Interest in Skin Cancer in Urban Populations: A Retrospective Analysis of Google Search Terms in Nine Large German Cities

Linda TIZEK[1,2], Maximilian C. SCHIELEIN[1,2], Melvin RÜTH[1], Rolf-Markus SZEIMIES[3], Wolfgang G. PHILIPP-DORMSTON[4,5], Stephan A. BRAUN[6], Christine HECKER[7], Bernadette EBERLEIN[1], Tilo BIEDERMANN[1] and Alexander ZINK[1]

[1]Department of Dermatology and Allergy, School of Medicine, Technical University of Munich, [2]The Institute for Medical Information Processing, Biometry, and Epidemiology, LMU Munich, Munich, [3]Department of Dermatology and Allergology, Vest Clinic, Recklinghausen, [4]Hautzentrum Koeln, Klinik Links vom Rhein, Cologne, [5]Faculty of Health, University Witten-Herdecke, Witten, [6]Department of Dermatology – General Dermatology and Venereology, Münster University Medical Center, Muenster, and [7]Department of Dermatology, Nuremberg Hospital North, Nuremberg, Germany

Skin cancer is a major public health issue, which could be reduced through prevention programmes. However, prevention utilization is not very prevalent. It is therefore important to understand individuals' interest in skin cancer. Google AdWords Keyword Planner was used to identify the search volume of terms relating to skin cancer in 9 German cities between July 2014 and June 2018. From a total of 1,203 identified keywords, 1,047 search terms were related to skin cancer, which had a search volume of 3,460,980 queries for the study period. Most terms referred to "identifying skin cancer". For melanoma, the number of Google searches per 100,000 inhabitants correlated with the cancer registry data for melanoma incidence rates (men: r = 0.810, women: r = 0.569). Assessment of this data for the different cities further enabled identification of regional variations, which could help to identify areas with a high need for targeted prevention campaigns.

Key words: skin cancer; melanoma; non-melanoma skin cancer; Google; search analysis; retrospective study; keratinocyte; risk assessment.

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Corr: Alexander Zink, Department of Dermatology and Allergy, School of Medicine, Technical University of Munich, Biedersteiner Str. 29, DE-80802 Munich, Germany. E-mail: alexander.zink@tum.de

SIGNIFICANCE

This study examined the Google search volume for skin-cancer-related terms in 9 German cities. Overall, 3.5 million searches related to skin cancer were observed between July 2014 and June 2018. Most of these searches focused on the identification of skin cancer (e.g. ABCD and pictures of skin cancer). In general, the number of search queries per 100,000 inhabitants was lower in larger cities, such as Berlin or Hamburg, in comparison with Stuttgart or Muenster. Analysis of the differences in search behavior between cities could help to identify areas with a high need for targeted prevention campaigns.

Skin cancer, including non-melanoma skin cancer (NMSC) and melanoma, is the most common carcinoma among Caucasians worldwide (1–4), with increasing incidence during recent decades (5–9). While the incidence of NMSC is 18–20 times higher than that of melanoma (1, 3), melanoma is more often fatal (10, 11). Thus, skin cancer presents an enormous socioeconomic burden (12–14), which could be reduced by early detection, diagnosis and treatment (15, 16). Specifically, the incidence of NMSC can be reduced through sun-protection measures (17–19). Despite substantial efforts to comprehensively implement primary prevention strategies (e.g. seeking shade, wearing sun protective clothing, using sun-screen) and secondary prevention strategies (e.g. regular self-examination, regular dermatological check-ups, skin cancer screening campaigns) (20), studies have shown that utilization of such strategies is not highly prevalent (21–23), particularly among individuals who spend a lot of time outdoors (24–27).

One way to investigate reasons for not using skin cancer prevention measures is to focus on the interest in skin cancer among the general population (28). As the Internet is a commonly used source of health information, search engine analysis represents a novel tool for investigating the general interest in various topics (16, 28–33). In Germany, approximately 90% of inhabitants use the Internet (34). More specifically, 95% use Google as their primary search engine (35), and 57% have used the Internet to search for health-related information (36). For example, a German study among patients with melanoma reported that 63% indicated the Internet as the most important source of media information (37). One US study revealed a positive correlation between Internet search volume and the incidence and mortality rates of melanoma and other common cancers (38). Additional studies have revealed an increasing number of Google searches related to health information in recent years (30, 39).

