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What does the general population know about nonmelanoma skin cancer? Representative cross-sectional data from Germany

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Abstract

Aim Nonmelanoma skin cancer (NMSC) is the most common form of cancer in white-skinned populations. However, there is a lack of comprehensive research on the general population's knowledge about NMSC.

Subjects and methods As part of wave 8 of the German National Cancer Aid Monitoring (NCAM), 4000 participants aged 16–65 years (49.3% female) were interviewed by telephone about NMSC. Questions included awareness of (colloquial) terms for NMSC, its signs, consequences, risk factors, prevalence, and severity.

Results Colloquial terms for skin cancer were heard of more often than medical terms (60.9–82.1% vs. 22.6–51.5%). In our sample, there was little familiarity with signs (15.8–36.4%), possible consequences (14.7–56.3%), prevalence (27.4%), and severity (29.0%) of NMSC. Most participants knew about UV-related risk factors for NMSC (73.0–78.7%). Women, those with higher education levels, full-time employment, lighter skin type, presence of more than 40 nevi, frequent childhood sunburns, or frequent intentional tanners achieved a higher knowledge score. Concern about NMSC was associated with more NMSC knowledge.

Conclusion We found knowledge gaps regarding signs, consequences, and prevalence of NMSC. To ensure early recognition and treatment, the general population should be further educated, specifically targeting male, less educated, and unemployed individuals.

Keywords Nonmelanoma skin cancer · Health literacy · Knowledge · Prevention

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Introduction

Knowledge about a disease has been found to be associated with preventive behavior (Park et al. 2018; Renner and Schwarzer 2003; Sessa et al. 2008; Taghipour et al. 2019; Werner 2003). This was also shown for skin cancer: increased knowledge about preventive behavior and risk factors for skin cancer was positively associated with better sun-protection behavior (Meyer et al. 2021; Turrisi et al. 2004; Ziehfreund et al. 2019). Therefore, enhancing individual knowledge and health-related competencies is important for promoting and maintaining good health (World Health Organization 2021).

Nonmelanoma skin cancer (NMSC), which most commonly occurs in the form of basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) (Lomas et al. 2012), is the most prevalent form of cancer in white-skinned populations (Zink 2017), and its incidence is expected to further increase (Madan et al. 2010). Despite its high prevalence, research on the general population's knowledge

about NMSC is scarce. Earlier research showed that the general population had low levels of awareness of the terms BCC and actinic keratosis (AK), precursor lesions of SCC, but high awareness of the association between skin cancer and sun exposure (Fernandez Figueras 2017; Halpern and Kopp 2005; MacKie 2004). In a recent study, qualitative interviews with individuals aged 55 to 85 years revealed a substantial knowledge gap, especially regarding the accurate definition of NMSC, its prevalence, possible signs, and potential risks (Brokmeier et al. 2023). To date, there has been no extensive research on what the general population knows about NMSC.

Previous research on knowledge about skin cancer in general identified differences depending on sociodemographic characteristics: Women and those with higher education had higher knowledge about skin cancer-related risk factors (Miles et al. 2005). However, research has yet to investigate possible associations between knowledge about NMSC and sociodemographic characteristics.

Besides knowledge, being concerned about a disease has been shown to be related to preventive behaviors (Kiviniemi and Ellis 2014; Sobkow et al. 2020), which underlines the importance of adequate education. A recent European study revealed that 46% of the general population was concerned about skin cancer in general (MacKie 2004). In an international comparison study, participants who lived in countries with a higher prevalence of BCC and AK had not only higher levels of awareness about skin cancer but also expressed more concerns (Halpern and Kopp 2005). However, we are not aware of any research that has specifically explored concerns regarding NMSC and its association with knowledge about NMSC.

Although NMSC is the most common form of cancer in white-skinned populations (Lomas et al. 2012; Zink 2017), to date, there is a lack of data reflecting what the general population knows about NMSC, whether they are aware of its signs and risks, and how they perceive its severity. For prevention measures, it is important to understand the current state of knowledge to develop tailored campaigns on knowledge and health literacy regarding NMSC. The goal should be to increase awareness and enhance preventive behavior, with the long-term aim of reducing the incidence of NMSC. Therefore, the present study had three aims: (1) to explore the general population's knowledge about NMSC, including knowledge of its signs, potential consequences, prevalence, severity, and potential factors contributing to its pathogenesis; (2) to investigate whether NMSC knowledge is associated with sociodemographic characteristics, skin-related characteristics, and tanning behavior; and (3) to examine whether knowledge about NMSC is related to concerns about NMSC.

