ORIGINAL ARTICLE

Impact of the Covid-19 pandemic on melanoma and non-melanoma skin cancer inpatient treatment in Germany – a nationwide analysis

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Abstract

Background SARS-CoV-2 has massively changed the care situation in hospitals worldwide. Although tumour care should not be affected, initial reports from European countries were suggestive for a decrease in skin cancer during the first pandemic wave and only limited data are available thereafter.

Objectives The aim of this study was to investigate skin cancer cases and surgeries in a nationwide inpatient dataset in Germany.

Methods Comparative analyses were performed in a prepandemic (18 March 2019 until 17 March 2020) and a pandemic cohort (18 March 2020 until 17 March 2021). Cases were identified and analysed using the WHO international classification of diseases codes (ICDs) and process key codes (OPSs).

Results Comparing the first year of the pandemic with the same period 1 year before, a persistent decrease of 14% in skin cancer cases (n = 19 063) was observed. The largest decrease of 24% was seen in non-invasive *in situ* tumours (n = 1665), followed by non-melanoma skin cancer (NMSC) with a decrease of 16% (n = 15 310) and malignant melanoma (MM) with a reduction of 7% (n = 2088). Subgroup analysis showed significant differences in the distribution of sex, age, hospital carrier type and hospital volume. There was a decrease of 17% in surgical procedures (n = 22 548), which was more pronounced in minor surgical procedures with a decrease of 24.6% compared to extended skin surgery including micrographic surgery with a decrease of 15.9%.

Conclusions Hospital admissions and surgical procedures decreased persistently since the beginning of the pandemic in Germany for skin cancer patients. The higher decrease in NMSC cases compared to MM might reflect a prioritization effect. Further evidence from tumour registries is needed to investigate the consequences of the therapy delay and identify the upcoming challenges in skin cancer care.

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Conflicts of interests

None.

Funding source

None.

Introduction

In January 2020, the first patient in Germany has been diagnosed with SARS-CoV-2, a new highly transmissible coronavirus, causing a coronavirus-associated acute respiratory disease called coronavirus disease 19 (Covid-19) that was first detected in Wuhan (China) in late December 2019.[1] A short time later, Germany and Europe were overwhelmed by a pandemic that has been unprecedented and that has claimed the lives of millions of people worldwide. Covid-19 has dramatically changed treatment procedures and workflows in hospitals all over the world. In Germany, in March 2020, a legal amendment in the *infection protection act* was introduced and in the following, major restrictions of social and public life were implanted for months to contain the pandemic. Simultaneously, hospitals were advised to reduce elective procedures and to prepare for the emerging of Covid-19 patients. In consequence, in most of the hospitals, material and staff were transferred to a certain degree to Covid-19 care and elective appointments and planned surgical activities were postponed for several weeks. Dermatology has been strongly affected by these measures in many hospitals in Germany.

Initial reports, especially from the United Kingdom (UK) and Italy, focused on the first months of the pandemic, which were characterized by massive restrictions, a high rate of Covid-19 hospital admissions and in some regions by dramatic states of emergency. These early reports suggest that the Covid-19 pandemic might have caused a substantial decrease in the number of skin cancer diagnosis in the first wave of the pandemic and might have led to a delay in skin cancer treatment.[2]

In this context, analysis of the North of England Cancer Network from March to June 2020 revealed a decrease in skin cancer diagnoses of 68.6% compared to the same period the last year before the pandemic. Results were not further specified, for example, according to subtype (e.g. malignant melanoma (MM) or non-melanoma skin cancer (NMSC)).[3] Data from a survey among skin cancer surgeons in the UK showed that approximately half of the respondent had to discontinue Mohs micrographic surgery in this period of early pandemic.[4] Evaluation of pathology reports in seven Italian pathology units revealed a reduction of 56.7% in skin cancer diagnosis in the first weeks of the pandemic compared to a prepandemic period.[5] Another Italian single institution analysis of surgeries performed in the first lockdown of the pandemic observed a 30% decrease in surgical activity and a reduction of 60% in new MM diagnosis.[6] Furthermore, an Italian retrospective multicentre trial, evaluating the immediate postlockdown period in the first pandemic year compared to the average of previous years showed a persistent reduction of 20% in MM diagnosis. In addition, there was early evidence of deterioration at the qualitative level with a higher detection rate of unfavourable tumours with higher Breslow tumour thickness, which was attributed to a delay in tumour diagnosis.[7]

Furthermore, analysis of outpatients in a single institution in Germany registered a significant decline in outpatient cases, especially in malignant skin diseases in the first pandemic wave, compared to previous years.[8]

Data on long-term trends in the pandemic, beyond the first wave, are sparse.