The aim of the present study was to investigate German inhabitants' interest in skin cancer, and whether geographical differences in interest have emerged, by analyzing Google search volumes in 9 German cities. Furthermore, the number of search queries within each city was compared with data from respective cancer registers in order to determine whether there was a correlation between interest and cancer incidence rates.

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Table I. Subcategorization of identified keywords related to skin cancer in Germany from July 2014 to June 2018

Subcategories	Non-melanoma skin cancer		Melanoma		Skin cancer in general[a]	
	Keywords ($n = 272$)[b]	Search volume ($n = 1,290,050$)	Keywords ($n = 209$)[c]	Search volume ($n = 671,440$)	Keywords ($n = 566$)[d]	Search volume ($n = 1,499,490$)
Treatment of skin cancer	15	29,300	31	55,710	47	145,450
Identifying skin cancer	123	260,870	67	116,500	233	501,100
Localization of skin cancer	60	71,130	33	36,690	130	157,030
Questions on skin cancer	28	34,150	33	34,760	133	158,180
General	76	934,780	63	443,930	114	642,050

[a]Skin cancer in general=all search terms contained only "skin cancer". [b]Thirty keywords were assigned to at least 2 subcategories. [c]Eighteen keywords were assigned to at least 2 subcategories. [d]Ninety-two keywords were assigned to at least 2 subcategories.

METHODS

Study design

A retrospective longitudinal study using Google AdWords Keyword Planner was carried out to identify the search volume of terms related to skin cancer between July 2014 and June 2018 in 9 large cities across Germany (Berlin, Hamburg, Munich, Cologne, Stuttgart, Nuremberg, Muenster, Magdeburg and Recklinghausen). Although Google AdWords Keyword Planner is used primarily to detect keywords for optimizing Google marketing campaigns, this tool can also be used for scientific purposes (30, 32, 33). The software provides monthly search volume data as estimated by Google. Search volume represents the total number of searches for selected keywords. To assess search volume within a specific field, words or phrases related to the topic are initially entered into the Keyword Planner; subsequently, the program finds keywords that are most relevant to the topic (40). Accordingly, 13 German terms were identified: "skin cancer" ("Hautkrebs"), "white skin cancer" ("weißer Hautkrebs"), "light skin cancer" ("heller Hautkrebs"), "nonmelanocytic skin cancer" ("nicht melanozytärer Hautkrebs"), "non-melanoma skin cancer" ("nicht melanozytärer Hautkrebs"), "NMSC" ("nicht melanozytärer Hautkrebs"), "basalioma" ("Basaliom"), "basal cell carcinoma" ("Basalzellkarzinom"), "spinalioma" ("Spinaliom"), "squamous cell carcinoma" ("Plattenepithelkarzinom"), "black skin cancer" ("schwarzer Hautkrebs"), "melanoma" ("Melanom") and "malignant melanoma" ("Malignes Melanom").

Statistical analysis

The authors reviewed and categorized all keywords into 6 groups, namely the German terms for "skin cancer in general", "NMSC", "melanoma", "skin alterations", "other malignant diseases" and "unspecific". However, keywords that were not associated with skin cancer were excluded from the analysis (e.g. "breast cancer"). Those keywords assigned to skin cancer-related categories were further classified into "treatment of skin cancer" (e.g. "NMSC treatment," "prevention"), "identifying skin cancer" (e.g. "skin cancer ABCD," "symptoms"), "localization of skin cancer" (e.g. "skin cancer on the face") or "questions on skin cancer" (e.g.