Materials and methods

Sample and data collection

Data for this manuscript were collected within the eighth wave of the National Cancer Aid Monitoring (NCAM) between October and December 2022. NCAM is a nationwide monitoring assessing UV-related risk behavior in a representative population sample in Germany. Cross-sectional data were collected from 4000 individuals aged 16 to 65 years via standardized computer-assisted telephone interviews (CATI; response rate 3 based on American Association for Public Opinion Research, 29.4%). A sample size of 4000 was determined by a sample size calculation using the analysis PROC POWER SAS software (SAS Institute Inc.). Participants were selected using a two-stage random sampling procedure (Diehl et al. 2022). All participants gave informed verbal consent prior to the interviews.

Outcome variables

To assess awareness of skin cancer, participants indicated with "yes" or "no" whether they had heard the following terms before: "White skin cancer," "light skin cancer" (both German colloquial terms for NMSC), "black skin cancer" (German colloquial term for malignant melanoma [MM]), "basal cell carcinoma," "squamous cell carcinoma," and "malignant melanoma." Items were presented in a randomized order.

Knowledge about NMSC was assessed with three item sets focusing on signs (four items), potential consequences (five items), and potential factors contributing to its development (four items). Answer options for each item were "yes," "no," and "I don't know." The items were derived from a qualitative study on NMSC conducted previously (Brokmeier et al. 2023) and pretested in cognitive interviews ($n = 15$). To build a score of knowledge about NMSC, responses were coded as correct or incorrect, with the response "I don't know" always coded as incorrect. Afterward, the correct answers were summed up, resulting in a score with values ranging from 0 to 12.

We included two questions on the comparison of NMSC and MM, asking which kind of cancer is perceived as (1) more severe and as (2) more prevalent. Answer categories were "more," "just as," "less," and "I don't know." The correct answers would be less severe (American Cancer Society 2022) and more prevalent (Urban et al. 2021), respectively. Further, one item assessed whether participants were concerned about developing NMSC themselves ("yes," "no," and "I have never thought about it").

Covariates

As sociodemographic characteristics, we included sex (coded as male/female), age (in years), migration background (yes/no; based on (Schenk et al. 2006)), school education (low/medium/high), employment (none/part-time/full-time), partnership status (with/without), and current or former outdoor occupation (yes vs. no). Moreover, participants were asked about risk factors for developing NMSC, i.e., their skin type following Fitzpatrick (1975) grouped into categories I–II vs. III–VI, high number of nevi (less vs. more than 40), as well as self-reported tanning behavior (current tanning bed use [yes vs. no] and intentional tanning in the sun), previous sunburns (before and after the 15th year of life [each not often vs. often]). Intentional tanning outdoors was operationalized as the number of occasions (on workdays, on weekends, on vacation) on which participants indicated to sunbathe outdoors in order to get a tan (3 occasions vs. 2 vs. 1 vs. never).

Statistical analysis

Data were weighted by sex, age, and geographic region to represent the German population according to official data from the German micro-census (Statista 2023). We conducted descriptive analysis of the included variables. Chi-square tests were performed to test for sex differences. T tests and ANOVAs were used to identify associations between the knowledge score and covariates. In the case of high variance heterogeneity, Welch tests were interpreted. Linear regression models were fitted to further examine these associations: model I included sociodemographic characteristics, model II skin-related risk factors, model III tanning behavior, and model IV all covariates from models I to III significantly associated with knowledge score values. To test for associations between knowledge and concern about, perceived severity, and prevalence of NMSC, ANOVAs were conducted. Missing data were excluded from analyses. All analyses were performed using SPSS version 29 (IBM Corporation, Armonk, NY, USA) with a predefined two-sided level of significance of $p < 0.05$.

Results

Four thousand individuals (49.3% female) aged 16–65 years (M 42.43, SD 14.02) participated in the survey. Sociodemographic and skin-related characteristics of participants stratified by sex are described in Table 1. Women reported higher levels of education, less full-time employment and outdoor occupation, and were more often in a relationship (each $p < 0.001$). Furthermore, they displayed more skin-related risk factors, i.e., lighter skin type ($p = 0.012$), more than 40 nevi ($p < 0.001$), frequent sunburns before ($p = 0.008$) and after the age of 15 ($p = 0.042$), and current tanning bed use ($p = 0.003$).

