



Seasonal interest in pectus excavatum and pectus carinatum: a retrospective analysis of Google Trends data

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Background: Individuals affected by chest wall deformities may search for information on these conditions on the web. Google data may reflect the global interest in health-related information. Our aim was to investigate the global trends in searches associated with the topics “Pectus excavatum“ and “Pectus carinatum“ using Google Trends.

Methods: We retrieved the global data from 1st January 2004 to 31st October 2019. We analyzed the relative search volume (RSV) for countries or areas with a no-low search volume. We compared differences in interest between seasons using the Kruskal-Wallis test with the *post-hoc* test.

Results: The median RSV for the pectus excavatum was equal to 58.00 (54.00–65.00) while for pectus carinatum 28.00 (23.25–31.00). The interest in pectus excavatum decreases on average by 0.98 RSV each year, while interest in pectus carinatum increased each year by 0.87 RSV. We observed the highest interest in analyzed topics during summer and the lowest during winter. The relative difference in interest between summer and winter was equal to 21.4% for pectus excavatum and 19.2% for pectus carinatum. Pectus excavatum was the most popular topic in n=51 countries or areas, while pectus carinatum in n=7 countries or areas/regions.

Conclusions: Globally, interest in pectus excavatum is higher than the interest in pectus carinatum that might reflect real-world prevalence. The interest in both topics shows seasonal variation. The Internet is an essential source of information on chest wall deformities. The medical professionals should provide quality content on pectus excavatum and pectus carinatum.

Keywords: Seasonal variation; pectus excavatum; pectus carinatum; Nuss procedure; Google Trends

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Introduction

Pectus excavatum (PE) and pectus carinatum (PC) account for 95–97% of all chest wall deformities. PE affects 0.1% of all live births, while PC is less common and occurs in 0.06% (1,2). They have aroused doctors' interest for centuries due to their unclear origin and challenging treatment (3). Chest

wall deformities lower the quality of life to the highest degree in the adolescent population. Compared to healthy individuals, patients with PE or PC are characterized by lower quality of life in the mental and physical sphere. These deformities both significantly disturb the individual's self-body image. Moreover, they may cause physical

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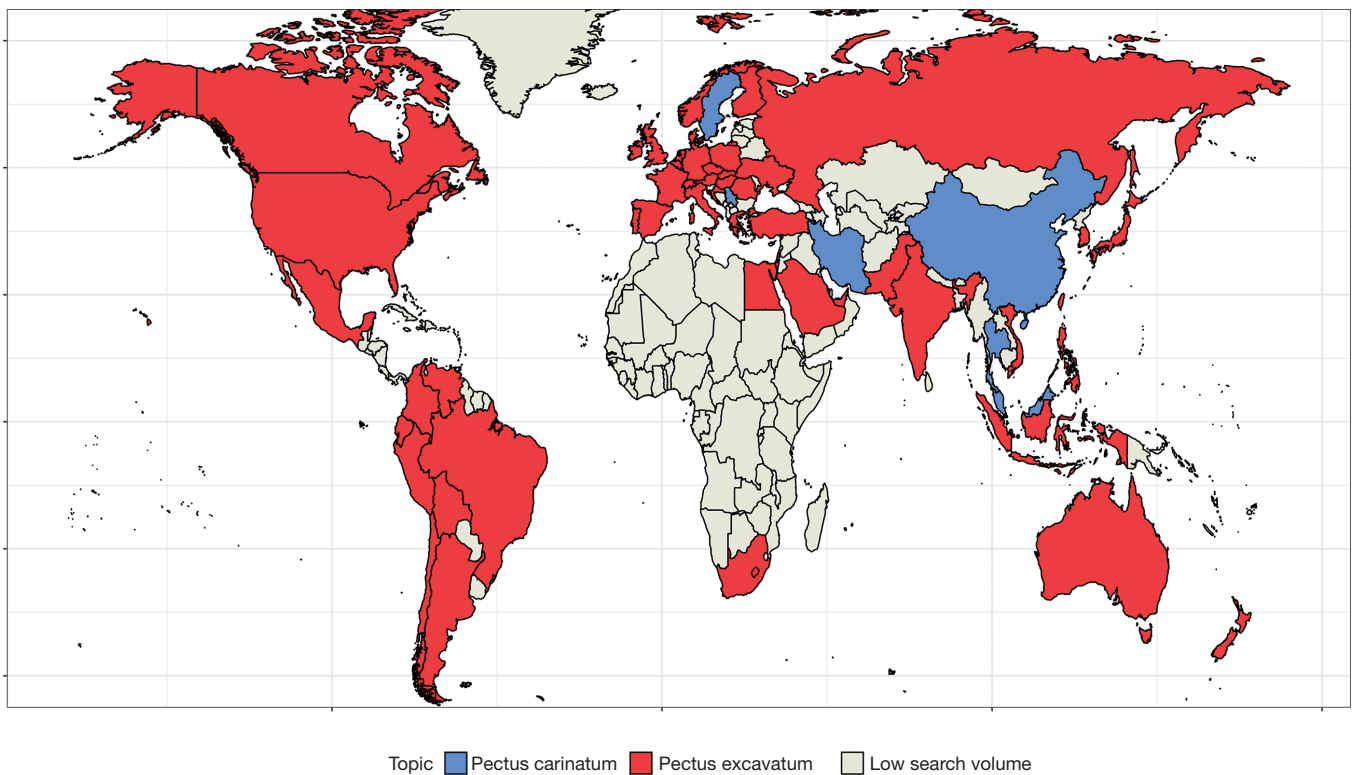