Table II. Comparison of the absolute and relative Google search volume of terms related to skin cancer in 9 German cities from July 2014 to June 2018

	Berlin *n* (%)	Hamburg *n* (%)	Munich *n* (%)	Cologne *n* (%)	Stuttgart *n* (%)	Nuremberg *n* (%)	Muenster *n* (%)	Magdeburg *n* (%)	Reckling-hausen *n* (%)
Inhabitants	3,574,830	1,810,438	1,464,301	1,075,935	628,032	511,628	311,846	238,136	114,003
Proportion of non-native Germans (58)	17.6	16.2	25.5	19.2	24.6	21.9	10.3	8.6	10.7
Incidence of melanoma[a]									
Men	9.8–12.9	12.2–16.0	14.7–23.4	23.4–29.1	n. a.	20.8–28.4	15.4–25.5	13.6–22.6	19.1–20.8
Women	8.7–11.1	11.5–14.0	12.0–22.0	25.2–29.1	n. a.	16.6–21.1	20.6–25.6	12.2–20.2	20.0–26.7
Searches related to skin cancer	985,660	591,890	617,060	435,090	314,050	228,440	146,150	93,150	49,490
NMSC	377,280	220,120	236,910	158,100	111,480	80,280	52,750	35,200	17,930
Melanoma	182,170	110,960	125,430	85,890	63,170	46,400	29,850	18,420	9,150
Skin cancer in general[b]	426,210	260,810	254,720	191,100	139,400	101,760	63,550	39,530	22,410
Searches per 100,000 inhabitants									
Searches related to skin cancer	27,572	32,693	42,140	40,438	50,005	44,650	46,866	39,116	43,411
NMSC	10,559	12,158	16,179	14,694	17,751	15,691	16,915	14,781	15,728
Treatment	189 (1.7)	249 (2.0)	315 (1.9)	352 (2.3)	441 (2.4)	502 (3.1)	600 (3.4)	621 (4.0)	851 (5.1)
Identification	1,894 (17.5)	2,359 (18.8)	3,102 (18.6)	2,917 (19.2)	4,027 (21.9)	3,817 (23.4)	3,970 (22.7)	4,413 (28.4)	5,219 (31.1)
Localization	464 (4.3)	688 (5.5)	822 (4.9)	894 (5.9)	1,095 (5.9)	1,085 (6.6)	1,196 (6.8)	1,197 (7.7)	1,246 (7.5)
Questions	239 (2.2)	323 (2.6)	413 (2.5)	396 (2.6)	552 (3.0)	526 (3.2)	468 (2.7)	559 (3.6)	623 (3.7)
General	8,029 (74.2)	8,914 (71.1)	12,006 (72.1)	10,615 (70.0)	12,299 (66.8)	10,404 (63.7)	11,278 (64.4)	8,722 (56.2)	8,728 (52.4)
Melanoma	5,172	6,129	8,566	7,983	10,058	9,069	9,572	7,735	8,026
Treatment	348 (6.7)	490 (7.8)	652 (7.4)	698 (8.5)	931 (9.0)	911 (9.8)	1,055 (10.8)	932 (11.7)	1,175 (14.2)
Identification	797 (15.3)	1,000 (15.9)	1,373 (15.7)	1,372 (16.7)	1,852 (17.9)	1,910 (20.5)	1,979 (20.3)	1,999 (25.2)	2,386 (28.9)
Localization	247 (4.7)	340 (5.4)	467 (5.3)	475 (5.8)	624 (6.0)	534 (5.7)	523 (5.4)	428 (5.4)	386 (4.7)
Questions	232 (4.5)	313 (5.0)	412 (4.7)	461 (5.6)	650 (6.3)	502 (5.4)	500 (5.1)	462 (5.8)	439 (5.3)
General	3,580 (68.8)	4,129 (65.8)	5,860 (66.9)	5,193 (63.3)	6,289 (60.8)	5,443 (58.5)	5,714 (58.5)	4,111 (51.8)	3,860 (46.8)
Skin cancer in general	11,977	14,406	17,395	17,761	22,196	19,889	20,379	16,600	19,657
Treatment	1,097 (8.7)	1,423 (9.2)	1,740 (9.4)	1,718 (9.0)	2,094 (8.8)	1,970 (9.2)	2,171 (9.9)	1,587 (8.8)	2,412 (11.3)
Identification	3,885 (30.9)	4,802 (31.1)	5,810 (31.2)	5,874 (30.8)	7,425 (31.1)	6,980 (32.5)	6,962 (31.8)	6,517 (36.1)	7,570 (35.4)
Localization	1,009 (8.0)	1,527 (9.9)	1,802 (9.7)	2,065 (10.8)	2,630 (11.0)	2,355 (10.9)	2,710 (12.4)	1,919 (10.6)	2,737 (12.8)
Questions	1,008 (8.0)	1,512 (9.8)	1,818 (9.8)	1,979 (10.4)	2,572 (10.8)	2,420 (11.3)	2,248 (10.3)	2,121 (11.7)	2,377 (11.1)
General	5,569 (44.3)	6,163 (39.9)	7,438 (40.0)	7,436 (39.0)	9,159 (38.4)	7,785 (36.2)	7,805 (35.6)	5,921 (33.3)	6,307 (29.5)