Of the entire sample, 82.1% had heard of the term "black skin cancer" (women 86.2%, men 78.0%, $p < 0.001$), 72.8% of "white skin cancer" (women 78.2%, men 67.5%, $p < 0.001$), 60.9% of "light skin cancer" (women 64.3%, men 57.5%, $p < 0.001$), 51.5% of "malignant melanoma" (women 58.5%, men 44.8%, $p < 0.001$), 30.7% of "basal cell carcinoma" (women 37.9%, men 23.7%, $p < 0.001$), and 22.6% of "squamous cell carcinoma" (women 26.9%, men 18.4%, $p < 0.001$) before.

The proportion of participants who correctly answered the items regarding signs, possible consequences, and factors contributing to the development of NMSC ranged between 14.7% (disagreeing that NMSC can progress to MM) and 78.7% (answering that sunbathing can contribute to the development of NMSC, Table 2).

Overall knowledge about NMSC was assessed by summing up correct answers to the items displayed in Table 2 (M 6.15, SD 2.48, range 0–12). The achieved knowledge score values were significantly associated with all covariates but outdoor occupation (Table 3). Characteristics associated with higher knowledge score values were female sex, age between 26 and 35 years, no immigrant background, higher levels of education, being employed, having a partner, lighter skin type, more than 40 nevi, frequent sunburns before and after the age of 15, and current tanning bed use. Intentionally tanning outdoors on two or three occasions was associated with higher knowledge scores compared to never tanning outdoors.

To simultaneously account for characteristics significantly associated with achieved knowledge score values, linear regression models were fitted (Table 4). Model IV showed a significant association with sex, indicating that men had a lower knowledge score ($p < 0.001$). Those with higher levels of education (each $p < 0.001$) and working full-time ($p = 0.048$) were more likely to have a high knowledge score than their counterparts. Regarding individual risk factors, lighter skin type ($p = 0.010$), more than 40 nevi ($p < 0.001$), frequent sunburns before the age of 15 ($p < 0.001$), and intentional tanning on two ($p = 0.006$) or three occasions ($p = 0.001$; each compared to those who never tanned outdoors) were associated with a higher knowledge score.

Approximately one quarter assumed NMSC to be more prevalent (27.4%) and less severe than MM (29.0%), and indicated to be concerned about NMSC (25.0%, Table 5). ANOVAs revealed significant differences in the knowledge score by the perceived NMSC prevalence ($p < 0.001$) and severity ($p < 0.001$, Table 5) compared to MM. Those who were

Table 1 Sociodemographic and skin-related characteristics of survey participants (NCAM 2022)

	n	%	Women n	Women %	Men n	Men %	$p\ (\chi^2)$
Sex							
Female	1970	49.3					
Male	2030	50.7					
Age group (in years)							
16–25	622	15.6	292	14.8	330	16.3	0.746
26–35	792	19.8	388	19.7	404	19.9	
36–45	786	19.7	389	19.7	397	19.6	
46–55	833	20.8	415	21.1	418	20.6	
56–65	965	24.1	486	24.7	479	23.6	
Missing	2						
Immigrant background							
Yes	532	13.4	263	13.4	269	13.3	0.915
No	3450	86.6	1697	86.6	1753	86.7	
Missing	18						
Level of education							
Low	703	19.6	305	17.1	398	22.1	**< 0.001**
Medium	1267	35.3	662	37.0	605	33.6	
High	1619	45.1	820	45.9	799	44.3	
Missing	411						
Employment							
None	899	22.5	472	24.0	427	21.1	**< 0.001**
Part-time	879	22.0	580	29.5	299	14.8	
Full-time	2209	55.4	911	46.4	1298	64.1	
Missing	13						
Current or former outdoor occupation							
Yes	905	22.8	328	16.8	577	28.7	**< 0.001**
No	3062	77.2	1628	83.2	1434	71.3	
Missing	33						
Partnership status							
Without partner	1173	29.7	521	26.9	652	32.5	**< 0.001**
With partner	2774	70.3	1417	73.1	1357	67.5	
Missing	53						
Skin type							
I or II	1703	43.0	879	45.0	824	41.0	**0.012**
III–VI	2258	57.0	1074	55.0	1184	59.0	
Missing	39						
More than 40 nevi							
Yes	1321	33.1	767	39.1	554	27.3	**< 0.001**
No	2669	66.9	1197	60.9	1472	72.7	
Missing	10						
Sunburn before the age of 15							
Not often	3559	89.1	1727	87.8	1832	90.4	**0.008**
Often	436	10.9	241	12.2	195	9.6	
Missing	5						
Sunburn after the age of 15							
Not often	3592	90.0	1752	89.1	1840	91.0	**0.042**
Often	397	10.0	215	10.9	182	9.0	
Missing	11						

