanoma. In order to determine a possible connection between tattoos and melanoma, more information on the incidence of TAM is necessary, which is explained as how often melanoma forms within tattoos. Therefore, we investigated the incidence of TAMs in the Netherlands from 1991 to 2023, which is the first time this topic is researched on a nationwide scale. Using data from a Dutch Pathology Registry (PALGA), we found 94 unique TAMs in 1991–2023. While this is more than double the number reported in literature thus far, the incidence is still low compared to the total amount of 142,492 melanoma cases in the Netherlands during that period. The Breslow thickness, a measure used for melanoma staging, remained consistently low (0.9 mm) over time. These and other findings indicate that tattoos are unlikely to play a significant role in melanoma development, or worsen prognosis. Similar studies can be performed in other countries to confirm our findings.

Introduction

Decorative tattooing is increasingly popular [1]. Although generally perceived as safe, tattoos have been associated with complications, including infections, allergic contact dermatitis, and granulomatous reactions [2–4]. While these complications are well-established, it remains unclear whether tattoos could increase the risk of cancer. For instance, Nielsen et al. [5] recently explored the link between tattoos and malignant lymphoma, but found no convincing association [6]. At the skin level, malignancies, including melanoma, have been reported in tattooed areas [1, 7, 8]. Beyond their potential direct carcinogenic effects, tattoos could obscure clinical signs of melanoma, potentially delaying diagnosis, leading to advanced disease stages, and worsening prognosis [1, 8, 9]. As tattooing continues to gain popularity, further research is needed to clarify its role in melanoma development.

If an association exists between tattoos and melanoma pathogenesis, the composition of tattoo ink could be a contributing factor. Tattoo inks are complex chemical mixtures containing pigments, precursors and by-products of pigment synthesis, and various additives [10]. Although tattoo inks are generally perceived as safe, chemical analyses repeatedly identified compounds classified by the International Agency for Research on Cancer (IARC) as carcinogenic or potentially carcinogenic to humans [5, 11]. Inks may contain carcinogenic impurities such as polycyclic aromatic hydrocarbons (PAHs) and degradation products of (azo) pigments, including primary aromatic amines [10, 12].

Pigment degradation may occur months to even years after a tattoo is applied because of UV exposure, metabolic processes, or laser removal [13]. Depending on the pigment type and its degradation rate, tattooed skin can be exposed to carcinogens for prolonged periods of time, potentially contributing to melanoma development. To address safety concerns, the European Union (EU) introduced restrictions on hazardous chemicals in tattoo inks under the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) Regulation in January 2022 [14]. However, concerns remain regarding the sufficiency and feasibility of these regulations, and compliance with their standards [15, 16].

Several case studies and literature reviews have explored the possible association between tattoos and melanomas, but the pathogenetic relationship remains unclear because of the limited number of cases [1, 8, 17, 18]. From 1938 to 2024, only 43 cases have been reported, with a recent review adding two more, bringing the total to 45 [8, 19]. To date, no nationwide epidemiological study has investigated the incidence of tattoo-associated melanoma (TAM). This study addresses this gap by analysing data from the nationwide network and registry of histo- and cytopathology in the Netherlands (PALGA). Its primary objectives were to determine TAM incidence, calculate the ratio of TAMs to tattoo-associated benign melanocytic lesions (BMLs), and compare TAM data with melanoma data from the general Dutch population from 1991 to 2023.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
I1: Skin lesion colocalized with intentionally acquired tattoo	E1: Skin lesion not colocalized with intentionally acquired tattoo
I2: Skin lesion possibly colocalized with intentionally acquired tattoo, combined with histopathological observation of tattoo pigment	E2: Skin lesion colocalized with a non-intentionally acquired tattoo (e.g., traumatic tattoo)
	E3: Skin lesion possibly colocalized with intentionally acquired tattoo, though no histopathological observation of tattoo pigment
	E4: Non-melanocytic skin lesions colocalized with intentionally acquired tattoo
	E5: Exclusion for other reasons, specified on a case-by-case basis, primarily due to uncertainty or unclear descriptions
	E6: Duplicates

I, inclusion criterion; E, exclusion criterion.