[a]Registered age-standardized incidence per 100,000 inhabitants between 2011 and 2014. [b]Skin cancer in general=search terms contained only "skin cancer".
NMSC: non-melanoma skin cancer.

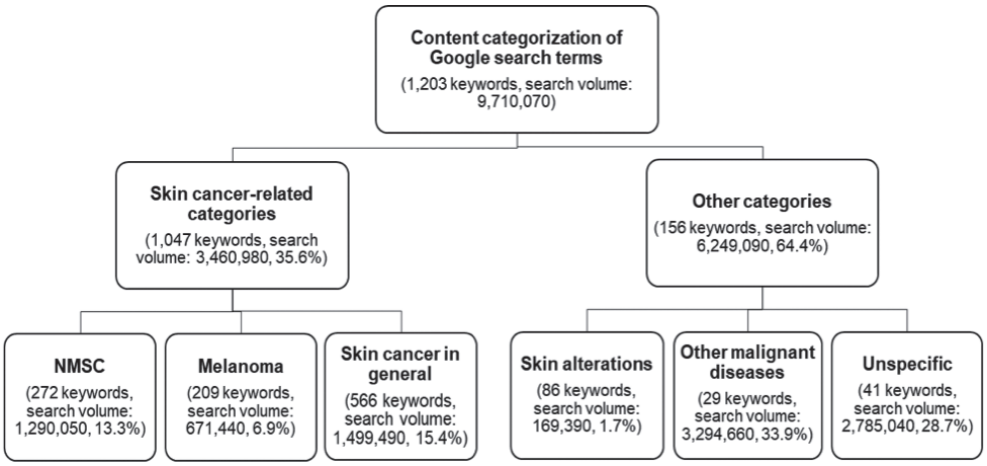

Fig. 1. Content categorization of search terms identified by Google AdWords Keyword Planner. NMSC: non-melanoma skin cancer; skin cancer in general: search terms contained only "skin cancer". All search terms were individually screened and assigned to categories. All terms that did not fit in any of those categories were classified as "unspecific".

"what are the risk factors for skin cancer?"). Searches that did not fit any of these subcategories were placed in a "general" (e.g. "white skin cancer") category. Keywords matching various criteria were assigned to several subcategories (**Table I**).

Descriptive data were generated for the identified keywords. To assess differences in search behavior per 100,000 inhabitants between cities (41), one-way analysis of variance (ANOVA) was used. Pearson's correlation coefficient was further used to investigate the relationship with age-standardized incidence of melanoma for men and women in the year 2014, since cancer registry data for melanoma incidence are available up to 2014 (**Table II**) (42–45). IBM SPSS Statistics (Version 25, IBM Corporation, Armonk, NY, USA) was used for all statistical analyses. Spatial analyses using geodata for administrative boundaries from the German Federal Agency for Cartography and Geodesy (46) were performed using a geographic information system (QGIS version 2.14.22, QGIS Development Team, 2016, Minden, Germany).

RESULTS

Overall, 1,203 keywords were identified, resulting in a search volume of 9,710,070 queries for the period from July 2014 to June 2018. Of these, 156 keywords were excluded from the final analysis, as they referred to "other malignant diseases" (e.g. "lung cancer"), "skin alterations" (e.g. "new mole") or were not assignable terms (e.g. "chemotherapy"). The remaining 1,047 keywords had an overall search volume of 3,460,980 queries and were assigned to the following categories: 272 referred to "NMSC" and 209 to "melanoma". A total of 566 terms did not fit into either the "NMSC" or "melanoma" category, as the terms contained only "skin cancer" and were thus included in the "skin cancer in general" category (**Fig. 1**). The most commonly searched keywords were "skin cancer" (n=454,140), "white skin cancer" (n=407,630), "basalioma" (n=191,730), "melanoma" (n=152,900), and "black skin cancer" (n=124,720).