Figure 1 Global interest in “Pectus carinatum” and “Pectus excavatum” from January 2004 through October 2019. The gray color represents countries or areas with a low search volume, which were not included in the analysis.

disorders (dyspnoea, chest pain, and palpitations) (4-6). Both cosmetic and functional impairments are the main inclusion criteria for correction (4,7-10).

Individuals affected by PE or PC may search for information on chest deformities on the Internet, which is used daily by the young generation. Internet traffic may mirror the interests of the population in health issues (11). Analysis of search engine queries enables one to estimate the interest in various medical issues and depict the specific data circulation worldwide (12). We hypothesize that the analysis of searches on chest wall deformities may reveal an under-researched phenomenon related to the dynamics and local distribution of interest. Google is one of the best search engines globally, and in 2019 acquired over 90 percent of the global search engine market (13). Therefore, we decided to use data from Google Trends (GT; <https://trends.google.com/trends/>).

This study was the first to assess the interest of internet users in PE and PC. Our study aimed to assess the global interest, its secular and seasonal trends, in the years 2004–2019 in the topics “Pectus excavatum” and “Pectus carinatum” among Google users.

Methods

We retrieved the data from GT. GT presents the data on Google queries since January 2004. The tool is freely available. The search volume is expressed as an index called relative search volume (RSV). RSV is an index and ranges from 0 (no interest) to 100 (maximum interest in a given period). RSV is also adjusted for the number of Google users in a given month. GT recognizes many “topics” that enable the analysis of RSV of the same “topic” in all languages. It facilitates the easy comparison of the given terms regardless of the language of Google users.

This study follows the GT data processing protocol from previous studies (12,14,15). We retrieved data for the period from 1st January 2004 to 31st October 2019. We obtained data for the PC and PE topics from regions worldwide, respectively. The search term “Funnel chest” matches the topic PE, while “Pigeon chest” does not match any topic. We visualized the most popular topic in each analyzed country and analyzed the relative popularity presented by GT (Figure 1). Data from countries or areas with low search volumes has been excluded using the relevant GT option.