Methods

Study Design and Data Source

This study employed an epidemiological retrospective exploratory cohort design using data from a nationwide network and registry of histo- and cytopathology in the Netherlands. Since 1991, PALGA has systematically collected reports from all 64 pathology laboratories in the Netherlands [20]. All patient records from 1991 to 2023 with malignant or BMLs on tattooed skin were included.

Data Collection

Patient data were retrospectively collected after obtaining ethical approval from the Privacy and Scientific Committee of PALGA (application number 2023-133). Two targeted queries were formulated to identify relevant cases (online suppl. material A; for all online suppl. material, see https://doi.org/10.1159/000549503): one focused on references to melanomas and tattoos, the other on nevi and tattoos. The anonymized datasets comprised patient demographics and histology reports, including conclusions and microscopy results, where available. All cases were manually reviewed for eligibility. Data were screened to identify tattoo-associated lesions (TAMs and BMLs), with predefined inclusion and exclusion criteria to ensure consistency in patient selection (Table 1). Uncertain cases were re-evaluated in multidisciplinary meetings with research physicians, dermatologists, and pathologists to minimize the risk of misclassification bias. Duplicates were resolved and revisions, re-excisions, and recurrences were consolidated to avoid double counting.

Data Compilation

Lesions were classified into three categories: benign (including dysplastic and spitz), intermediate (melanoma in situ, superficial atypical melanocytic proliferation of uncertain significance [SAMPUS], melanocytic tumour of uncertain malignant potential [MELTUMP]), and invasive melanoma. The relevant characteristics of TAMs and BMLs, including patient demographics, clinical features, histopathological findings, and TNM classification, were extracted and compiled. Staging was conducted based on the 8th edition of the American Joint Committee on Cancer (AJCC) melanoma staging system [21].

Data Analysis

Categorical variables are presented as numbers and percentages, while discrete and continuous variables are reported as medians with ranges. Selected features were grouped in 5-year intervals to identify temporal trends. No TAMs were registered between 1991 and 1998. Hence, this period was combined into a single longer interval. The number needed to excise (NNE) was calculated as the ratio of total melanocytic lesions on tattoos to TAMs [22].

Netherlands Cancer Registry Data

To compare TAM characteristics with those of melanomas in the general Dutch population, data from the Netherlands Cancer Registry (NKR) were obtained using the NKR Data & Figures application [23]. Information on the incidence, sex, age, and stage at diagnosis from 1991 to 2023 were extracted and analysed. However, detailed histopathological data were not available through the NKR Data & Figures application. Further details on NKR data sourcing are provided in online supplementary material B.

Results

Melanomas in the General Dutch Population (NKR)

In 1991–2023, 142,492 melanomas were diagnosed in the Netherlands, with a higher incidence among females (n = 76,341; 53.6%) than males (n = 66,151; 46.4%). An increasing trend in the annual incidence was observed, as shown in Figure 2. In the total population, the median age at diagnosis was calculated at 59.5 years. Most melanomas were classified as stage I (61.4%) (Table 2).

Inclusion

The search conducted using PALGA identified 4,475 lesion excerpts from 4,416 patients (online suppl. material A). During initial screening, 627 excerpts with tattoo-associated lesions were selected. After deduplication, 613 excerpts were retained. Additionally, 44 cases were excluded based on various exclusion criteria. The final dataset comprised 569 patient excerpts representing 561 separate melanocytic lesions. Among these, 94 were classified as TAM and 467 as BML (Fig. 1).

Malignant-to-Benign Ratio and NNE

The ratio of malignant to benign tattoo-associated melanocytic lesions was 1:5, with a calculated NNE of 6.0.

Tattoo-Associated BMLs

The median age at BML diagnosis was 37 years, with a higher incidence in males (n = 264; 56.5%). The majority of the histological subtypes consisted of common nevi (n = 428; 91.7%); the remaining BMLs were classified as dysplastic (n = 31; 6.6%) and Spitz nevi (n = 8; 1.7%) (online supplementary material C; Table 1).