Comparisons between cities

As expected, Berlin (n=990,550), Hamburg (n=591,890) and Munich (n=617,060) had the largest overall search volumes, as they are Germany's largest cities by population. However, the highest number of search queries per 100,000 inhabitants was observed in Stuttgart and Muenster, with 50,005 and 46,866 searches, respectively. In comparison, the lowest per capita rates were observed in Hamburg (n=32,693) and Berlin (n=27,572, **Fig. 2**). In total, the mean relative number of searches was 35,573 per 100,000 inhabitants.

The category "skin cancer in general" had the highest search volume, with 1,499,490 queries. Within this category, most keywords referred to "identifying skin cancer" (n=233, Table I). Of these keywords, almost half focused on images of skin cancer (n=102), which

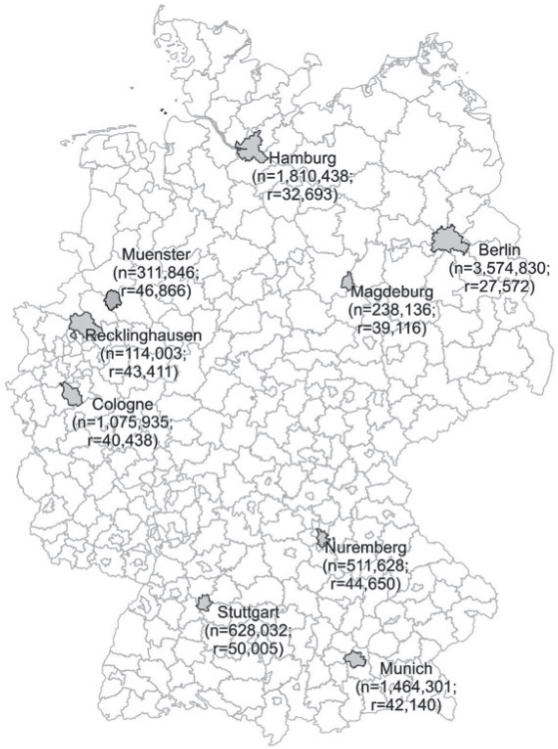

Fig. 2. Google search volume of skin cancer-related terms in 9 German cities from July 2014 to June 2018. n: number of inhabitants; r: number of search queries per 100,000 inhabitants.

had a mean search volume of 5,150 searches/100,000 inhabitants, being highest in Recklinghausen (7,570 searches/100,000 inhabitants) and lowest in Berlin (3,852 searches/100,000 inhabitants). The analysis revealed significant differences only in the subcategories of "localization" and "questions" within some cities. For example, the number of searches/100,000 inhabitants including information on the localization was significantly lower in Berlin ($n=1,009$) than in all other cities except for Hamburg ($n=1,527$, $p=0.974$), Munich ($n=1,802$, $p=0.334$) and Magdeburg ($n=1,919$, $p=0.124$).

A total of 1,290,050 searches focused on NMSC. Therefore, the highest search volume was observed in the subcategory "general" ($n=934,780$), followed by "identifying" ($n=260,870$, Table I). While there were no significant differences in the overall number of searches within the cities, a significantly higher number of searches/100,000 inhabitants focusing on identifying were observed in Recklinghausen ($n=5,219$) compared with Berlin ($n=1,894$, $p=0.003$) and Hamburg ($n=2,359$, $p=0.025$, Table II).

A mean of 6,901 searches/100,000 inhabitants referred to melanoma, ranging from 5,172 to 10,058. Compared with NMSC, a significantly higher number of searches regarding "identifying", but also regarding "treatment", was observed in Recklinghausen compared with Berlin ($p=0.004$ and $p=0.037$, respectively). In 2014, the highest age-standardized melanoma incidence rate was 28.4/100,000 for men in Nuremberg and 29.1/100,000 for women in Cologne. During the same year, the highest numbers of searches/100,000 inhabitants related to melanoma were observed in Stuttgart ($n=1,283$), Nuremberg ($n=1,179$), Munich ($n=1,053$) and Cologne ($n=1,031$). A significantly high correlation between the number of search queries and the incidence rate in men ($r=0.810$, $p=0.015$) was identified. This correlation was stronger than the correlation with the incidence rate in women ($r=0.569$, $p=0.141$).

