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The relationship between bone sarcoma incidence/ /mortality rate in Poland and Internet searches — Google Trends Analysis

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Introduction. Internet searches reflect public awareness, which may be influenced by cancer epidemiology. The aim was to characterize the relationship between the occurrence of bone cancer and the number of Internet searches in Poland. A secondary goal was to assess the relationship between awareness campaigns and online searches. The last goal was to assess the incidence and mortality rate of bone sarcoma in Poland over 10 years.

Material and methods. The epidemiology data of bone cancer in 2010-2020 were analyzed in relation to search volume index (SVI) in Google Trends for terms — 'osteosarcoma', 'chondrosarcoma', 'Ewing sarcoma', 'bone cancer', 'bone tumor'.

Results. On average, 317.6 (± 29.8) new cases of bone cancer were diagnosed annually, and 272.2 (± 43.3) patients died annually. Correlations between incidence rates and SVI for terms: osteosarcoma ($r = 0.17$; $p = 0.035$), chondrosarcoma ($r = 0.36$; $p < 0.001$) and Ewing sarcoma ($r = 0.21$; $p = 0.008$), and between mortality rate and SVI for terms: chondrosarcoma ($r = 0.42$; $p < 0.001$) and bone cancer ($r = 0.20$; $p = 0.012$) were noted. There was no increase in interest in the topic of bone cancer in July (Sarcoma Awareness Month) in Poland and worldwide.

Conclusions. The incident and mortality rate of bone sarcomas is correlated with the number of online searches for individual phrases. Awareness campaigns do not significantly increase interest in the topic of bone sarcomas on the Internet. Epidemiological data on bone cancer in Poland are comparable to worldwide data.

Keywords: bone sarcoma, google trend, epidemiology, bone cancer, incidence, mortality

Introduction

Primary malignant bone cancers (bone sarcomas) are a group of rare tumors of mesenchymal origin, the incidence of which is estimated at 0.5–1% of all adult oncological patients and 5–7% in children [1]. The most common types of primary bone cancer are osteosarcoma, chondrosarcoma and Ewing sarcoma [2]. The first one affects about 1–2 people per million per year, while the second one occurs with a frequency of about 0.5 people per million per year and the third type mainly affects patients under 18 years of age and is estimated to affect 2.93 children per million worldwide [3]. The risk of developing primary malignant bone tumors has a bimodal distribution, with the first peak in the 2nd–3rd decade of life (osteosarcoma) and the second peak in the 6th–7th decade of life (chondrosarcoma) [1]. The Internet has become a significant source of information in the field of health and medicine for both health care professionals and patients. According to available data, currently up to half of cancer patients search for information

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about the disease on the Internet [4, 5]. In addition, information from the Internet has been considered a surrogate tool for estimating epidemiology and collecting data on disease patterns and population behavior [5]. Google Trends, a recent technological advance in data acquisition, was used to examine many topics related to oncology, including the seasonality of interest in cancer or the effectiveness of awareness campaigns [6, 7]. Moreover, a relationship between media reports, such as the death or cancer of a famous people, and subsequent public interest on the Internet, were reported [8–10].

Oncological disease registries are a valuable source of information. However, rigorous data from nationwide registries are often unavailable, especially for rare cancers such as bone sarcoma. Moreover, as in most registries, epidemiological data in the National Cancer Registry in Poland are delayed on average by 2 to 3 years until the incidence data are made public. Therefore, Internet search data may be a new and promising tool for estimating the number of new cases. We hypothesized that the number of Internet searches would be positively correlated with the registry-recorded incidence and mortality of bone sarcoma. To test this hypothesis, we conducted a study comparing the number of Internet searches for bone cancer, normalized to the total number of searches, with published bone cancer incidence and mortality rates in Poland. Additionally, we checked whether Sarcoma and Bone Cancer Awareness Month, which takes place in July, increases the number of online searches.

Material and methods

We used Google search volume data collected via Google Trends (https://trends.google.com/trends/) to estimate the relative volume of searches for primary bone sarcoma by specific provinces (voivodeships) in Poland. The Google Trends application is a free and public analytical tool started in 2004. It provides data with the option to provide search information for specific geographic regions such as countries, regions or cities. Data from the application are provided as the "search volume index" (SVI) or "relative search volume" (RSV), which shows the number of searches for a specific term per time point in relation to the total number of searches on the Google search engine during that time period. This is scaled from 0 to 100, 100 signifying the peak search volume for the search term during the time period. For example, the province with the most searches for the term, Osteosarcoma, relative to the total number of searches, would be assigned an SVI = 100, while other provinces that have a lower relative search volume for this phrase would have a lower SVI compared to this value.