We hypothesize that the CoV-2 pandemic has a major impact on skin cancer care in German hospitals, with potential differences between skin cancer subtypes and different patient groups.

Materials and methods

Objectives

The aim of this study was to describe and to analyse treatment patterns of inpatient skin cancer cases in a nationwide dataset of all German hospitals throughout the Covid-19 pandemic.

Dataset and study design, and inclusion criteria

For this retrospective, observational study, we used performance data provided by the National Institute for the Hospital Remuneration System (InEK). In Germany, hospitals are required by law to report data of all inpatients in an anonymized form to InEK. These data are collected with the purpose of continuously developing the existing reimbursement system, which is based on diagnosis-related groups (DRG). Since 2020, access to these data has been possible during the year, albeit with considerable restrictions for the public.

All skin cancer inpatient cases in Germany were registered from 1 January 2019 until 30 September 2021 in this study. Of these, two groups were defined and further analysed, a prepandemic group covering the period from 18 March 2019 until 17 March 2020 and a pandemic group covering the period from 18 March 2020 until 17 March 2021. The date 17 March 2020 was chosen as a cut-off date due to the national hospital emergency plan by the German Government to combat the pandemic.

Skin cancer cases were identified by ICD-10-WHO codes [C43 for malignant Melanoma (MM), D03 for Melanoma *in situ* (MiS), C44 for non-melanoma skin cancer (NMSC) and D04 for carcinoma *in situ* (CiS) of the skin, including Bowen disease and erythroplasia]. Of note, the definition of CiS chosen in this study does not include actinic keratosis (ICD L57.0), since this diagnosis represents a deviant patient population, which usually follows outpatient therapy algorithms. Surgical procedures were identified by the operation and procedure code (OPS). We included the OPS code 5–894: Local excision of diseased skin and subcutaneous tissue (referred to as minor surgical procedures); 5–895: Radical and expanded excision of diseased skin and subcutaneous tissue, including micrographic surgery (referred to as extended surgical procedures); 5–898: Nail surgery; and 5–899: Excision of diseased skin and subcutaneous tissue not further classified. Sentinel lymph node surgery in MM cases was identified by the OPS codes 5–401.01, 5–401.02, 5–401.03, 5–401.11, 5–401.12, 5–401.13, 5–401.51, 5–401.52 and 5–401.53.

Due to data privacy reasons, the register automatically censors cases if there might be the possibility of drawing conclusions at the individual case level or for a specific hospital. In order to show a complete picture of the data situation, we have listed these cases separately in our evaluation (Table 1).

Clinical parameters

The following data on case characteristics were collected: Sex, age by category, comorbidities the patient clinical complexity level (PCCL), hospital size and the hospital carrier type. The patient clinical complexity level (PCCL) score is calculated in a complex procedure from the secondary diagnosis values (complication or comorbidity level values – CCL) and indicates the severity of the comorbidities based on a score between 0 and 6. PCCL was used in this analysis to compare the severity of the disease levels of the patients.

Table 1 Comparison of inpatient skin cancer cases and subtypes treated in German hospitals in a prepandemic dataset (18 March 2019 to 17 March 2020) and a pandemic dataset (18 March 2020 to 17 March 2021)

