Does sunscreen use comply with official recommendations? Results of a nationwide survey in Germany

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Abstract
Background The use of sunscreen can reduce the risk of UV-induced skin lesions. Health authorities have provided recommendations for the correct use of sunscreen: Sufficient amount of sunscreen should be applied at least 30 min before the sun exposure and should be reapplied every 2 h.
Objective We aimed to research the practice of sunscreen use in a population-based and representative sample in Germany.
Methods For this cross-sectional survey, 3000 German residents aged 14–45 years were surveyed in standardized telephone interviews in 2018. Survey participants provided data on the frequency of sunscreen use in summer, timing of (re-)application and their skin characteristics. The data were weighted by age, sex, educational level and federal state to ensure the national representativeness of the sample.
Results Overall, 79.4% of respondents used sunscreen always, often or sometimes when being exposed to the sun. However, 87.2% of sunscreen users did not follow the recommendations on timing of application, 59.5% did not comply with the timing of reapplication. We also saw, that people potentially used too little sunscreen. These data did not differ noticeably by skin types of participants.
Conclusion Our study revealed deficits in use of sunscreen in Germany, indicating that people here pay little attention to the recommendations of health authorities, regardless of their skin type. There is therefore an urgent need for targeted public information on this issue. Improving public knowledge on correct sunscreen use through educational campaigns or individual counselling by health professionals could be a first step.

Conflict of interest
The authors declare no conflicts of interest.

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Introduction
Exposure to ultraviolet (UV) radiation from sunlight is considered a major modifiable environmental risk factor for skin cancer.1 Therefore, primary prevention of skin cancer focuses on reducing UV exposure through the promotion of sun protection behaviour, including seeking shade and covering-up strategies.2 An important element of this preventive strategy is the use of sunscreen. Reviews of existing studies have shown that sunscreen use reduces the risk of squamous cell carcinoma and actinic keratosis.3,4 Literature provides inconsistent information on the impact of sunscreen use regarding the prevention of malignant melanoma.5–7 These results should, however, be interpreted against the backdrop of high heterogeneity of the included studies. Yet sunscreen is undoubtedly able to delay sunburns and to reduce UV-induced skin lesions.
To help individuals to use sunscreens correctly, international and German health authorities (WHO, German Cancer Aid, Federal Office for Radiation Protection) have provided recommendations: A sufficient amount of sunscreen should be applied at least 30 min before the sun exposure and should be reapplied every 2 h. The general recommendation for sunscreen is 2 mg of sunscreen per cm² of skin surface, corresponding to about 40 g of sunscreen (about one-fifth of a usual sunscreen bottle) for a full body application to achieve the labelled sun protection factor (SPF), and therefore an optimum UV-protection in a typical adult.8

In international studies, 6–80% of all participants reported using sunscreen.9–13 However, previous research showed a rather low knowledge about the timing of sunscreen application: 34%14 to 66% of respondents15 knew that sunscreen should be applied at least 30 min before sun exposure. Tempark et al.16 showed that only 15–26% of adolescents applied sunscreen before going into the sun. Similarly, the knowledge on and practice of sunscreen reapplication were rather insuffi cient in previous studies: about two-third of respondents did not know about the recommended frequency of reapplying sunscreen15,17 and only a minority (29–42%) reported reapplying sunscreen as recommended.17,18 Additionally, previous research showed that people apply too little sunscreen: the average amount of sunscreen applied was between 0.60 and 0.80 mg/cm², which is less than half of the recommended amount.18–20

Previous studies, however, were conducted in selective populations, e.g. beachgoers,9,19 outdoor workers,13,21 high school students10,17 or in regional samples.15 We are not aware of any studies exploring the practice of sunscreen use in a population-based representative sample. Using a large representative database we aimed to research whether the self-reported practice of sunscreen use is in accordance with the above-mentioned recommendations by health authorities. The results of our study will help to identify the needs for further public education on sunscreen use.

Materials and methods

Study setting

This study is based on data from the National Cancer Aid Monitoring (NCAM), which is a nationwide representative survey of individual exposure to natural and artificial UV radiation. In the fourth wave of NCAM we collected data from n = 3000 individuals aged between 14 and 45 years who were living in Germany. Participants were surveyed from October to December 2018 using computer assisted telephone interviews. All participants gave their verbal consent to this study. Detailed methods have been described previously.22 The study was approved by the Ethics Committee of the Medical Faculty Mannheim, Heidelberg University (2007-269E-MA).

Instruments and measures

The questionnaire used in this study comprised items on practice of sunscreen use as well as skin type characteristics.