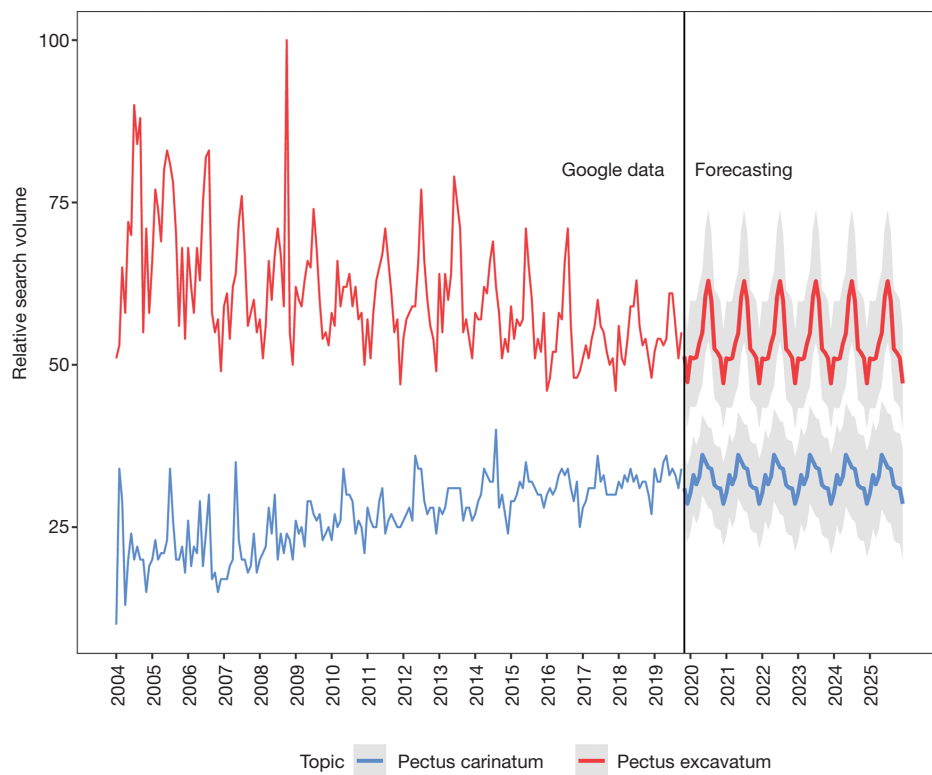


Figure 2 Relative search volume (RSV) of the “Pectus carinatum” and “Pectus excavatum” topics worldwide from January 2004 through October 2019 and forecasted model until December 2025.

In seasonal analyze we considered the following seasons: spring (March, April, May), summer (June, July, August), autumn (September, October, November), and winter (December, January, February). We calculated the relative amplitude between the season with the highest and the lowest RSV and expressed the outcome as a percentage (Figure 2).

Most of the Google users live in the Northern Hemisphere. For this reason, seasonal variation may have an association with the season in the northern part of the globe (12,16). Therefore, we analyzed both the PC and PE topics in two countries or areas from the Southern Hemisphere: Argentina and Australia. We performed a comparison of RSV between the season in Argentina and Australia with the Northern Hemisphere.

Moreover, we search for the presence of “Nuss procedure” and “Ravitch procedure” as topics. Only the “Nuss procedure” was matched by GT as a topic. We retrieved the global data for the “Nuss procedure” and PE topics. We excluded countries or areas with a low search volume. We searched for discrepancies between the number of countries or areas with a no-low search volume on both

topics (Figure 1).

Statistical analysis

Furthermore, we performed a descriptive analysis and forecasting until 31st December 2025 using an exponential smoothing state-space model with Box-Cox transformation, autoregressive-moving average errors, trend, and the seasonal components (TBATS) method from Kendall and forecast packages of the R-programming language (16,17). We calculated the change over time using the linear regression model. We compared differences in interest between seasons using the Kruskal-Wallis test with the *post-hoc* Manny-Whitney U test.

The study is a retrospective analysis of the open statistics of search engine queries. Therefore, the project did not require ethical committee approval.