	Malignant melanoma			Non-melanoma skin cancer			Melanoma *in situ*			Carcinoma *in situ* of the skin		
	Pre-pandemic	**Pandemic**	***P*-value**	**Pre-pandemic**	**Pandemic**	***P*-value**	**Pre-pandemic**	**Pandemic**	***P*-value**	**Pre-pandemic**	**Pandemic**	***P*-value**
Total *N*	31 910	29 822		94 989	79 679		3127	2367		3745	2840	
Sex *N* (%)			0.0410			**0.0016***			0.8169			0.6619
Male	17 735 (55.6)	16 251 (54.5)		55 440 (58.4)	46 955 (58.9)		1566 (50.1)	1150 (48.6)		2014 (53.8)	1570 (55.3)	
Female	14 169 (44.4)	13 569 (45.5)		39 537 (41.6)	32 724 (41.1)		1561 (49.9)	1217 (51.4)		1732 (46.2)	1270 (44.7)	
Unknown/Divers	6 (0.0)	2 (0)		12 (0.0)	0 (0.0)		–	–		–	–	
Age groups			0.1714			**0.0016***			0.5639			0.2957
<65 years	13 300 (41.7)	12 645 (42.4)		14 783 (15.6)	12 933 (16.2)		876 (28.0)	719 (30.4)		513 (13.7)	439 (15.5)	
65–74 years	7022 (22.0)	6619 (22.2)		17 699 (18.6)	14 865 (18.7)		751 (24.0)	563 (23.8)		659 (17.6)	518 (18.2)	
≥75 years	11 588 (36.3)	10 558 (35.4)		62 507 (65.8)	51 881 (65.1)		1500 (48.0)	1085 (45.8)		2573 (68.7)	1883 (66.3)	
Patient Clinical Complexity Level (PCCL)			0.2718			0.9755			0.8169			0.6619
0	21 980 (68.9)	20 345 (68.2)		72 941 (76.8)	61 099 (76.7)		2825 (90.3)	2154 (91.0)		2972 (79.4)	2295 (80.8)	
1	3618 (11.3)	3591 (12.0)		6973 (7.3)	5865 (7.4)		135 (4.3)	115 (4.9)		277 (7.4)	205 (7.2)	
2	2297 (7.2)	2097 (7.0)		6744 (7.1)	5683 (7.1)		92 (2.9)	61 (2.6)		243 (6.5)	164 (5.8)	
3	3090 (9.7)	2926 (9.8)		7059 (7.4)	5941 (7.5)		67 (2.1)	33 (1.4)		231 (6.2)	155 (5.5)	
4	860 (2.7)	791 (2.7)		1103 (1.2)	959 (1.2)		7 (0.2)	4 (0.2)		21 (0.6)	21 (0.7)	
5	61 (0.2)	69 (0.2)		163 (0.2)	127 (0.2)		1 (0.0)	0 (0.0)		1 (0.0)	0 (0.0)	
6	4 (0.0)	3 (0.0)		6 (0.0)	5 (0.0)		–	–		0 (0.0)	0 (0.0)	
Hospital size			<**0.001***			<**0.001***			0.2464			0.6619
>1000	14 463 (45.3)	15 007 (50.3)		39 646 (41.7)	34 033 (42.7)		1589 (50.8)	1157 (48.9)		1655 (44.2)	1284 (45.2)	
500–999	9549 (29.9)	8619 (28.9)		29 903 (31.5)	23 574 (29.6)		961 (30.7)	696 (29.4)		1160 (31.0)	833 (29.3)	
200–499	3490 (10.9)	2947 (9.9)		13 142 (13.8)	11 381 (14.3)		183 (5.9)	153 (6.5)		534 (14.3)	425 (15.0)	
<200	3295 (10.3)	3232 (10.8)		12 298 (12.9)	10 669 (13.4)		335 (10.7)	306 (12.9)		387 (10.3)	285 (10.0)	
Censored	1113 (3.5)	8 (0.0)		0 (0)	22 (0.0)		59 (1.9)	55 (2.3)		9 (0.2)	13 (0.5)	
Hospital Carrier type			<**0.001***			<**0.001***			0.0002			0.2690
Public	22 463 (70.4)	21 188 (71)		60 438 (63.6)	50 269 (63.1)		2294 (73.4)	1607 (67.9)		2289 (61.1)	1685 (59.3)	
Private	4020 (12.6)	4059 (13.6)		16 924 (17.8)	14 158 (17.8)		461 (14.7)	384 (16.2)		642 (17.1)	465 (16.4)	
Non-profit	4314 (13.5)	4567 (15.3)		17 627 (18.6)	15 230 (19.1)		313 (10.0)	321 (13.6)		805 (21.5)	677 (23.8)	
Censored	1113 (3.5)	8 (0.0)		0 (0.0)	22 (0.0)		59 (1.9)	55 (2.3)		9 (0.2)	13 (0.5)	
Comorbidities[†]			0.2718			0.0348			n.a.			0.1912
Dementia	385 (1.2)	327 (1.1)		3460 (3.6)	2842 (3.6)		15 (0.5)	14 (0.6)		81 (2.2)	59 (2.1)	
Cerebrovascular diseases	398 (1.2)	385 (1.3)		2068 (2.2)	1715 (2.2)		11 (0.4)	11 (0.5)		53 (1.4)	22 (0.8)	
Cardiovascular diseases	6728 (21.1)	6231 (20.9)		36 901 (38.8)	30 933 (38.8)		546 (17.5)	411 (17.4)		1310 (35.0)	990 (34.9)	
Congestive heart failure	2214 (6.9)	2131 (7.1)		12 633 (13.3)	10 527 (13.2)		193 (6.2)	140 (5.9)		497 (13.3)	384 (13.5)	
Art. Hypertension	11 428 (35.8)	10 671 (35.8)		54 169 (57.0)	44 969 (56.4)		1458 (46.6)	1078 (45.5)		2055 (54.9)	1563 (55.0)	
Chronic pulmonary disease	983 (3.1)	898 (3.0)		5084 (5.4)	4382 (5.5)		81 (2.6)	77 (3.3)		142 (3.8)	126 (4.4)	
Renal failure	1739 (5.4)	1491 (5.0)		10 232 (10.8)	8953 (11.2)		119 (3.8)	100 (4.2)		501 (13.4)	360 (12.7)	