Tattoo-Associated Melanomas

The annual TAM incidence increased over time, paralleling the trend observed for total melanomas in the Dutch population (Fig. 2). The overall incidence of TAM during the study period was low, comprising 0.07% of all diagnosed cutaneous melanoma cases in the Netherlands. The characteristics of the included TAMs (n = 94) are summarized in Table 2. Each excerpt contained a single TAM except for 1 case with two TAMs, which were located on separate tattoos. One case involved permanent makeup, specifically, tattooed eyebrows.

Breslow thickness categorization revealed that most TAMs measured <0.8 mm (n = 39; 41.5%), followed by the 1.1–2.0 mm subgroup (n = 20; 21.3%). The majority of patients were diagnosed with clinical stage I (n = 72; 76.6%). Anatomically, most TAMs were located in the upper extremities (n = 41; 43.6%), followed by the trunk (n = 38; 40.4%), lower extremities (n = 9; 9.6%), and the head/neck region (n = 1; 1.1%).

Additional histopathological characteristics were occasionally observed in TAMs (Table 3). Table 4 presents selected TAM features stratified into 5-year intervals. Males were diagnosed more frequently with TAMs than females, although this difference appears to diminish over time. The median age at diagnosis showed an increasing trend. The median Breslow thickness remained consistent across intervals, except for 1999–2003, where the median was based on a single value owing to incomplete data for one of the 2 cases. In the four most recent intervals (2004–2023), the majority of TAMs were classified as stage I. Anatomically, the upper extremities and trunk consistently represented the most common sites for TAMs over time (Table 4).

Discussion

The association between tattoos and melanomas remains a topic of debate, with case studies and systematic reviews highlighting the need for further research and robust data. While isolated TAM cases may no longer be considered significant for dermatologists to report due to existing case reports in the literature, larger case series could potentially elucidate this debated issue. To our knowledge, this is the first epidemiological study to evaluate TAM incidence on a nationwide scale. Using registry data, 94 unique TAM cases were identified in the Netherlands from 1991 to 2023 – the largest series to date [8]. However, these cases accounted for only 0.07% of the 142,492 melanomas recorded by the NKR during the same period [23]. While both TAM and total melanoma incidence showed an upward trend and tattoo prevalence increased, the absolute number of TAMs remained low. This suggests that tattoos are unlikely to play a significant role in melanoma pathogenesis. Nevertheless, causality cannot be ruled out definitively based on this single study.

Key Differences between TAM and General Melanoma Characteristics

This study identified key differences between TAMs and melanoma in the general population. TAMs were nearly twice as common in males, in contrast to the

Table 2. Patient demographics, incidence, and characteristics of TAMs vs. total melanoma registered in the Netherlands Cancer Registry (NKR)

	Tattoo-associated melanoma (TAM)	Total melanoma (NKR)
Incidence, *n* (%)	94 (100.0)	142,492 (100.0)
Sex, *n* (%)		
Male	61 (64.9)	66,151 (46.4)
Female	33 (35.1)	76,341 (53.6)
Age, years (range)		
Median	48.0 (24–77)	59.5 (N/A)
Melanoma stage, *n* (%)		
I	72 (76.6)	87,492 (61.4)
II	17 (18.1)	25,001 (17.5)
III	–	12,873 (9.0)
IV	–	4519 (3.2)
Unknown[a]	5 (5.3)	12,607 (8.8)
Topography, *n* (%)		
Head/neck	1 (1.1)	–
Trunk	38 (40.4)	–
Upper extremity	41 (43.6)	–
Lower extremity	9 (9.6)	–
Missing	5 (5.3)	–
Category, *n* (%)		
Invasive melanoma[b]	90 (95.7)	–
Melanoma in situ	2 (2.1)	–
Intermediate[c]	2 (2.1)	–
Breslow thickness, mm (range)		
Median	0.9 (0.2–10.0)	–
Subcategories Breslow thickness, mm, *n* (%)		
<0.8	39 (41.5)	–
0.8–1.0	16 (17.0)	–
1.1–2.0	20 (21.3)	–
2.1–4.0	12 (12.8)	–
>4.0	2 (2.1)	–
Missing	5 (5.3)	–
Ulceration, *n* (%)		
Yes	10 (10.6)	–
No	74 (78.7)	–
Missing	10 (10.6)	–