Time course of search behavior

Across all cities, the highest number of searches was in July 2015 (NMSC: $n=38,180$, melanoma: $n=20,450$, and skin cancer in general: $n=40,580$) and the lowest was in December 2017 (NMSC: $n=19,750$, melanoma: $n=12,100$, and skin cancer in general: $n=21,320$). Each year, the monthly number of search queries was higher in the spring and summer than in the autumn and winter. Apart from these seasonal variations, the number of Google searches remained relatively stable over the entire study period (**Fig. 3**a).

Figs 3b and c outline Google search trends per 100,000 inhabitants in each city. Except for Cologne, Magdeburg and Recklinghausen, the highest number of search queries/100,000 inhabitants was in July 2015 for each remaining city (Berlin: $n=889$, Hamburg: $n=957$, Munich: $n=1,481$, Stuttgart: $n=1,621$, Nuremberg: $n=1,499$ and Muenster: $n=1,456$). Across the 3 aberrant cities, most searches were observed during June 2017 in Cologne ($n=1,092$), June 2016 and May 2017 in Magdeburg ($n=1,033$) and May 2018 in Recklinghausen ($n=1,316$). While Nuremberg had the highest search query range (606–1,499 searches/100,000 inhabitants), the lowest range was observed in Hamburg (499–957 searches/100,000 inhabitants).

DISCUSSION

The aim of the present study was to investigate general interest in skin cancer across Germany and whether specific geographical differences exist regarding search volume and terms of interest. Furthermore, the number of search queries/100,000 inhabitants in each city was compared with melanoma cancer registry data to assess whether there was a correlation.

Previous studies have shown that Google search analyses are an effective tool for assessing disease trends (38), as well as understanding health information seeking behavior (28, 30, 32, 33). In total, almost 3.5 million Google searches related to skin cancer were observed within 4 years in our study, representing 17.6% of all skin cancer-related Google searches across all of Germany ($n=19,849,230$) (30). When comparing the number of Google searches/100,000 inhabitants across the cities, we found that Berlin ($n=27,572$) and Hamburg ($n=32,693$) had a comparatively low number. However, in comparison with the number of search queries/100,000 inhabitants regarding pruritus, the search volume of skin cancer-related queries was nearly twice as high (Berlin: $n=13,641$; Hamburg: $n=18,303$) (47). In general, the present study revealed, that within the context of skin cancer, especially when searching for NMSC, many people searched for general information. In addition, there was great interest in skin cancer identification ($n=879,650$). In all categories, nearly half of the search terms that were classified as "identifying" were used to search for images (NMSC: 72/123 keywords, melanoma: 30/67 keywords, and skin cancer in general: 102/233 keywords). Many individuals also searched for symptoms or how to identify skin cancer, which indicates that people may use the Internet for skin disease information prior to consulting a physician.

The Google data for 2014 showed that Nuremberg ($n=1,179$), Munich ($n=1,053$) and Cologne ($n=1,031$) had some of the highest numbers of melanoma searches/100,000 inhabitants. Cancer registry data on melanoma incidence (42–45) showed that the age-standardized incidences were comparatively high in Nuremberg and Cologne (Table II). Analysis revealed a high correlation between the data, which was stronger in men ($r=0.810$) than in women ($r=0.569$). Accordingly,