Results

The median RSV of the PE topic equaled 58.00 (54.00–

Table 1 Comparison of relative search volume between each season

Region	Topic	Sp	Su	F	W	Differences between seasons	Post-hoc test
Worldwide	Pectus carinatum	29.00 (24.75–32.00)	31.00 (25.50–33.00)	27.00 (22.50–30.00)	26.00 (21.00–28.50)	H(3) =21.11; P<0.001	Sp vs. F: P=0.03; Sp vs. W: P<0.01; Su vs. F: P<0.01; Su vs. W: P<0.001
Worldwide	Pectus excavatum	59.00 (56.00–64.00)	67.00 (62.00–74.25)	55.00 (54.00–58.00)	54.00 (51.00–58.00)	H(3) =70.17; P<0.001	Sp vs. Su: P<0.001; Sp vs. F: P<0.01; Sp vs. W: P<0.001; Su vs. F: P<0.001; Su vs. W: P<0.001
Argentina	Pectus carinatum	4.00 (3.00–9.00)	4.00 (1.75–6.00)	5.00 (2.50–7.00)	5.00 (2.00–7.00)	H(3) =1.87; P=0.60	–
Argentina	Pectus excavatum	10.50 (8.00–17.00)	11.00 (9.00–16.00)	13.00 (9.00–16.00)	14.00 (11.50–19.50)	H(3) =9.37; P=0.02	Sp vs. W: P=0.040 Su vs. W: P=0.040
Australia	Pectus carinatum	16.50 (11.75–21)	16.00 (12–20)	18.00 (14.50–22)	16.00 (11.50–21)	H(3) =1.69; P=0.64	–
Australia	Pectus excavatum	25.00 (17.00–31.00)	26.50 (19.75–30.00)	28.00 (22.50–34.00)	25.00 (23.00–32.50)	H(3) =5.40; P=0.14	–

Data are presented as medians (interquartile range). F, fall; Sp, spring; Su, summer; W, winter.

65.00), while for PC it was 28.00 (23.25–31.00). We observed the maximum interest in PE during October 2008 (RSV =100.00), while in PC during August 2014 (RSV =40.00).

We observed the highest interest in analyzed topics during summer and the lowest during winter (Table 1). The relative amplitude between summer and winter was equal to 21.4% for PE (P<0.001) and 19.2% for PC (P<0.001). Different seasonal variation was significant for PE in Argentina, and the relative amplitude was equal to 27.3% (Table 1).

PE was the most popular topic in n=51 countries or areas, while PC in n=7 countries or areas/regions (mainland China, Hong Kong, Iran, Malaysia, Serbia, Sweden, Thailand) (Figure 1). We observed the highest relative interest in PE in Turkey, Austria, Germany, Switzerland, and France, while for PC: mainland China, Thailand, Serbia, Hong Kong, Malaysia and Iran.

The interest in PE decreases on average by 0.98 RSV each year, while interest in PC increased each year by 0.87 RSV (Figure 2). In the forecasted model, the yearly changes were equal to +0.08 for PE and +0.01 RSV for PC.

The “Nuss procedure” topic had a no-low search volume in n=16, mostly Western countries or areas (Figure 3). PE had a no-low search volume in n=43 countries or areas with a simultaneously low search volume for the “Nuss procedure”.

Discussion

We analyzed the secular and seasonal variation, as well as the geographical distribution of interests. We found that the interest of users in PE is significantly higher than in PC. Moreover, we noticed certain countries or areas where PC is more popular than PE. We documented that the interest in both topics shows seasonal variation. However, the global interest in PC is increasing on a year by year basis. Finally, in some countries or areas we observed a discrepancy between interest in PE and the Nuss procedure.

We found that Google users’ interest in PE is, on average, two times higher than in PC. Our results are consistent with the epidemiology: PE is a more common deformity, indicating more significant interest in this defect (1,2,7).

Another notable finding in the present study was that the interest in PE changes annually, while interest in PC increases over time. It may indicate that PE is slightly losing interest. The possible explanation for this observation may