Percentages may not total 100 due to rounding adjustments. DPN, deep penetrating nevus; MELTUMP, melanocytic tumour of uncertain malignant potential; N/A, not available; NKR, Netherlands Cancer Registry; SAMPUS, superficial atypical melanocytic proliferation of uncertain significance; TAM, tattoo-associated melanoma. [a]NKR melanoma staging data were not yet available for 2023; these cases were categorized as "unknown." [b]Superficial spreading (*n* = 78), nodular (*n* = 5), DPN-like (*n* = 1), lentigo maligna (*n* = 1), not specified (*n* = 5). [c]SAMPUS (*n* = 1), MELTUMP (*n* = 1).

higher overall melanoma rates in females. This sex-based difference may reflect a greater prevalence, number, or size of tattoos among males, although data on Dutch tattoo demographics are limited.

The NNE for TAMs was 6.0, notably lower than the average NNE of 9.71 for general melanomas reported in a meta-analysis, which varied by clinical setting: 22.62 in primary care, 9.60 for dermatologists, and 5.85 for pigmented lesion specialists [24]. This lower NNE might result from reluctance to excise tattooed lesions in order to avoid damaging tattoos, leading to excisions only when malignancy is strongly suspected.

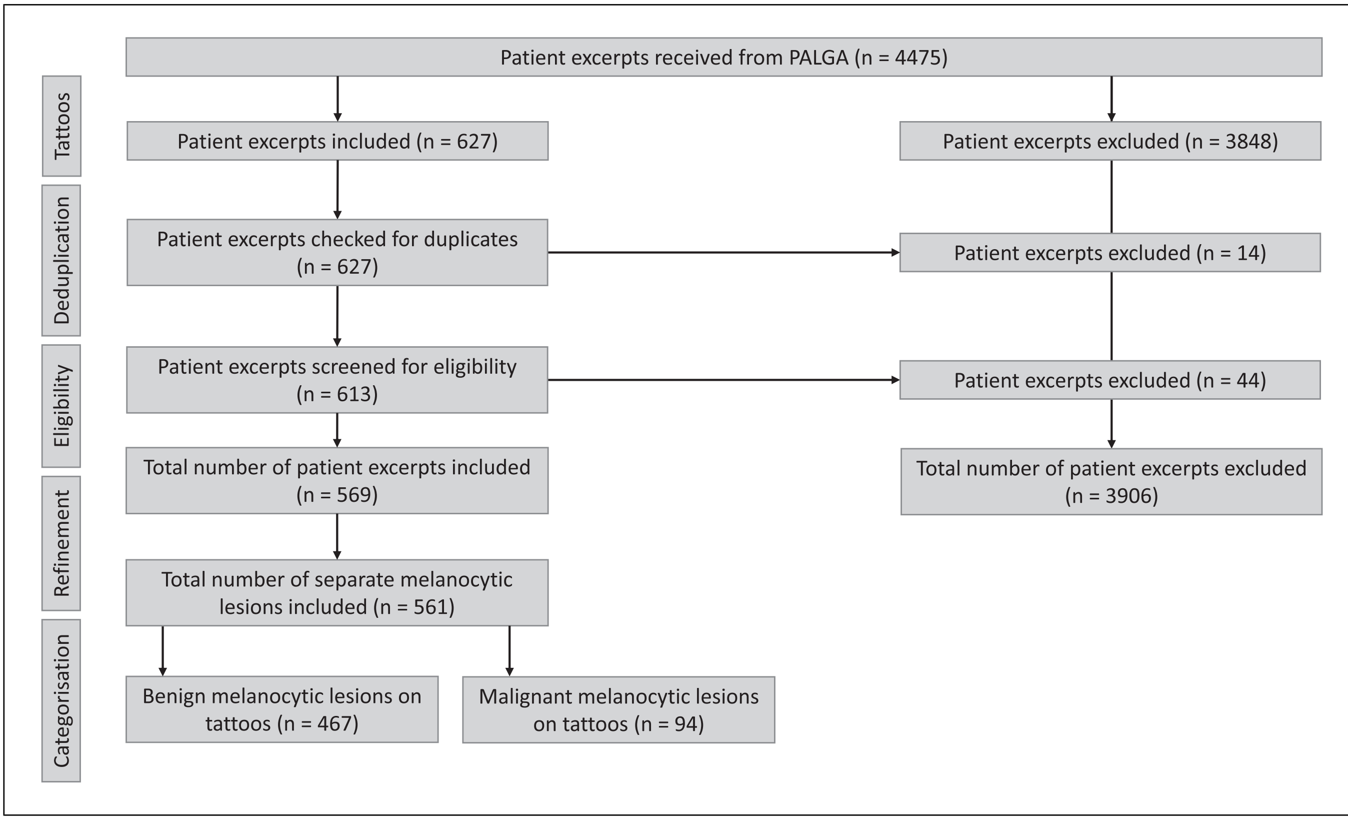

Fig. 1. Flow chart of the inclusion process. *n*, number.

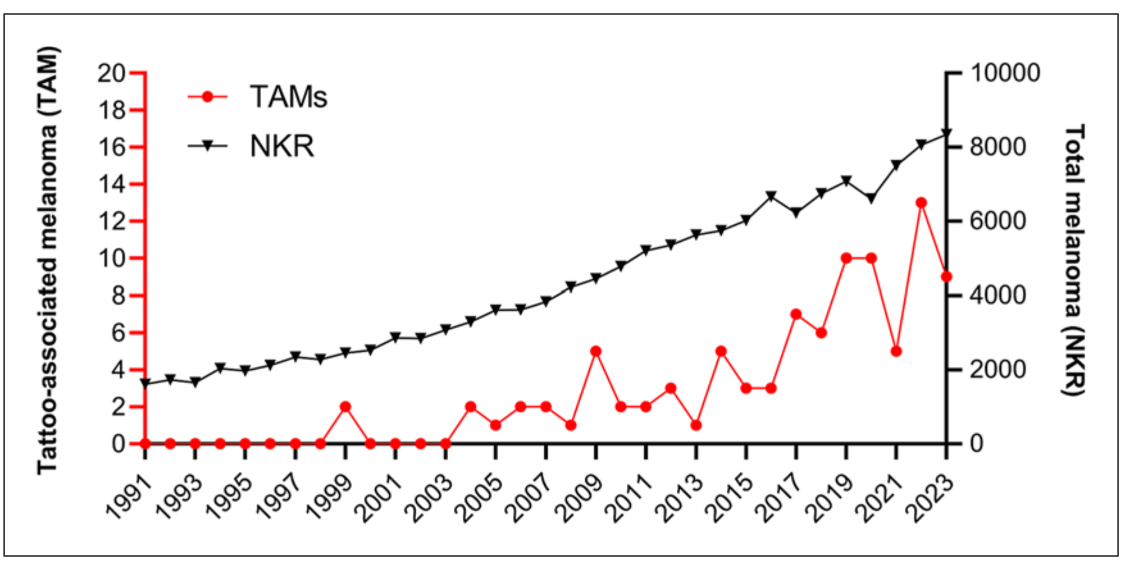

Fig. 2. Annual TAM incidence (TAMs; left *Y*-axis; red dotted line) and annual total melanoma incidence (NKR; right *Y*-axis; black dotted line) in the Dutch population from 1991 to 2023. The total annual incidence of melanoma was determined on the basis of the Dutch National Cancer Registry. TAMs (*n* = 94) comprised 0.07% of all melanomas (*n* = 142,492). NKR, Netherlands Cancer Registry; TAM, Tattoo-associated melanoma.

Table 3. Histopathological features of TAMs

Histopathological feature, *n* (%)	Yes	No	No information
Microsatellites	1 (1.1)	76 (80.9)	17 (18.1)
Regression	13 (13.8)	55 (58.5)	26 (27.7)
Dermal mitoses	26 (27.7)	11 (11.7)	57 (60.6)
Lymphangio invasion	1 (1.1)	26 (27.7)	67 (71.3)
Perineural growth	1 (1.1)	17 (18.1)	76 (80.9)

Percentages may not total 100 due to rounding adjustments. *n*, number; TAM, tattoo-associated melanoma.