Sunscreen use Participants were asked (i) how often they use sunscreen with an SPF of 20 or higher (never, rarely, sometimes, often and always),23–25 (ii) on which parts of the body they apply sunscreen (face, shoulders, arms, legs and other), following Al Robaee,26 (iii) when they apply sunscreen before going out on sunny summer day (at the beginning of sun exposure, 5 min before, 15 min before, 30 min before, ≥45 min before), following Wang and Dusza,27 (iv) how often they reapply sunscreen (every hour, every 2 h, every 3 h, every 4 h or later, never), following Wang and Dusza.27 For these questions, participants were asked to think of their habits when they are outside on a sunny summer day for more than 15 min.23 Additionally, participants were asked (v) about the lowest SPF of sunscreen preparations they used during the last summer (SPF 15, 20, 30, 50, >50) and (vi) about the highest SPF of sunscreen preparations they used during last summer (SPF 15, 20, 30, 50, >50).

We also gathered an estimation of the amount of sunscreen the participants would usually apply using the following open-ended item: ‘How many times can you apply sunscreen to your entire body when wearing usual swimwear, using a 200 mL bottle of sunscreen?’. Hault et al.21 used a similar question to ask outdoor workers about the sunscreen amount they would use. For our analyses, the answers were recoded into five categories: ≤5, 6–20, 21–40, >40 times.

The items were developed according to previously validated instruments, comprehensively examined in a cognitive pretest (n = 15) including category selection probing and comprehension probing. We then revised the items according to the results of the pretest. For example, we saw that it was important to specify the definition of the entire body. We also considered it essential to train the interviewers to answer requests on the size of the bottle that 200 mL correspond to the size of a regular water glass in Germany.

Skin type were assessed using the self-reported skin type according to Fitzpatrick’s classification (Fitzpatrick; type I–VI). For bivariate analyses, we grouped the study population into three groups, people with pale skin (skin type I–II), medium skin (skin type III) and darker skin (skin types IV–VI).

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics 24 (IBM Corp., Armonk, NY, USA). We used descriptive analyses to explore the practice of sunscreen use within the German population. Additionally, to explore the distribution of variables of interest by skin type of participants, we performed the chi-square tests. P-values <0.05 were considered to be significant.

The data were weighted by sex, age, educational level and state of residence to be representative of the German population.
**Results**

Six out of ten participants (64.5%) stayed in the sun with the intention of getting tanned very often, often or sometimes during the last summer. Overall, 46.4% of study participants ($n = 1389$) used sunscreen always or often and 33.0% ($n = 986$) used it sometimes when being in the sun in summer. Most frequently, these individuals applied sunscreen on the face (87.0%) and on the shoulders (79.2%), followed by ‘on the arms’ (70.1%), ‘on the legs’ (53.4%) and ‘on other parts of the body’ (40.8%).

About an eighth (12.8%) reported applying sunscreen at least 30 min before any exposure to the sun (Fig. 1a). One-third (34.1%) applied sunscreen directly when being in the sun. Four out of ten participants (40.5%) reapplied sunscreen every hour or every two hours (Fig. 1b). Fifteen percent reported to never reapply sunscreen.

About one-third of the sample (35.7%) reported having skin types I–II, skin type III (31.7%) and skin types IV–VI (32.6%). Slightly more participants with pale skin reported to apply and to reapply sunscreen according to the recommendations: 14.1% of those with skin type I or II applied sunscreen at least 30 min before being exposed to the sun vs. 10.3% of those with skin types IV–VI ($P < 0.001$; Table 1). Participants with pale skin used sunscreen with higher SPF more frequently than those with darker skin did. For the majority of participants with skin type I–II (68.8%), SPF ≥30 was the lowest SPF they used during the last summer (vs. 38.5% of participants with skin type IV–VI; $P < 0.001$; Table 1). The highest SPF most of these persons (63.8%) used was SPF ≥50 (vs. 31.4% of those with darker skin; $P < 0.001$; Table 1).

In the opinion of study’s participants, the content of a 200 mL bottle of sunscreen is enough to cover the entire body on average 16.5 times (Mdn = 15.0, SD = 10.8). Only 7.5% were convinced that this amount would suffice for up to five applications (Fig. 2). The majority (59.0%) suggested that this amount would be sufficient for 6–20 applications. It was remarkable that 583 participants (19.4%) were not able to give any response to this question. We saw significant differences in the amount of sunscreen which the participants would apply according to one’s own skin type (Table 1). In general, it was still low amongst those especially prone to sunburn and skin cancer (skin type I–II), as well as in participants less sensitive to photodamage (skin types IV–VI).