Table 1 *Continued*

	Malignant melanoma			Non-melanoma skin cancer			Melanoma *in situ*			Carcinoma *in situ* of the skin		
	Pre-pandemic	Pandemic	*P*-value	Pre-pandemic	Pandemic	*P*-value	Pre-pandemic	Pandemic	*P*-value	Pre-pandemic	Pandemic	*P*-value
Dialysis	74 (0.2)	57 (0.2)		670 (0.7)	593 (0.7)		4 (0.1)	0 (0.0)		18 (0.5)	9 (0.3)	
Diabetes	3405 (10.7)	3127 (10.5)		16 726 (17.6)	13 621 (17.1)		328 (10.5)	217 (9.2)		617 (16.5)	461 (16.2)	
Obesity	1216 (3.8)	1063 (3.6)		3854 (4.1)	3203 (4.0)		87 (2.8)	59 (2.5)		95 (2.5)	59 (2.1)	
Organ transplantation	28 (0.1)	31 (0.1)		1201 (1.3)	1078 (1.4)		0 (0.0)	0 (0.0)		111 (3.0)	85 (3.0)	
HIV & AIDS	35 (0.1)	31 (0.1)		212 (0.2)	195 (0.2)		0 (0.0)	0 (0.0)		28 (0.7)	22 (0.8)	
Solid tumourstumors‡	273 (0.9)	270 (0.9)		1189 (1.3)	967 (1.2)		6 (0.2)	4 (0.2)		12 (0.3)	0 (0.0)	
Leukaemia and Lymphomas	101 (0.3)	121 (0.4)		990 (1.0)	875 (1.1)		6 (0.2)	0 (0.0)		16 (0.4)	4 (0.1)	

* $P < 0.01$ was considered to indicate statistically significant differences.
† Column percentages may not sum to 100% due to missing data.
‡ Diagnostic codes for secondary skin cancers and cancer metastasis were excluded.

The following OPS codes and ICD-10 WHO codes were evaluated to determine comorbidities: dialysis 8-853 to 8-855; dementia F00-F03; cerebrovascular diseases I60-I69; cardiovascular diseases I20-I28, I30-I52, I70-I79; arterial hypertension I10-I15; Chronic pulmonary disease I27.8, I27.9, J40-J47, J60-J67, J68.4, J70.1, J70.3; renal failure N18-N19, N25, Z49, Z94.2, Z99.0, I12.0, I13.1; diabetes E10-E14; obesity E66; organ transplantation Z94.0-Z94.4, Z94.81, Z94.88, Z94.9; AIDS B20-B24, Z21; leukaemia and lymphoma C81-C96 and solid tumours C00-C76, exclusive C43 and C44.

The information on COVID-19 cases and hospitalization rate was obtained from the Robert Koch Institute.[9]

Ethics

Since the register data were anonymized, no ethical approval was required.

Statistical analysis

Variables were reported as frequencies and percentages. If indicated, normality distribution was tested by the Shapiro–Wilk test. Ordinal data were analysed by using the Mann–Whitney rank sum test and binary variables were analysed by the chi-square test. To account multiple testing, we used the Bonferroni–Holm correction.

Statistical analyses were performed using Microsoft Excel and SigmaPlot 12.0 software (Systat Software, Inc.). All *P*-values reported are two sided. $P < 0.01$ was considered to indicate statistically significant differences.