Table 1 (continued)

	n	%	Women		Men		p (χ^2)
			n	%	n	%	
Current tanning bed use							
Yes	203	5.1	121	6.2	82	4.1	**0.003**
No	3787	94.9	1845	93.8	1942	95.9	
Missing	10						
Intentional tanning							
Never	443	11.2	226	11.6	217	10.8	0.230
On one occasion	387	9.7	203	10.4	184	9.1	
On two occasions	819	20.6	413	21.1	406	20.1	
On three occasions	2324	58.5	1113	56.9	1211	60.0	
Missing	27						

$n=4000$ aged 16–65 years. Data are weighted by sex, age, and geographic region. Rounding errors may occur due to data weighting. *NCAM* National Cancer Aid Monitoring. Significant associations are displayed in bold font

Table 2 Item sets inquiring about signs, possible consequences, and factors contributing to the development of NMSC with coded answers

What do you think are signs of NMSC?	Item correct/ incorrect	Correctly answered (% of valid answers)	Missing data (n)
Reddish, rough, scaly skin spots	Correct (Madan et al. 2010)	36.4	32
Alterations in nevi	Incorrect (Clark et al. 1984)	19.8	30
Bleeding or poorly healing skin spots	Correct (Jones et al. 2020)	36.3	30
Light or white spots on the skin	Incorrect (Navarrete-Dechent et al. 2016)	15.8	33
What do you reckon are possible consequences of white skin cancer?			
Surgery	Correct (Madan et al. 2010)	55.5	33
Metastatic spread	Correct (Madan et al. 2010)	42.2	46
NMSC can progress to MM	Incorrect (Clark et al. 1984)	14.7	41
Radiation therapy or chemotherapy	Correct (Veness et al. 2019; Zink 2017)	45.4	33
Recurrence of NMSC	Correct (Madan et al. 2010)	56.3	46
What do you believe contributes to the development of NMSC?			
Sunbathing	Correct (Gordon 2013)	78.7	22
UV radiation during outdoor occupation	Correct (Gordon 2013)	77.1	27
Using tanning beds	Correct (Firnhaber 2012)	73.0	23
Weakened immune system	Correct (Zink 2017)	57.9	22

$n=4000$, aged 16–65 years. Data are weighted by sex, age, and geographic region. *NMSC* nonmelanoma skin cancer. *MM* malignant melanoma. Items of each item set were presented in randomized order. Answer categories were *yes*, *no*, and *I don't know*. The latter was always coded as incorrectly answered

concerned about NMSC achieved the highest knowledge score ($p<0.001$) compared to those who were not concerned or had never thought about it before. Those who answered the questions on prevalence, severity, and concern with "I don't know" or "I have never thought about it", respectively, showed the lowest knowledge scores.

Discussion

In our nationwide representative sample, we found higher familiarity with colloquial terms for skin cancer than with medical terms. Signs and possible consequences of NMSC were less known, but the association of UV-related risk

Table 3 Sociodemographic and skin-related characteristics associated with NMSC knowledge