**Discussion**

The aim of our representative study was to research the sunscreen use in summer in a large and representative sample from Germany. We found that nearly eight out of ten respondents used sunscreen always, often or sometimes in summer. Nonetheless, we discovered deficits in the use of sunscreen. Participants’ behaviour did not always comply with official recommendations.

Some of our results are in line with previous research. In our study, participants applied sunscreen most frequently on face and shoulders (87.0% and 79.2%), which corresponds with the results of earlier studies. Also regarding the reapplication of sunscreen, our findings are similar to those from US-American and Danish studies, which showed that more than half of the participants did not reapply sunscreen within the recommended time interval. Previous studies found that only one-third of the participants knew that they should apply sunscreen at least 30 min before sun exposure. Our study revealed an even lower number (12.8%).

In our study, only a minority of sunscreen users followed the recommendations on times of application and reapplication. One-third applied sunscreen when being in the sun and 15% never reapplied it. We noticed that the data did not differ noticeably in regard to skin types of participants. While previous studies suggested that individuals with pale skin are more aware of their skin sensitivity and are therefore more likely to protect themselves from UVR, our study does not support this finding. Our results rather suggest that people in Germany are less likely to be aware of this recommendation regardless of their skin type, i.e. of the individual sensitivity to UV-related damages.

Due to our study’s design, we were not able to collect data on the amount of sunscreen, participants use for each individual application. A face-to-face study would be the means of choice, in which the amount of sunscreen that participants intend to use can be weighed. However, our findings give an indirect indication that most individuals would use only insufficient amounts. One fifth of study participants was not aware of the amount of sunscreen they should apply. Our respondents suggested that on average the content of a 200 mL bottle of sunscreen is enough to

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**Figure 1** Timing of sunscreen application and reapplication. (a) Timing of sunscreen application before going out on a sunny summer day. (b) Timing of sunscreen reapplication.
cover the entire body 16.5 times. This corresponds to 12 mL of sunscreen per use for the whole body, which is one-third of the recommended amount. Although the sunscreen amount of 2 mg/cm² is the quantity needed to achieve the labelled SPF tested under laboratory conditions, in reality, consumers often apply the amounts they feel comfortable with. Several studies showed that the negative appraisal of properties of sunscreen when applied (e.g. stickiness and greasiness) is one of the central barriers for using sunscreen.29–31

The findings of our representative study are particularly worrying and emphasize the need for the promotion of knowledge on times of sunscreen use. Furthermore, clear and real-life information on the amount of sunscreen required to ensure an optimal sun protection, need to become more familiar. A notice that sunscreen should be applied generously or information on the amount of sunscreen in mL (as it is currently stated in different internet sources and on sunscreen bottles) are obviously not sufficient. Instead, German health authorities could suggest the so-called teaspoon-rule, to specify the amount of sunscreen:32 one teaspoon should be applied to each arm and forearm, one teaspoon to face, scalp and neck; two teaspoons to the torso; and two teaspoons to each thigh and leg. Another possibility to achieve the labelled SPF value is a double application of sunscreen, as suggested by Teramura et al.33 To reach a broader population, health insurance companies can inform their insurants on sunscreen use on a regular basis, and the manufacturer

| Table 1 Practice of sunscreen use regarding skin type of study participants |
|--------------------------------------------------|
| **Skin type of the respondent** | **I–II (%)** | **III (%)** | **IV–VI (%)** |
| **Timing of sunscreen application** | | | <0.001 |
| ≥45 min before | 2.5 | 3.0 | 1.5 |
| 30 min before | 11.6 | 10.3 | 8.8 |
| 15 min before | 32.0 | 24.1 | 22.3 |
| 5 min before | 24.1 | 27.1 | 23.9 |
| When I am in the sun | 28.4 | 34.8 | 41.6 |
| Do not know/n.a. | 1.4 | 0.6 | 1.9 |
| **Timing of sunscreen reapplication** | | | <0.001 |
| Every hour | 14.0 | 11.7 | 11.7 |
| Every 2 h | 32.3 | 27.9 | 21.4 |
| Every 3 h | 25.2 | 24.3 | 20.0 |
| Every 4 h | 13.0 | 18.1 | 20.8 |
| Never | 12.4 | 14.3 | 19.4 |
| Do not know/n.a. | 3.1 | 3.6 | 6.8 |
| **Lowest SPF used in last summer** | | | <0.001 |
| SPF 15 | 5.3 | 13.0 | 23.0 |
| SPF 20 | 25.6 | 41.0 | 39.1 |
| SPF 30 | 43.9 | 35.8 | 28.8 |
| SPF ≥50 | 24.1 | 9.2 | 6.8 |
| Do not know/n.a. | 1.1 | 1.0 | 2.3 |
| **Highest SPF used in last summer** | | | <0.001 |
| SPF 15 | 0.2 | 1.9 | 2.8 |
| SPF 20 | 3.5 | 9.2 | 18.3 |
| SPF 30 | 32.0 | 50.5 | 45.6 |
| SPF ≥50 | 63.0 | 37.0 | 30.5 |
| Do not know/n.a. | 1.3 | 1.4 | 2.8 |
| **Number of times sunscreen can be applied to the entire body using a 200 mL bottle of product** | | | <0.001 |
| ≤5 times | 8.1 | 8.1 | 6.5 |
| 6–20 times | 62.4 | 61.4 | 52.9 |
| 21–40 times | 11.1 | 11.6 | 15.8 |
| >41 times | 0.6 | 1.4 | 2.0 |
| Do not know/n.a. | 17.9 | 17.5 | 22.9 |