In the study, we analyzed 5 search terms (topics) in Google Trends, namely: 1) osteosarcoma; 2) chondrosarcoma; 3) Ewing sarcoma; 4) bone tumor; 5) bone cancer, within 10 years (from January 1, 2010 to December 31, 2020) for all provinces in Poland. The above phrases are related to primary bone neoplasms and more than one phrase has been selected to determine which phrases are most searched for in the field of primary bone sarcoma. The term 'Bone sarcoma' was not used due to the very low number of Google searches in Poland and worldwide. The application was accessed for the current study on September 15, 2023. Next, we used data from the National Cancer Registry [pol. Krajowy Rejestr Nowotworów (KRN); https://onkologia.org.pl/pl] website to obtain epidemiological data on primary bone sarcoma new cases and deaths. We used the age-adjusted incidence and mortality rates by province for bone sarcoma for the period from 2010 to 2020. Incidence and mortality included both genders.

We used Pearson correlation coefficients to evaluate the relationship between bone sarcoma incidence and mortality rates and Google SVIs by voivodeships in Poland. Each relationship was checked visually for outliers, and if outliers were present, the Pearson correlation coefficient and p value were compared with a Spearman rank-order correlation coefficient and p value for concordance. Statistical significance was defined as p value < 0.05. All analyses were performed using the Statistica 13.0.2 program (StatSoft Polska Co. Ltd., Kraków. Poland).

Results

The most frequently searched phrase related to bone sarcoma in Poland was 'Bone tumor', followed by 'Osteosarcoma' and 'Bone cancer'. The above trend is also confirmed by the results obtained in worldwide searching. However, worldwide searches for the term 'osteosarcoma' peaked in 2019, when the 9-year-old daughter of Spain's national football team coach, Luis Enrique, died from bone cancer (Fig. 1). However, this peak was not so clear in the Google search in Poland. Over a period of 10 years, there was no significant increase in interest in the topic of bone cancer in July (Sarcoma Cancer Awareness Month) worldwide and in Poland (Tab. I).

We found statistically significant correlations between incidence rates and relative Google search volume (SVI) in Poland from 2010 to 2020 for the terms: osteosarcoma ($r = 0.17$; $p = 0.035$), chondrosarcoma ($r = 0.36$; $p < 0.001$) and Ewing sarcoma ($r = 0.21$; $p = 0.008$). When examining cancer mortality, we noted statistically significant correlations between the mortality rate of bone neoplasms and relative Google search volume for terms: chondrosarcoma ($r = 0.42$; $p < 0.001$) and bone cancer ($r = 0.20$; $p = 0.012$). The rest of the terms relating to bone neoplasms did not have statistically significant correlations with incidence or mortality rates. The Table shows the correlation coefficients between actual incidence rates and relative Google search volume for bone neoplasms in Poland (Tab. II). We did not observe a statistically significant relationship between the number of cases and deaths by voivodeship (regions) and SVI.

Over 10 years, 3494 new cases of bone cancer were diagnosed in Poland and 2994 people died from this disease. For compression, on average, 317.6 (± 29.8) new cases of primary