	Number	Mean	SD	*P*
Total score	3822	6.15	2.48	
Missing	178			
Sex				**< 0.001**
Female	1900	6.39	2.39	
Male	1923	5.91	2.54	
Missing	177			
Age group (in years)				**0.009**
16–25	573	6.00	2.31	
26–35	733	6.38[a]	2.29	
36–45	757	6.16	2.47	
46–55	807	6.21	2.51	
56–65	949	5.99[a]	2.67	
Missing	181			
Immigrant background				**0.013**
Yes	489	5.91	2.24	
No	3316	6.19	2.51	
Missing	195			
Level of education				**< 0.001**
Low	654	5.58[a, b]	2.47	
Medium	1214	6.11[a, c]	2.46	
High	1564	6.45[b, c]	2.43	
Missing	568			
Employment				**< 0.001**
None	853	5.84[a, b]	2.57	
Part-time	843	6.13[a]	2.49	
Full-time	2115	6.29[b]	2.42	
Missing	189			
Current or former outdoor occupation				0.191
Yes	844	6.25	2.38	
No	2952	6.13	2.51	
Missing	204			
Partnership status				**0.013**
Without partner	1115	6.00	2.52	
With partner	2655	6.22	2.45	
Missing	230			
Skin type				**< 0.001**
I or II	1603	6.34	2.33	
III–VI	2182	6.02	2.56	
Missing	215			
More than 40 nevi		**< 0.001**		
Yes	1280	6.61	2.32	
No	2539	5.92	2.52	
Missing	181			
Sunburn before the age of 15				**< 0.001**
Not often	3402	6.07	2.49	
Often	416	6.79	2.25	
Missing	182			
Sunburn after the age of 15				**< 0.001**
Not often	3442	6.09	2.49	
Often	374	6.70	2.25	

Table 3 (continued)

	Number	Mean	SD	P
Missing	184			
Current tanning bed use				**0.002**
Yes	193	6.63	2.14	
No	3621	6.13	2.49	
Missing	186			
Intentional tanning				**0.003**
Never	429	5.74[a, b]	2.67	
On one occasion	364	6.05	2.64	
On two occasions	777	6.15[a]	2.56	
On three occasions	2228	6.25[b]	2.38	
Missing	202			

$n = 4000$, aged 16–65 years. Data are weighted by sex, age, and geographic region. *NMSC* nonmelanoma skin cancer. *SD* standard deviation. Owing to variance heterogeneity, Welch tests were used except for the variable partnership status. [a, b, c] Significantly different from group a/b/c ($p < 0.05$, Bonferroni post-hoc test). Significant associations are displayed in bold font

Table 4 Linear regression analysis of characteristics associated with knowledge score

	Model I Socio-demographics		Model II Skin-related risk factors		Model III Tanning behavior		Model IV Final	
	β	p	β	p	β	p	β	p
Sociodemographic characteristics								
Male sex	−0.082	**<0.001**					−0.065	**<0.001**
Age (in years)	−0.038	**0.031**					−0.010	0.591
Immigrant background	−0.045	**0.010**					−0.032	0.069
Level of education								
Low	Ref						Ref	
Medium	0.082	**<0.001**					0.092	**<0.001**
High	0.148	**<0.001**					0.156	**<0.001**
Employment								
None	Ref						Ref	
Part-time	0.014	0.519					0.000	0.988
Full-time	0.062	**0.005**					0.044	**0.048**
Having a partner	0.020	0.251						
Skin-related risk factors								
Skin type								
I or II			Ref				Ref	
III–VI			−0.042	**0.011**			−0.045	**0.010**
More than 40 nevi			0.117	**<0.001**			0.098	**<0.001**
Oftentimes sunburn before the age of 15			0.064	**<0.001**			0.081	**<0.001**
Oftentimes sunburn after the age of 15			0.027	0.124				
Tanning behavioral risk factors								
Current tanning bed use					0.038	**0.019**	0.029	0.090
Intentional tanning								
Never					Ref		Ref	
On one occasion					0.036	0.088	0.037	0.095
On two occasions					0.063	**0.009**	0.072	**0.006**
On three occasions					0.095	**<0.001**	0.092	**0.001**
n	3347		3774		3790		3322	

$n = 4000$, aged 16–65 years. *MD* missing data. Data are weighted by sex, age, and geographic region. Model IV included all significantly associated covariates from models I to III. Significant associations are displayed in bold font