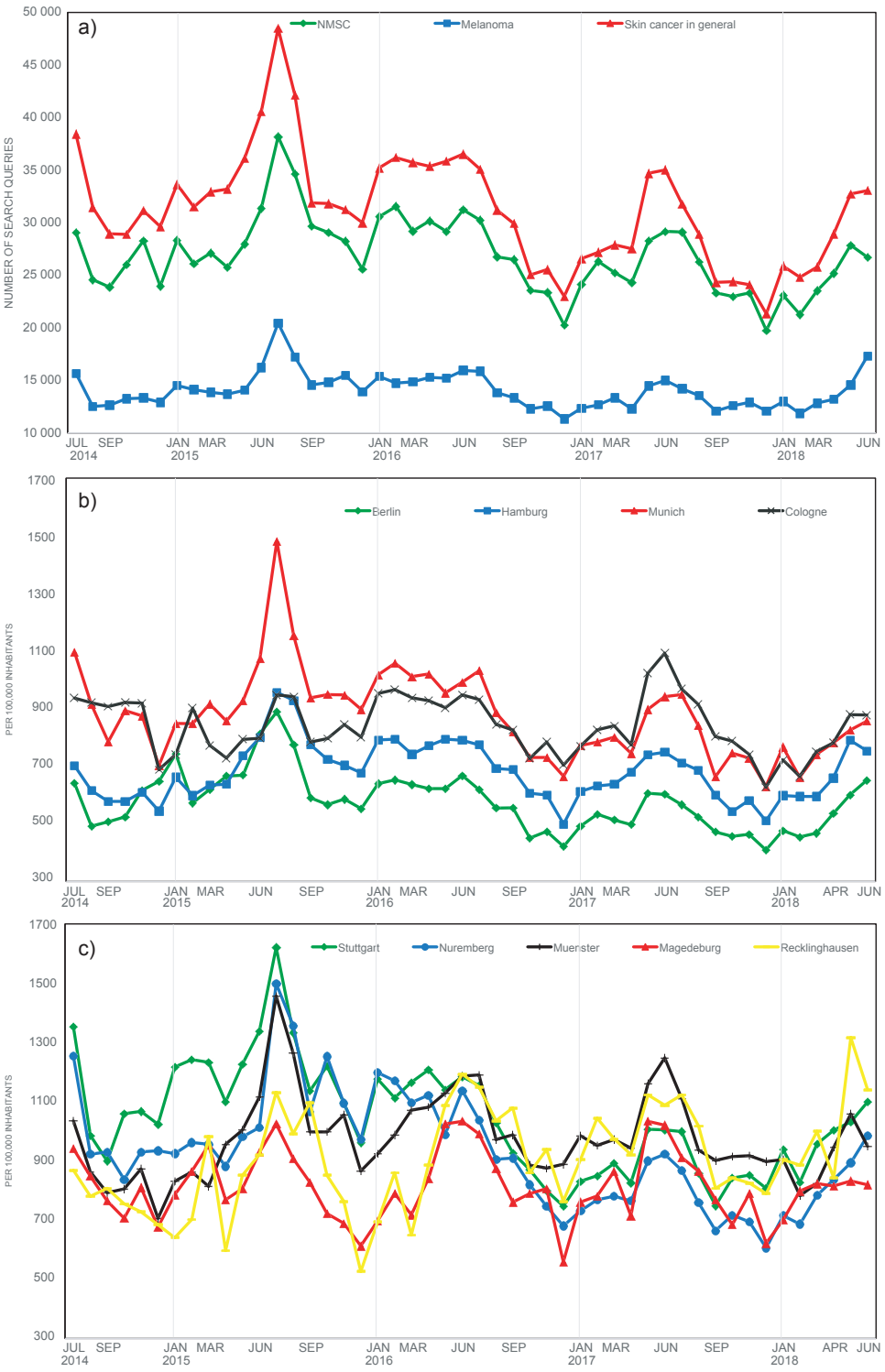

Fig. 3. Trends in Google search volume of skin cancer related terms from July 2014 to June 2018. (a) In 9 large German cities ($n = 9{,}729{,}149$ inhabitants). (b) In 4 German cities with more than 1 million inhabitants. (c) In 5 German cities with less than 1 million inhabitants.

this study confirms that the search volume somewhat represents cancer incidence rates, as previously shown by Wehner et al. in the US (38). This correlation might be due to the fact that the Internet is the most important source of media information for people affected by melanoma (37). Another study revealed that people with skin cancer who use the Internet for health-related information regarding their diagnosis were more likely to be younger, female and more-highly educated (48). Our analysis of Google searches, however, enables no conclusion as to users' age, sex, or education. It is possible that such associations between searching information and actually having skin cancer could be due to various demographics of the population sampled in the present study. Thus, it is possible that there is a clear correlation between search volume and registered incidence

(also in the context of NMSC), but this comparison is not feasible, as many registries exclude NMSC or are incomplete (42–45).