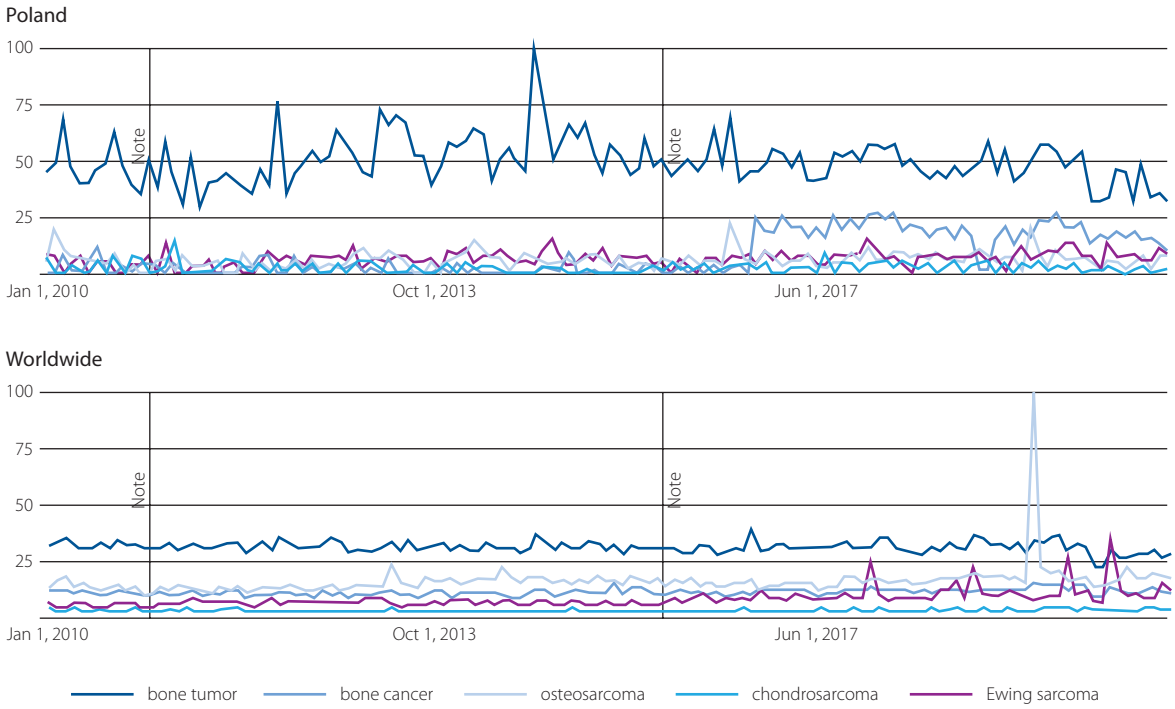

Figure 1. The chart shows the search volume index (SVI) for five phrases from 2010 to 2020. The top figure represent data from Poland, while the bottom figure shows worldwide searches. Topics: bone tumor (yellow), bone cancer (green), osteosarcoma (blue), chondrosarcoma (red), Ewing sarcoma (purple)

Table I. Comparison of the search volume index (SVI) from worldwide data in July (sarcoma cancer awareness month) and in other months of the year

Topic	Average SVI in July (SD)		Average SVI in other months (SD)		p value	
	World	Poland	World	Poland	World	Poland
Bone tumor	30.36 (± 2.1)	49.36 (± 10.4)	31.29 (± 2.3)	49.64 (± 10.6)	0.195	0.947
Bone cancer	11.00 (± 0.7)	8.09 (± 9.1)	11.26 (± 1.2)	7.88 (± 9.0)	0.509	0.827
Osteosarcoma	14.82 (± 3.2)	10.40 (± 12.9)	16.04 (± 8.1)	11.76 (± 11.2)	0.622	0.110
Chondrosarcoma	3.18 (± 0.4)	1.84 (± 1.01)	3.20 (± 0.4)	2.18 (± 2.3)	0.896	0.072
Ewing sarcoma	7.36 (± 1.5)	6.01 (± 2.6)	8.36 (± 4.0)	6.24 (± 3.4)	0.410	0.489

SD — standard deviation

malignant bone tumors were diagnosed per year in Poland and 272.2 (± 43.3) patients died per year (Fig. 2).

Discussion

Our study is the first to show a relationship between the number of new cases of bone sarcoma and the number of searches for phrases related to bone sarcoma in Google. However, this only applies to specific phrases, like 'osteosarcoma', 'chondrosarcoma', and 'Ewing sarcoma', as more general phrases such as 'bone cancer' and 'bone tumor' do not correlate with the number of new cases. There may be several reasons for this result. First of all, the phrases 'bone cancer' and 'bone tumor' are the most frequently used phrases in Google regarding the topic, however, they can also be used to search for information about bone metastases or benign lesions, which occur much more often than bone sarcomas. Second, the most common bone sarcomas in the adult and pediatric population are osteosarcoma, chondrosarcoma, and Ewing sarcoma, and therefore use of these phrases in Google may correlate with the overall number of bone sarcomas in the population. The situation is different with the mortality rate, which is correlated only with the phrases 'bone cancer' and 'chondrosarcoma'. In another study, Wehner et al. [11] noted that online searches are corelated with cancer incidences. They observed that the relative search volume was highly related to the level of cancer incidence rates in 5 of the 8 most commonly diagnosed cancers in the United States: colon cancer, lung cancer, lymphoma, melanoma and thyroid cancer. However, the correlation for mortality rates was statistically significant only for the 4 most common cancers: colon cancer, lung cancer,

Table II. Correlation coefficients between bone cancer incidence and mortality rates and relative google search volume index (SVI), 2010 to 2020