Table 4. Patient and melanoma characteristics of TAMs, stratified in 5-year intervals[1]

	1999–2003	2004–2008	2009–2013	2014–2018	2019–2023
Incidence, *n* (%)	2 (2.1)	8 (8.5)	13 (13.8)	24 (25.5)	47 (50.0)
Sex, *n* (%)					
Male	2 (100.0)	8 (100.0)	10 (76.9)	14 (58.3)	27 (57.5)
Female	0 (0.0)	0 (0.0)	3 (23.1)	10 (41.7)	20 (42.6)
Age, years	38 (24–52)	39 (25–52)	40 (26–69)	50 (24–77)	49 (31–76)
Category, *n* (%)					
Invasive melanoma	2 (100.0)	8 (100.0)	13 (100.0)	23 (95.8)	44 (93.6)
Melanoma in situ	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.2)	1 (2.1)
Intermediate	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (4.3)
Breslow thickness, mm	2.3 (N/A)	1.0 (0.3–1.6)	0.8 (0.3–3.6)	0.9 (0.4–10.0)	0.9 (0.2–4.0)

Values are presented as medians (range) unless otherwise stated. mm, millimetre; N/A, not available; *n*, number; TAM, tattoo-associated melanoma. [1]The years 1991–1998 are excluded, as no TAMs were registered during this interval. Percentages may not total 100 due to rounding adjustments.

Tattoos may also obscure melanoma signs, delaying the detection of subtle changes and resulting in excisions at later stages [1, 8, 9]. However, TAMs in this study exhibited a lower median Breslow thickness (0.9 mm) and were predominantly diagnosed at stage I, similar to general melanomas, suggesting that diagnostic delays are unlikely despite these diagnostic challenges.

The low Breslow thickness and early stage diagnosis of TAMs may be attributed to the increased noticeability of suspicious changes within the tattoos. Since existing nevi are typically avoided during tattooing, alterations in nevi or newly formed pigmented lesions within tattoos may be more apparent [25, 26]. This increased noticeability likely prompts earlier clinical evaluation, potentially explaining why TAMs are diagnosed at a younger median age of 48.0 years compared to the general Dutch melanoma population, where the median age ranges from 51.0 to 64.2 years (NKR: 59.5 years) [27–29]. Similarly, a systematic review by Lebhar et al. [8] reported a lower age of diagnosis for TAMs (45.2 years) compared to 60.6 years in the general population. However, this age difference may partly reflect the prevalence of high cumulative sun damage melanomas, such as desmoplastic and lentigo maligna subtypes, which are more common in older individuals [30].

Considering the Limited Role of Tattoos in Melanoma Development

The potential carcinogenicity of tattoo pigments, which might contribute to earlier TAM onset, lower NNE, and younger age at diagnosis, warrant consideration. While tattoos have been suggested to increased lymphoma risk, the proposed mechanism appears to be less relevant to melanoma [5]. Degraded pigments and impurities can migrate to regional lymph nodes, potentially exposing proliferating cells to carcinogens [5, 7]. However, tattoo pigments are injected into the deeper dermis, away from melanocytes residing in the epidermis [10]. Carcinogenic pigment degradation products that form in the dermis over time may enter the local lymph or blood vasculature, rather than diffuse towards the epidermis. Therefore, any carcinogenic impact on melanocytes is likely minimal, aligning with the low TAM incidence observed in this study and challenging the idea that tattoos significantly increase the risk of melanoma. This idea is further challenged by the absence of multiple melanomas within a single tattoo among the included excerpts. Tattooed skin can contain multiple milligrams of potentially harmful pigments per squared centimetre, and some pigment types can degrade 87–99% over time [31, 32]. If the resulting carcinogenic pigment degradation products would indeed affect melanocytes, multiple melanomas could be expected to form in a single tattoo, alongside a higher TAM incidence. However, only solitary melanomas were found in this study.

Furthermore, regulatory measures, such as the EU's REACH Regulation enforced in January 2022, aim to reduce health risks by restricting hazardous chemicals in tattoo inks [14]. While these measures may reduce the carcinogenic potential of EU inks, compliance remains critical, and inks from outside the EU are not regulated, posing oversight challenges [16].