The results of the current study are consistent with previous studies showing a higher number of searches during the summer (30, 39). This could be due to the fact that diagnoses of NMSC and melanoma are more common in the late spring and early summer (49), which could influence an increase in search volume. In addition to these factors, search volume might be influenced by public health policies and media campaigns (50). For example, the peak search volume in July 2015 might have resulted from the recognition of NMSC as an occupational disease for outdoor workers in Germany during this time-frame (51, 52). Furthermore, the annual increase in search queries in May might be a result of the prevention campaign Euromelanoma, which uses various means of public communication (e.g. newspapers, radio) to promote skin cancer awareness and information (53).

Similar to a previous US study, the number of search queries observed in the present study remained relatively stable, with the exception of seasonal differences (39). However, these results are in contrast to a previous study from Germany, which revealed an increase in Google searches related to skin cancer between 2013 and 2017 (30). A possible explanation for these disparate findings could be that the prior study examined search volumes across the whole of Germany, while the current study focused on a smaller subset of the population. Thus, there could be differences in search behavior based on a variety of population factors (e.g. age, rural vs. urban residence, etc.). For example, outdoor workers (e.g. farmers) who have NMSC more frequently (23, 27, 54–56), and thus might have a greater interest in skin cancer, typically live in rural areas (and rural areas were not examined in the present study). Furthermore, the recognition of NMSC as an occupational disease of outdoor workers might have a large impact on the observed increases in Google searches, which were not extensively assessed in the present study.

Study limitations

Some limitations of this study should be noted. Even though 90% of the German population uses the Internet (34) and 95% of users rely on Google as a search engine (35), younger aged groups use the Internet more frequently. More than 90% of individuals aged 14–39 years use the Internet every day, while only 44% of people aged 60 years and older do so (34). Thus, we may have underestimated the specific terms searched by people with skin cancer, as older individuals are affected more frequently (2, 3, 10). Although no clear association between the percentage of non-native Germans and the number of search terms was found in this study, the study results might be somewhat influenced by this factor, as only German terms for skin cancer were considered. Another limitation is that only the search volumes within large German cities were examined; these could be different in rural areas that are more likely to have an undersupply of physicians (57) as well as a higher proportion of outdoor workers, who have a higher risk for NMSC (54). Furthermore, the correlation detected between the number of searches and melanoma incidence might be overestimated, as data for both were available only for the year 2014. Data on melanoma incidence further separates between men and women, while Google does not provide information on users' general demographics. A further limitation was that the monthly search volumes were based on estimates from a Google algorithm, with no further information. Thus, it is not possible to fully assess data precision. Finally, Google suggests an automatic completion of search terms, which might bias people's search behavior. Often-searched terms are possibly more easily searched, while less frequently searched terms are neglected.

Conclusion

The results of this study show a correlation between the number of searches and incidence of melanoma in large German metropolitan areas. Thus, Google search analyses are extremely useful for obtaining an overview of a population's interest in skin cancer. Since there was a high proportion of general searches, or searches that focused on the identification of skin cancers, the study indicates that, in all likelihood, in addition to people with a skin cancer diagnosis, many unaffected people might look for health-related information on the Internet before consulting a physician. Thus, there is great potential for improving people's awareness by offering comprehensive and reliable information via the Internet, for example through government-funded trustworthy information/websites about skin cancer. In general, it seems to be useful to monitor a potential increase in knowledge due to the Internet. Future studies might first examine people's baseline knowledge and then measure how people searched for information, which websites are frequently consulted, whether the received information is satisfactory, and whether knowledge is gained. The further analysis of different cities could enable the identification of regional variations; for example, regional undersupply of public health information. Given that there is a correlation between the number of search queries and the incidence of melanoma, future research could focus on regions with a low supply of physicians or a high proportion of outdoor workers to better analyze whether there are some areas with a specifically high need for receiving certain prevention campaigns.

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