	Incidence		Mortality	
Topic	r (correlation coefficient)	p value	r (correlation coefficient)	p value
Osteosarcoma	0.17	0.035	0.03	0.712
Chondrosarcoma	0.36	< 0.001	0.42	< 0.001
Ewing sarcoma	0.21	0.008	0.12	0.123
Bone cancer	0.05	0.490	0.20	0.012
Bone tumor	0.04	0.626	0.03	0.733

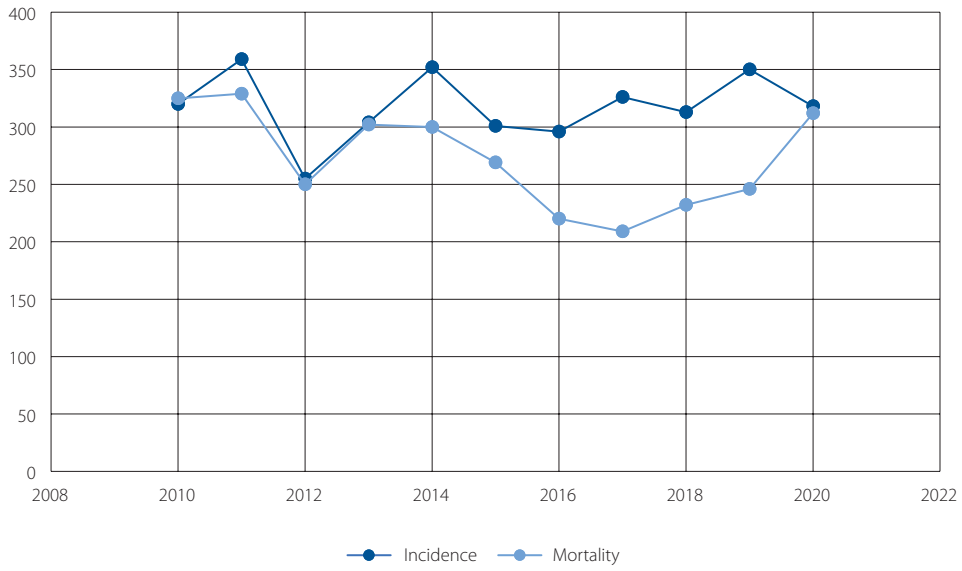

Figure 2. The graph shows the trend of incidence and mortality rate due to bone neoplasms in the period 2010–2020 in Poland

melanoma, lymphoma [11]. Phillips et al. [12] noted in their study, relative search volume was highly related to the level of cancer incidence for breast, prostate, lung, uterine cancers and leukemia in the USA. The above studies indicate that in the case of common cancers, Google Trends can be used as a tool for estimating the number of new cases. However, in our study we show that such a relationship also occurs in rare types of cancer such as bone sarcoma. Wehner et. al also noted in their study the relationship between the cancer incidence rate in the United States and SVI depending on the state [11]. However, in another study conducted in Peru, Luna-Abanto et al. [13] did not note such a relationship when correlating the SVI with the incidence by province, for breast, cervical and colorectal cancer. Also in our study, the incidence rate of bone sarcomas divided into provinces did not show any correlation with searches in Google Trends.

Some studies observed the significant impact of social campaigns and awareness months on the increase in interest in specific cancer topics in Google searches [6–8]. Nishimura et al. [6] in their study showed that breast cancer awareness month had significant impacts on U.S. public interest in breast cancer from 2012 to 2021, with peaks in the RSVs from 21.9% to 46.7%, while lung cancer and prostate cancer awareness months did little to affect the public interest in lung or prostate cancer. Also, Cohen et al. [8] showed that public interest in 6 out of 13 cancers (cervical cancer, colorectal cancer, skin cancer, ovarian cancer, breast cancer and lung cancer) was significantly higher in their respective awareness months when compared to the rest of the year. However, this correlation was not observed in less common cancers in the population, such as esophageal cancer, pancreatic cancer, testicular cancer, brain cancer, blood cancer and thyroid cancer [8]. Demirici et al. [14] found that the bladder cancer awareness month did not cause an increase in online interest in Google. In our study, we also did not observe an increase in public interest in the topic of bone sarcomas during Sarcoma Cancer Awareness Month in July — both in Poland and worldwide. However, during data collection, we observed that global searches for the term 'osteosarcoma' peaked in 2019, when the 9-year-old daughter of the coach of the Spanish national football team