Results

In the period from 18 March 2019 to 17 March 2021 analysed in this study, a total of 248 479 skin cancer inpatient cases were identified in Germany. Of these were 70.3% NMSC (n = 174 668), 24.8% MM (n = 61 732) and <7% MiS or CiS (n = 12 079) of the skin. Comparing the pandemic period (18 March 2020 until 17 March 2021) with the prepandemic period (18 March 2019 until 17 March 2020), the overall reduction in skin cancer cases treated in German hospitals was 14% (n = 19 063). The largest relative decrease of 24% was seen in non-invasive *in situ* tumours (MiS n = 760; CiS n = 905), followed by NMSC with a reduction of 16% (n = 15 310) and invasive MM with a reduction of only 7% (n = 2088; Fig. 1a). Looking in more detail at the phase of the first Covid-19 pandemic wave, which hit Germany from March to May 2020, the decrease of 28% in inpatient skin cancer cases (n = 5049) was more pronounced compared to the overall period (Fig. 1b).

Furthermore, a comparison of the skin cancer cases with the Covid-19 hospitalization rate in German hospitals shows that in each wave there was a concomitant decrease in skin cancer cases with the increasing Covid-19 hospitalization rate (Fig. 2). The decline in skin cancer inpatient cases was particularly pronounced in the first two waves, although the recorded overall

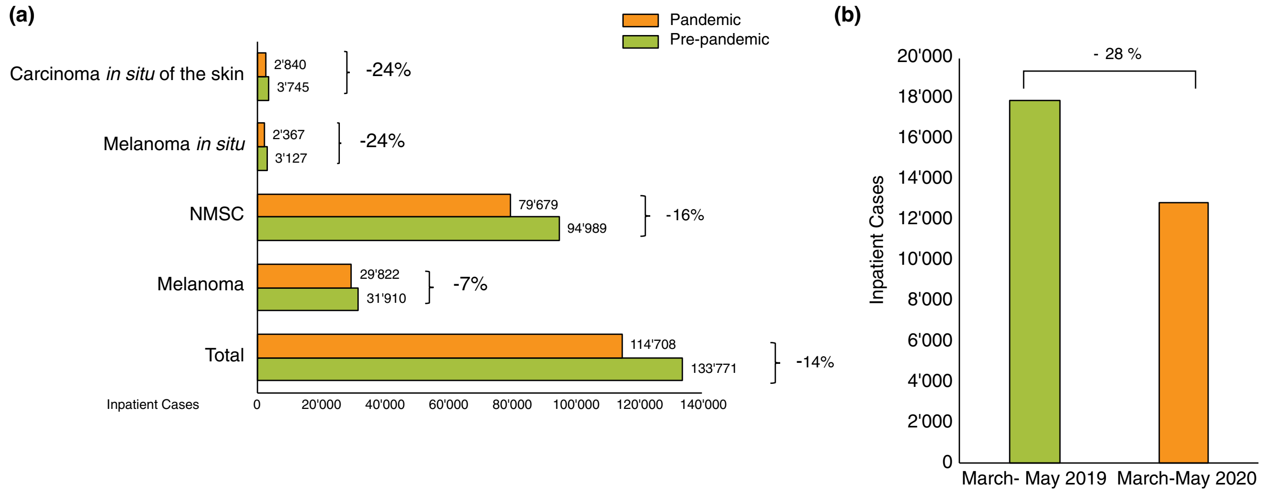


Figure 1 (a) Comparison of skin cancer cases treated in German hospitals in a prepandemic cohort (18 March 2019 to 17 March 2020) and a pandemic cohort (18 March 2020 to 17 March 2021). The relative decrease in each entity is indicated in percentage. (b) Comparison of the first pandemic wave (March to May 2019 to the same period in 2020).