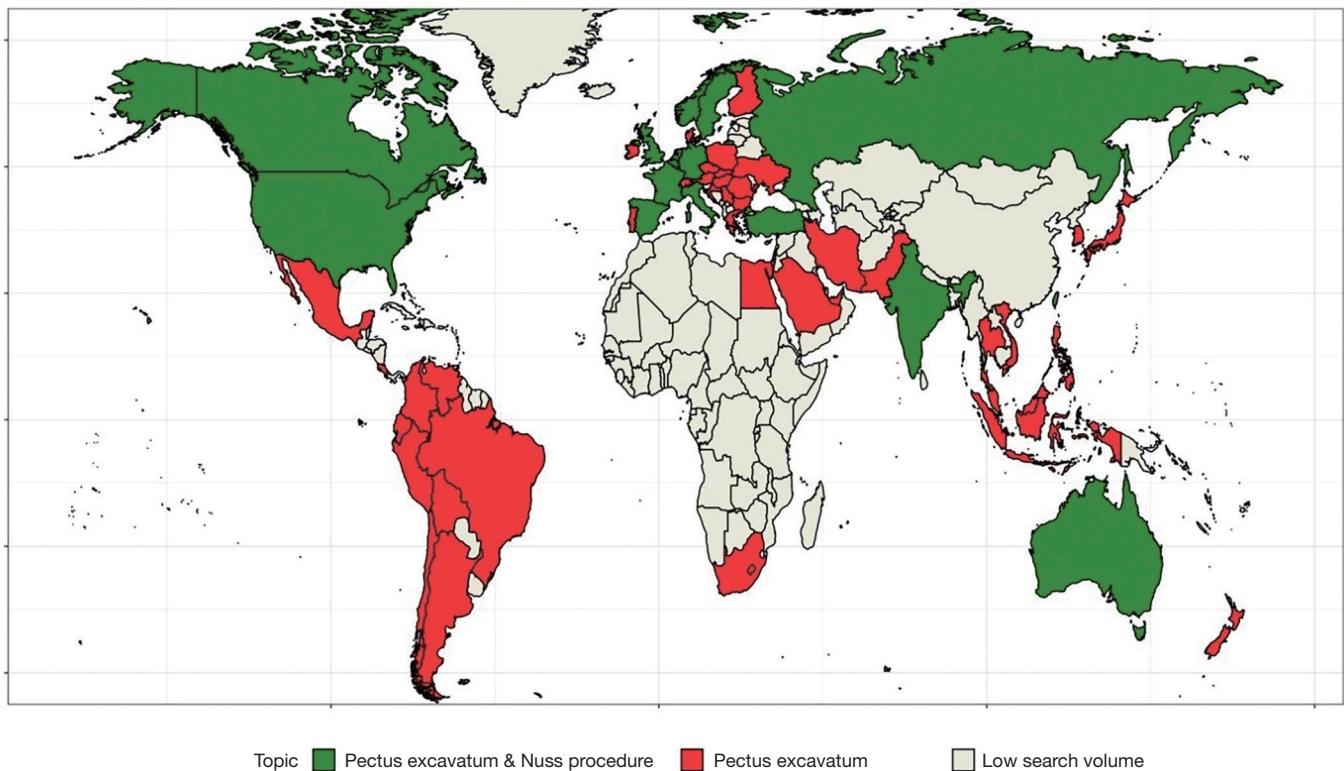


Figure 3 Countries or areas with a no-low search volume from January 2004 through October 2019 for both “Pectus excavatum” and “Nuss procedure” as well as for “Pectus excavatum” only. The gray color represents countries or areas with a low search volume that were not included in the analysis.

be the earlier and better qualification for treatment and more effective, commonly used corrective methods.

Both surgical and non-operative methods are available for the corrective treatment of PE and PC. In the case of PE, treatment is possible through the surgical Nuss procedure. Due to its clinical efficiency and minimal invasiveness, the Nuss procedure became the preferred operative intervention in PE. The Nuss procedure’s efficiency for PE exceeds 90% and gives satisfactory long-term cosmetic outcomes (6,8,18). Despite the high efficiency for PE, in some cases, it is possible to effectively use a vacuum bell, which is a non-invasive treatment method (19,20). Compressive external bracing is a high profile, non-invasive PC treatment method that could succeed in growing patients (21). If this method is insufficient, the available operative methods are the open-surgery Ravitch procedure or the minimally-invasive Abramson technique (5,22,23).