Table 5 Mean NMSC-knowledge score depending on estimated prevalence/estimated severity compared to MM and reported worrying about developing NMSC

	n	%	n	Mean	SD	p
				NMSC-knowledge		
Estimated prevalence of NMSC compared to MM						**< 0.001**
Less prevalent	797	20.2	755	6.14[a, b, c]	2.34	
Equally prevalent	971	24.6	938	6.72[a, d]	2.26	
More prevalent	1081	27.4	1054	6.92[b, e]	2.12	
I don't know	1103	27.9	1056	4.90[c, d, e]	2.59	
Missing	47		196			
Estimated severity of NMSC compared to MM						**< 0.001**
Less severe	1148	29.0	1113	6.48[a]	2.31	
Equally severe	1483	37.4	1432	6.56[b]	2.24	
More severe	492	12.4	461	6.73[c]	2.36	
I don't know	839	21.2	795	4.62[a, b, c]	2.56	
Missing	37		198			
Concern about NMSC						**< 0.001**
Yes	986	25.0	961	7.14[a, b]	2.15	
No	1482	37.6	1429	6.04[b, c]	2.52	
I have never thought about it	1471	37.3	1392	5.59[a, c]	2.44	
Missing	61		218			

$n = 4000$, aged 16–65 years. Data are weighted by sex, age, and geographic region. Rounding errors may occur due to data weighting. *NMSC* nonmelanoma skin cancer. *MM* malignant melanoma. Owing to variance heterogeneity, Welch tests were used. [a, b, c, d, e] Significantly different from group a/b/c/d/e ($p < 0.05$, Bonferroni post-hoc test). Significant associations are displayed in bold font

factors with NMSC was agreed with by most participants. However, only about three out of ten participants estimated NMSC to be more prevalent and less severe than MM. Women, those with higher education levels, full-time employment, lighter skin types, more than 40 nevi, frequent sunburns during childhood, and intentional outdoor tanners achieved higher knowledge scores. Furthermore, concern about NMSC was associated with more NMSC knowledge.

The higher familiarity with colloquial terms for NMSC and MM compared to medical terms seems not surprising given that the target group was the general population and not health professionals. However, a quarter of the participants had never heard even the colloquial terms before, which is in contrast to the high incidence and prevalence of NMSC. These findings underline the importance of considering health literacy and the current state of knowledge of individuals, e.g., in physician–patient communication (Sim et al. 2016), and of enhancing knowledge about NMSC in future prevention campaigns addressing the general population.

More than eight out of ten individuals were unaware that light or white spots on the skin are not typical signs of NMSC (Navarrete-Dechent et al. 2016). This may be explained by the German colloquial use of the term "white skin cancer" to describe NMSC. Although the introduction of the term "light skin cancer" into the German language

was considered an attempt to avoid this misunderstanding, our sample was much less familiar with this term compared to other colloquial terms. The fact that most participants were unfamiliar with the potential signs of NMSC may indicate that they would not be able to identify NMSC, and consequently, would not seek medical care. In addition, the majority believed that NMSC could progress to MM and that NMSC is less prevalent than or equally prevalent as MM. This underestimation has also been shown in previous qualitative research (Brokmeier et al. 2023) and was confirmed in the general population in this representative study. Future health education should focus on clarifying terms, clinical signs, and eliminating misconceptions; for example, "white skin cancer" is not synonymous with white spots on the skin, and NMSC cannot progress to MM (Clark et al. 1984). Data from other countries should be gathered to investigate whether these misconceptions exist only in Germany.

Although knowledge about NMSC was associated with several sociodemographic determinants, there was no association with outdoor occupation. This finding is of concern because outdoor occupation is a known risk factor for SCC (Loney et al. 2021; Schmitt et al. 2011) owing to the high exposure to UV radiation. Consequently, the official German guideline for skin cancer prevention demands the education of outdoor workers by their employers regarding skin cancer risks and prevention (Leitlinienprogramm Onkologie 2021).

Thus, we would have expected higher knowledge score values among outdoor compared to indoor workers. This may point to a deficit in current educational measures in the outdoor occupation sector. It seems necessary to increase knowledge about the risk factors, signs, and consequences of NMSC in outdoor workers to obey prevention guidelines and, ideally, to enhance sun protective behavior.

In line with previous research (Miles et al. 2005), women were more familiar with both medical and colloquial terms for skin cancer and achieved higher knowledge scores. This raises concern since men seem to be at greater risk of developing SCC (Schmitt et al. 2011). As outlined before, outdoor occupation is a known risk factor for SCC (Schmitt et al. 2011) and more men than women work outdoors, as reflected in our sample. Another explanation could be found in behavioral differences between men and women: Men seem to be less aware of the consequences of unprotected UV exposure and are less likely to engage in sun-protective behavior (Görig et al. 2018; Haluza et al. 2016; Miles et al. 2005), which might lead to a higher incidence of NMSC among men. Furthermore, higher education levels and full-time employment were associated with increased knowledge about NMSC, which is in line with previous studies on skin cancer knowledge (Duarte et al. 2018; Keeney et al. 2009; Miles et al. 2005). In Germany, higher education levels are associated with better health literacy in general (Schaeffer et al. 2017). Since education and employment are interrelated (Gangl 2003), this might further explain the lower levels of NMSC-knowledge among unemployed participants in our sample. Therefore, future prevention measures should tailor their content to male, lower educated, and unemployed individuals.