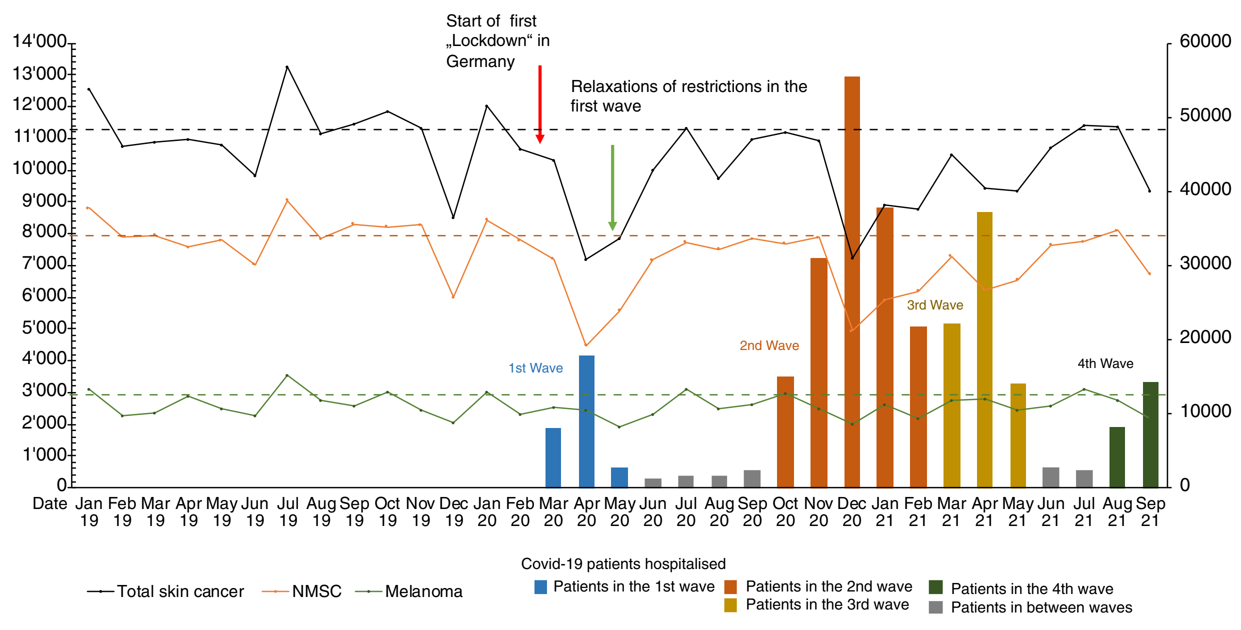
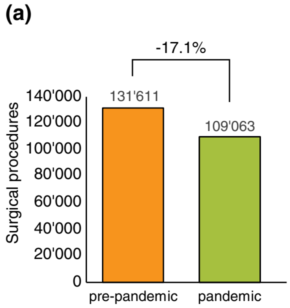


Figure 2 Timeline of skin cancer cases treated in German hospitals throughout from Jan 2019 to Sep 2021. Bars indicate the number of Covid-19 patients hospitalized. Dotted lines represent the prepandemic mean of skin cancer cases (black line = total skin cancer cases, orange line = NMSC and green line = MM).

Covid-19 hospitalization rate in the first wave was significantly lower than in the second and third waves. While NMSC showed a marked decline in each wave, reaching only up to the prepandemic mean in the recovery phases, the decline in MM was not as pronounced, with recovery phases showing an increase above the prepandemic mean (Fig. 2).



(b)

	Pre-pandemic	Pandemic	Δ%
Total	131'611	109'063	-17.1
Minor surgical procedures	18'648 (14.2)	14'054 (12.8)	-24.6
Extended surgery	112'623 (85.6)	94'715 (86.8)	-15.9
Nail surgery	299 (0.2)	257 (0.2)	-9.8
Not classified	41 (0.0)	37 (0.0)	-17.1

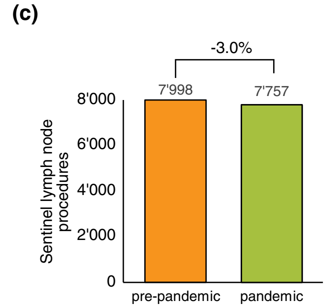


Figure 3 Decrease in surgical procedures in skin cancer throughout the Covid-19 pandemic. (a) Total number of surgical procedures in invasive melanoma and non-melanoma skin cancer cases treated in German hospitals in a prepandemic cohort (18 March 2019 to 17 March 2020) and a pandemic cohort (18 March 2020 to 17 March 2021). (b) Relative and absolute distribution of different surgical procedures identified by OPS code in the pre- and postpandemic dataset. Minor surgical procedures are defined as local skin excisions of diseased skin and subcutaneous tissue with a surface of ≤4 cm^2 (OPS 5–894). Extended surgery is defined by radical and expanded excision of diseased skin and subcutaneous tissue, including micrographic surgery ≥4 cm^2 (OPS 5–895); nail surgery was identified by OPS 5–898 and excisions of the skin not further classified were identified by OPS 5–899. (c) Inpatient cases of malignant melanoma that received sentinel lymph node surgery in the above defined prepandemic and pandemic period.