Additionally, behavioural differences between tattooed and non-tattooed populations could also influence melanoma risk. Although tattooed individuals reported heavily sun-exposed lifestyles more often, they also showed increased use of sun protection [33]. Protecting tattoos from sun exposure is commonly advised to prevent fading and cracking caused by UVR [34]. This targeted protection might reduce UV-related melanoma risk on tattooed skin.

Moreover, tattoos may provide protection against skin cancers. Lerche et al. [35] observed delayed development of UV-induced squamous cell carcinoma (SSC) in mice with black tattoos, likely due to UV absorption by the pigment, which decreases backscattering of light to the epidermis. This suggests a potential protective effect for melanomas as well.

In summary, this study provides epidemiological insights into the association between tattoos and melanomas. The findings do not indicate a causal relationship, as evidenced by the low TAM incidence rate. However, improving the safety of tattoo ink and screening tattooed skin for suspicious lesions remain crucial. Primary prevention, such as reducing UVR exposure and promoting sun protection, is essential [36]. Tattoo artists can contribute by encouraging sun protection habits [34]. While many already advise protecting tattooed skin, few tattoo artists stress the importance of full-body sun protection. Incorporating skin cancer education, including sun protection and mole checks, into tattooing practices could further reduce melanoma risk in the tattooed population.

Study Limitations and Future Outlook

This study faced limitations due to potentially incomplete or inconsistent tattoo documentation, which may have introduced selection and misclassification bias. Data on melanoma risk factors were unavailable, preventing adjustment for confounders, and clinical data limitations restricted TAM staging to stages I or II. Additionally, skewed population sizes and missing melanoma characteristics have hindered meaningful statistical comparisons with the general population.

Despite these challenges, this study utilized nationwide registry data, providing comprehensive coverage of histopathologically confirmed melanomas in the Netherlands. As the first database-driven study of TAMs, it addressed an understudied topic, offering unique insights. Future research should expand to other countries to increase the sample size and reliability. Comparative studies on lifestyle factors, such as sun exposure and protection practices, and investigations into ink composition under the 2022 REACH Regulation could further clarify the potential carcinogenic effects of tattoos.

Conclusion

This epidemiological study identified 94 unique cases of TAMs from 1991 to 2023 in the Netherlands from the nationwide Pathology Registry (PALGA). These cases accounted for 0.07% of all diagnosed melanomas during the same period. With an NNE of 6.0 and median Breslow thickness of 0.9 mm, these findings provide valuable insights into the occurrence of melanoma on tattooed skin and suggest that tattoos are unlikely to play a significant role in melanoma development. However, continued research is essential to confirm these results and further investigate the broader health implications of tattoos, ensuring informed decisions for both public health and individual safety.

Key Message

Tattoos are unlikely to play a substantial role in melanoma development or negatively impact prognosis.

Statement of Ethics

Anonymized patient data were retrospectively obtained after approval of the privacy and scientific committee (application # 2023-133) from the nationwide network and registry of histo- and cytopathology in the Netherlands (PALGA). Informed consent forms were obtained from patients by PALGA. Patient data in this study were acquired from PALGA in a fully anonymized format.

Conflict of Interest Statement

Nicolas Kluger – Laroche Posay: consulting fees; NAOS Bioderma: consulting fees; Pierre Fabre: lectures. No conflicts of interest are declared by the remaining authors.

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Author Contributions

Joey J.J.P. Karregat: conceptualization; data curation; formal analysis; investigation; methodology; writing – original draft; writing – review and editing; and supervision. Kim Schipper: conceptualization; data curation; formal analysis; investigation; methodology; writing-original draft; writing-review and editing. Albert Wolkerstorfer: conceptualization; data curation; formal analysis; investigation; methodology; writing-original draft; writing-review and editing; supervision; and project administration. Elisabeth H. Jaspars: conceptualization; data curation; formal analysis; and writing-review and editing. Norbertus A. Ipenburg: formal analysis and writing – review and editing. Nicolas Kluger: investigation and writing-review and editing. Yannick S. Elshot: conceptualization; data curation; formal analysis; investigation; methodology; writing-original draft; writing-review editing; supervision; and project administration.

Data Availability Statement

The data that support the findings of this study are not publicly available due to institutional restrictions but are available from the corresponding author upon reasonable request.

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