In addition, we found that potential risk factors for skin cancer, i.e., lighter skin type, more than 40 nevi, and frequent sunburns before the age of 15 were associated with more knowledge. In short, those at risk for skin cancer were better informed about NMSC. However, from our data, we cannot determine whether this vulnerable group uses better measures for sun protection. Nonetheless, a literature review showed that those with lighter skin types were most likely to engage in sun protection behaviors (Kasparian et al. 2009). Another risk factor for NMSC is UV-related risk behavior (Gordon 2013). We found more knowledge about NMSC among those who reported intentional tanning compared to those who did not intentionally tan. Previous research has shown similar patterns with regard to tanning bed use. Tanning bed users showed better knowledge of potential risks of UV radiation than non-users (Altsitsiadis et al. 2012; Schneider et al. 2009). Such findings can complicate prevention efforts because those who know the most are engaging in risky behaviors despite their knowledge.

We found higher knowledge score values among those who reported to be concerned about NMSC. This may imply that information and education about NMSC could lead to greater concern about NMSC in the general population. Concerns and worries about a disease have been shown to be associated with greater intentions to engage in preventive behaviors (Sobkow et al. 2020) and actual protective behaviors (Kiviniemi and Ellis 2014). However, our results are based on cross-sectional data and we cannot deduce causality regarding the association between knowledge and concern. Furthermore, ethical implications must be considered when using worry and fear in prevention campaigns (Chapman 2018). Since NMSC is rarely fatal (Leiter et al. 2017), the key to successful prevention of NMSC should not be based on people's worries and fears. Rather, it should be based on informing and educating the general population in a sensitive way to learn more about NMSC, to be able to classify risks and signs, and to seek medical help if needed.

Limitations

Our nationally representative findings are based on self-reported data and we cannot rule out a social desirability bias (Nederhof 1985). As a result, our findings may overestimate the knowledge about NMSC in the general population, which implies that the actual level of knowledge in the population is even lower. Another weakness of self-reported data could be a recall bias, especially for questions that target behaviors or events in the distant past (e.g., sunburns before the age of 15). To enhance the generalizability of our findings, we followed the highest methodological standards, including a two-stage sampling method, non-responder analysis, and data weighting to reflect the general German population. Finally, intentional tanning, outdoor occupation, and use of tanning beds were the only UV-related behaviors included in this study. Thus, other ways of being exposed to UV radiation, e.g., outdoor physical activity, should be explored in future research as potential correlates of knowledge about NMSC.

Conclusion

This study was among the first to comprehensively assess the knowledge about NMSC in the general population. Our findings have implications for practical applications. While familiarity with colloquial terms for skin cancer and UV-related risk behaviors as risk factors for NMSC was comparably high, knowledge about signs, consequences, prevalence, and severity of NMSC was rather low. This suggests that individuals might not recognize NMSC on their skin, stressing the importance of educational interventions and skin cancer screening. Besides public health campaigns, expert recommendations, e.g., from general practitioners or dermatologists, can be effective in informing individuals

about health behaviors (Sheeran et al. 2020) and may help individuals identify skin alterations by raising awareness about NMSC. However, health professionals should pay attention to their choice of words, as medical terms have been shown to be less familiar to the general population. Furthermore, educational campaigns should target male, less educated, and unemployed individuals, as they tended to know less about NMSC.

Declarations

The present work was performed in partial fulfillment of the requirements for obtaining the degree "Dr. rer. biol. hum." (LLB) at the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU).

Ethics approval The Ethics Committee II of the Medical Faculty Mannheim, Heidelberg University (2017-662N-MA, Mannheim, December 6, 2017) approved the design and procedures of this study.

Consent to participate All participants gave consent to take part in the study.

Consent for publication Not applicable.

Conflicts of interest The authors have no competing interests to declare that are relevant to the content of this article.

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