Analysing tumour subgroups, MM showed no statistically significant differences in the distribution of sex, age, case severity (PCCL) or comorbidities (Table 1). However, there were significant differences in the distribution of MM cases among hospital size with an absolute and relative increase (14 463 vs. 15 007; 45.3% vs. 50.3%) of patients treated in maximum-size hospitals in the pandemic (hospitals with capacities ≥1000 beds; $P < 0.001$). Nevertheless, these differences have to be interpreted with caution, considering the large proportion of censored cases in the prepandemic cohort (n = 1113; 3.5%; Table 1). In contrast, the statistically significant differences among hospital carrier types cannot be attributed to one of the different types and are likely to be attributed to the decline in the censored group (3.5% vs. 0%; Table 1). For MiS, there was a marked shift in the proportion of cases that were treated in public hospitals to those treated in private and non-profit institutions during the pandemic period compared to the prepandemic cohort (67.9% vs. 73.4%).

In NMSC, statistically significant differences in distribution of sex and age were seen ($P = 0.0016$) with a greater proportion of men (58.9% vs. 58.4%) and a higher proportion of patients younger than 65 years (16.2% vs. 15.6%) in the pandemic cohort. The trend seen in MM, with a relative increase in cases treated in maximum-size hospitals (≥1000 beds), is similar to NMSC, also with an increase in cases treated in maximum-size hospitals and a concomitant relative decrease in the proportion of cases treated in medium-size hospitals (500–999 beds). Furthermore, there were significant differences in the distribution of hospital carrier types ($P < 0.001$) with a higher relative proportion of cases in non-profit clinics (19.1% vs. 18.6%).

Analysing surgical procedures in skin cancer inpatients, a major decrease of 17% ($n = -22\,548$) comparing the pandemic with the prepandemic period is seen (Fig. 3a). Of interest, the largest decrease of 24.6% was observed in minor surgical procedures (defined as an excised area of ≤4 cm^2), followed by a decrease of 15.9% in extended surgery (including microcraphic surgery), followed by a decrease of 14.0% in nail surgery and of 9.8% in *skin surgery, not further classified* (Fig. 3b).

In a separate analysis, sentinel lymph node surgery of MM cases was compared in the two datasets and, interestingly, there was only a slight decrease of 3% in the pandemic period (n = 241; Fig. 3c).

Discussion

In this national analysis, a marked decrease of more than 19 000 of skin cancer inpatient cases (14%) and a decrease of over 22 000 surgical skin cancer inpatient procedures (17%) were observed in the first year of the pandemic in Germany compared to the same period before the pandemic. These results of a long-term observation period demonstrate that the care situation of skin cancer patients has changed persistently throughout the course of the pandemic and so concerns arise that this decrease might reflect a major backlog of skin cancer patients, which might lead to a poorer patient outcome in the future.

In contrast to the present investigation, previous studies focused mainly on the period of the first pandemic wave and the subsequent weeks in spring and summer 2020, showing decreasing numbers of skin cancer cases between 34 and 70% in different investigated inpatient and outpatient collectives in

Europe.[3,5,6,10] In line with these findings, the here investigated German inpatient dataset also showed a stronger decrease in skin cancer cases of 28% during the first months of the pandemic (first pandemic wave) compared to the overall period. Considering that Germany has a relatively high density of hospital beds compared to other European countries and that the incidence of Covid-19 was in a lower range compared to others, it is of particular relevance that despite these favourable conditions, there was no sufficient recovery of skin cancer inpatient cases within the observation period of 1 year.[11]

Looking at the numbers of skin cancer cases in relation to the pandemic course, it is noticeable that the case numbers, especially in NMSC, did not increase above the prepandemic level after the decline in each infection wave. This phenomenon is particularly pronounced after the first wave but is also observed after the second and third waves (Fig. 2). This leads to a cumulative deficit of inpatient treatments after the first year of the pandemic. The reasons explaining this fact are multiple and currently not completely understood. First, it may be that due to the slow growth rates of NMSC (and especially BCC) treatments were further postponed by patients or physicians. Second, capacity limitations at many inpatient skin cancer facilities in Germany were not directly related to the course of the pandemic, but in many cases persisted throughout the entire first year of the pandemic. Furthermore, many other reasons, such as a shift of surgeries to the outpatient setting or lower incidences due to the excess mortality in the population at risk, should be discussed. Of interest, recently published data from the Netherlands cancer registry support our theory of a *real deficit* by observing a backlock of around 1150 SCC and 11 767 BCC still remaining at the end of 2020 in the Netherlands.[12]