— Luis Enrique — died of bone sarcoma. A similar trend was observed by Gianfredi et al. [9] in their study, where they noted increased interest in online searches in the terms 'neuroendocrine tumor' and 'pancreatic cancer' after the famous Italian rapper Fedez, revealed that he had undergone surgery due to pancreatic cancer in March 2022. Also, Kamiński et al. [10] describe that most disease search peaks are related to date of diagnosis or death from dissease of famous people. They give the following examples: Selena Gomez with lupus, Ashton Kutcher with vasculitis or Lady Gaga with fibromyalgia. Kaleem et al. [15] showed a significant increase in public interest in Google searches for lung cancer, pancreatic cancer, endometrial cancer, cervical cancer, brain cancer, and glioblastoma after a celebrity-related event covered in the media. In our study, the increase in interest in the topic of osteosarcoma on Google increased more than 6 fold in August 2019. No social campaign or event has been able to increase public interest in the topic of bone cancer to such a significant extent. This shows what a significant impact the topics discussed by celebrities have on society's awareness, especially in the case of rare diseases.

There is an unchanging trend in the last 10 years of new cases of bone sarcoma in Poland, which is on average 318 (between 250–350) cases per year, and in line with the literature. It is estimated that primary malignant bone tumors constitute approximately 0.2% of all malignant tumors. In Poland, on average, approximately 170 000 new cases are diagnosed each year, which means that the estimated number of new cases of bone sarcomas should be approximately 340. Also, if we take into account that the incidence of bone sarcomas is 0.9 per 100 000 people, in relation to the average Polish population over the last 10 years (approximately 38 million), we obtain a similar result — 340 new cases per year [16]. Since 2014, a decrease in the number of deaths due to bone sarcomas has been observed, from approximately 300 per year to approximately 235. However, this trend changed in 2020, when the mortality rate was again above 300 cases per year. The reason for this could be the COVID-19 pandemic, which significantly limited access to medical care and specialists. A multicenter study showed that SARS-CoV-2 virus infection is one of the risk factors for death in pediatric oncology patients [17]. Moreover, it was shown that the delay in diagnosis increased during the pandemic, which influenced the later detection of the disease in bone sarcoma patients [18, 19]. Moreover, Kamiński et al. [20] showed that public opinion interest, represented by online searches in Google in many cancers during the COVID-19 pandemic, was significantly lower than in the prepandemic period. Consequently, a loss of interest in cancer may delay the diagnosis of malignancies and worsen the long-term outcomes, which may result in an increase in mortality.

This study has many limitations. Using Google search data to estimate disease rates may not be fully generalizable because the data is limited to people who have access to the Internet and use Google. However, currently in Poland the majority of the population has permanent access to the Internet. We can therefore assume that even if the oncological patient was not able to use the Google search tool, closest family could indeed do so. Moreover, in the study we only used phrases related to the three most common types of bone sarcomas, without taking into account other rare types that were included in the incidence and mortality rate statistics. However, the aim of our study was to determine whether there is a correlation between the number of patients with a rare cancer such as bone sarcomas and public interest estimated based on online searches — not an accurate estimate of the number of patients with a given type of cancer based on Google searches. Another limitation is the reliability of data from the national cancer registry. Data comes from reports by physicians. For this reason, some patients may not be reported. However, the KRN currently provides the most reliable and easily accessible data on the number of malignant neoplasms cases in Poland.

Conclusions

Bone sarcoma incidence is correlated with online search volume. For the potential estimation of the number of patients based on Google searches, the most appropriate phrases are: 'Osteosarcoma', 'Chondrosarcoma' and 'Ewing sarcoma'. However, this tool cannot be used to estimate the incidence rate divided into regions in Poland. Furthermore, there was no increase in public interest in the topic of bone sarcoma during the awareness campaign in July (Sarcoma Cancer Awareness Month). However, there was a significant increase in public interest in the topic of osteosarcoma related to famous people activity. The additional use of stories from celebrities with bone sarcoma may help increase public interest during awareness campaigns. Epidemiological data on bone cancer in Poland are comparable to worldwide data.

Article information and declarations

Data availability statement

Data available on request.

Ethics statement

The Institutional Review Board was permitted to perform the present study without full review, which is necessary for interventional studies on humans, according to national regulations.

Authors contributions

Dawid Ciechanowicz — conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, visualization, writing — original draft preparation.

Maria Wójtowicz — investigation, writing — original draft preparation.

Andrzej Bohatyrewicz — supervision, validation, writing — review & editing.

Daniel Kotrych — supervision, writing — review & editing.

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Conflict of interest

The authors declare no conflict of interest.

Supplementary material

None.

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