n = 2383 individuals aged 14–45 years old who participated in the National Cancer Aid Monitoring in 2018 and who reported to have used sunscreen during the last summer; data are weighted by sex, age, educational level and state of residence.

SPF, sun protection factor.
of sunscreen can be encouraged to provide such information on the packaging of sunscreens.

Health authorities should update their recommendations with regard to the use of sunscreens that are labelled to provide ‘instant protection’, since such assertions can be misleading for consumer. Whether such products containing physical sunscreens, e.g. zinc oxide and titanium dioxide, provide protection immediately after the application is still the topic of debates.\textsuperscript{34} In our study, we did not differentiate between use of physical and chemical sunscreen, since most popular products in Germany contain only chemical sunscreens.\textsuperscript{35}

Since a high amount of sunscreen did not automatically result in perfect body coverage, information material should also focus on where to apply sunscreen. In their experimental study focusing on sunscreen application routine, Jovanovic et al.\textsuperscript{36} showed that a considerable surface of the body remained un-covered when exposed to the sun, especially upper back, feet, backs of arms and hands. Information material should therefore indicate that sunscreen needs to be applied on these areas too.

To inform the population on sunscreen use, health professionals could also play a key role. In NCAM survey wave 2016, dermatologist and physicians were reported to be the most important sources of information about skin cancer prevention (data not shown). In Germany, a biannual skin cancer screening is part of the healthcare routine of insurants aged 35 and over. The lifetime prevalence of skin cancer screening use here is about 39%.\textsuperscript{37,38} In addition to the whole body skin examination, dermatologists and physicians, who are enabled to perform this screening, are supposed to counsel their patients on primary prevention of skin cancer. On this occasion, they can inform their patients on the correct use and the selection of sunscreen suitable for their individual skin type. Such medical advice could be especially beneficial for patients with pale skin. In our study, these persons had insufficient practice and knowledge on sunscreen use, despite their higher risk of skin cancer due to their skin type.

**Limitations**

Some limitations should be considered when interpreting the results of our study. Firstly, in our study we focused on sunscreen use as the only one strategy for the prevention of UV-induced skin damages. We did not gain any information whether sunscreen was used in combination with other photoprotective strategies as it is recommended. We also do not know whether the participants did not use sunscreen because they protected themselves in other ways (e.g. by clothes or by staying in the shade). Thus, we cannot make a conclusion about the quality of the overall UV-protective routine of our study’s respondents.

Secondly, our data are based on self-reports of study’s participants. Therefore, we cannot rule out a recall bias on the use of sunscreen. To reduce this bias, the survey was conducted shortly after the summer months (October to December) and we asked participants about their sunscreen use generally in summer but not only during the last summer.

Thirdly, we asked the study participants about sunscreen use when being outdoors on a sunny day for more than 15 min in order to gather their general sunscreen use habits. Nonetheless, we cannot rule out that some participants referred their answers to concrete occasions when they spent a very short time in the sun and saw no need to apply and to reapply sunscreen. However, the participants in the cognitive pretest of this study reported that their answers to the questions on sunscreen use referred rather to their general sunscreen use routine.

**Conclusion**

This study revealed deficits in practice of sunscreen use in Germany, indicating an urgent need for action regarding this issue. The improvement of public knowledge on the correct application of sunscreen (e.g. public information campaigns using internet and social media, accessible and easy comprehensible information on websites of German health authorities), and individual medical advice on sunscreen use provided by healthcare professionals could be first steps to improve the use of sunscreen in the general population and especially in people with a higher risk for skin cancer.

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