The proportionately greater decrease in NMSC and in *in situ* cases compared with MM is suggestive of a risk adapted prioritization effect. This observation is emphasized in the analysis of surgical procedures, where minor surgical procedures decreased more pronounced compared to extended surgical procedures. The finding that sentinel lymph node procedures decreased only marginally (3%) indicates that the capacity for inpatient surgical care of higher-grade MM could be maintained during the pandemic in Germany. These data are particularly interesting, as a poorer care situation of MM patients during the pandemic would be expected from recently published outpatient data. For example, analysis of cases in a single university dermatology outpatient clinic in Germany revealed a reduction in MM cases of more than 80% in the period of the first pandemic wave.[8] Evaluations of outpatient cases of 153 dermatology practices in the USA showed a decrease in MM cases by 43.1%, in cutaneous squamous cell carcinoma (cSCC) of 44.1% and in basal cell carcinoma (BCC) of 51.2% during the first wave of the pandemic.[13]

A potential explanation for the observation –*in situ* tumours decreased more than invasive tumours – is that a transition to an outpatient setting may have been possible more frequently for these tumours compared to invasive tumours. However, it must be taken into account that *in situ* tumours of the skin, treated in an inpatient setting, represent a specific population of tumours that are regularly difficult to treat. These are tumours that affect large areas by horizontal growth, especially in surgically demanding body areas (e.g. lentigo maligna of the face or acral Bowen's disease). In our clinical experience, we have the strong impression that these patients presented less frequently since the beginning of the pandemic. For this reason, there is a great concern that patients have misjudged these tumours due to the generally mild symptoms and may present with tumours in more advanced stages in the future.

The more pronounced decrease in *in situ* tumours in public hospitals compared to other carrier types could be due to the fact that public hospitals in Germany were more closely involved in the pandemic emergency plan and thus a stronger priorization effect can be the cause. According to the InEK data, Covid-19 patients were treated in public hospitals in over 50% of cases and in private hospitals in only 13%.

Analysis of case characteristics for NMSC showed significant differences in age distribution between groups, with a relative increase in the proportion of those under 65 years of age in the pandemic cohort, a trend that was also seen in malignant melanoma. These observations indicate that patients aged 65 years and older were more affected than younger patients by the reduced hospital admission rate. This finding can mainly be attributed to the fact that higher age was identified early as a major risk factor for severe illness from Covid-19 and that this was broadly communicated to the general population. People of this age category and their treating physicians may have valued the risk of a severe Covid-19 infection higher than possible harm from skin cancer and therefore avoided medical contacts or postponed skin cancer treatments. Another possible explanation could be that, especially in impaired, geriatric patients, a certain degree of health supervision by their relatives was missing due to contact restrictions. Furthermore, taking into account the excess mortality in Germany, hospitalization, convalescence and death of Covid-19 itself might also have contributed to a certain reduction in skin cancer diagnosis, especially in patients of higher age.

The observation of significant differences in the gender distribution of NMSC cases, with less females in the pandemic cohort, is difficult to explain and reasons might be multifactorial. Interestingly, analysis of skin biopsies in a Canadian population-based trial also observed significant fewer biopsies in keratinocyte skin tumours in a pandemic cohort. Differences in tumour stages between males and females and behavioural differences have been discussed as potential reasons.[14]

Differences in the distribution of cases in terms of hospital size and carrier, with a trend towards a relatively higher proportion of cases in hospitals with a maximum bed capacity, provide evidence that dermatology care facilities were affected by the pandemic to varying degrees across regions.

This study has three major limitations. First, it includes only inpatients and a possible shift of surgical procedures to the outpatient sector or a reduced referral rate from outpatient physicians cannot be measured. Second, due to the secondary retrospective data, other causal effects cannot be determined and therefore only possible explanations can be discussed. Third, qualitative data such as Breslow tumour thickness and other prognostic relevant markers have not been recorded in the dataset and should be further addressed.

In conclusion, this study provides evidence for a persistent decrease in skin cancer inpatient cases in Germany during Covid-19 pandemic. Despite all favourable preconditions in Germany, no complete recovery in inpatient cases occurred in the first year of the pandemic. Reasons for this fact are complex and require further investigations. It can be speculated that patients and their treating physicians valued the risk of a Covid-19 infection higher than possible harm from skin cancer and therefore avoided medical contacts or postponed skin cancer treatments. Covid-19 morbidity and mortality should also be considered as a contributing factor.

Furthermore, it may be that physicians restricted the indication for inpatient treatment and at least part of the treatments were performed in an outpatient setting. Nevertheless, it is highly likely that we would face a 'wave' of delayed skin cancer cases, posing new challenges for treating physicians. Further investigations, particularly on qualitative prognostic data from tumour registries, are needed to provide a better picture for the upcoming challenges in skin cancer care.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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