A large part of these procedures is performed by surgeons in specialized centers, access to which in some countries or areas is limited (24,25). The Nuss

procedure provides favorable long-term results and heals the chest deformity (8,18,26-28). The recurrence rate is inconsiderable, and most patients have not been further affected (8,9). It is tempting to hypothesize that the Nuss procedure reduces the “pool” of patients with PE. Besides the Nuss technique, in some PE patients, conservative treatment could give favorable results. Techniques like vacuum bell may also allow patients with mild PE to avoid surgery and explain why PE’s interest decreases in some countries or areas. (19,20). The interest in both PE and PC may fluctuate due to the nature of these deformities. They tend to be minimally visible in childhood, worsening during development, and becoming more noticeable in adolescence (5). They significantly reduce the quality of life, cause shyness, apprehension, and could lead to depression (4,29). This is associated with the deformity’s perception as a serious bodily defect and results in higher internet interest among adolescents (10,11).

Moreover, the recurrence rate after corrective operations is also an important issue. For example, after using the

Ravitch technique, it may range from 2% to even 37%, contrary to the Nuss procedure, which requires a repeat procedure in 0.2–3% of cases (28,30–32). This is worth highlighting because patients with recurrence may seek a second opinion and help at another surgery center using Google (33).

It is also worth discussing that the highest interest in both deformities shows a seasonal trend. The global interest peaks during summer. It could be related to the number of people and their activity in the Northern Hemisphere. We confirmed our observation, analyzing seasonal variation in two countries or areas from the Southern Hemisphere. In Argentina, the interest in PE is significantly higher during the Southern Hemisphere's astronomical summer. It can be hypothesized, that the differences between the seasons may be associated with the greater interest in patients' chest appearance during warm months. The untreated deformity may prevent individuals from taking their shirts off during summer activities such as swimming or playing on the beach. This discomfort may motivate some people to search for information related to deformities. It is conceivable to hypothesize, the chance for more accurate and earlier self-diagnosis is higher in the summer months.

Therefore, greater interest in this problem should result in the wide availability of professional medical and psychological help. In this regard, the pediatrician, the primary care physician, and the psychologists may play a pivotal role in early detection and subsequent, comprehensive patient care.

PE was the most popular topic in 51 countries or areas, whereas the PC was more popular in 7 countries or areas/regions (mainland China, Hong Kong, Iran, Malaysia, Serbia, Sweden, Thailand). However, this does not correlate with accurate epidemiological data. The Google search engine studies people's interest at a given time and place. It describes the given population's interest in a subject. Unfortunately, research on the global epidemiology of PE and PC is limited and it should be emphasized that the available studies are performed on limited populations. For instance, the prevalence of PE is 0.23% in the United States (5), in Iran, the chest deformities affect 1.03% of the population (34) and in the northern region of Brazil—1.95% of the population of 11- to 14-year-old students (35). The literature documents a similar incidence of both deformities worldwide and does not indicate geographical location's influence on its occurrence (7,36,37). The complete lack of interest in PE in China and subsequent 100% of interest

in PC is peculiar. It is difficult to explain such a significant difference due to the lack of relevant data on the prevalence of PC and PE in this country. Therefore, it is conceivable to hypothesize that in this case, Google does not match this topic properly.

Moreover, there are no data that would indicate a higher incidence of PC in countries or areas where PC was more popular than PE in GT. It is possible that GT is not a reliable source of information about China due to the fact that most Chinese use other browsers (38). Based on our results, we suggest a more thorough epidemiological study in 7 countries or areas/regions where PC is the most frequently searched record. A related point to consider is that some studies report lower appearance satisfaction in PC than in PE (4). In this regard, it would also be interesting to examine how representatives in these countries or areas perceive their bodies in terms of PE and PC.

We documented that there are countries or areas where the Nuss procedure is not well known. Most of the records found come from the Western world. A possible explanation may be that PE and its treatment methods are not very popular in all countries or areas. It is tempting to hypothesize that it is not a popular method for patients, pediatricians and primary care physicians, who may not know when and where to direct potential patients. The availability of qualified surgery centers, where the Nuss procedure can be performed, could also confirm this observation. The number of patients qualified for surgery increases every year since the introduction of the Nuss bar procedure. This observation is also followed by the enhancing amount of medical papers (31). The total yearly number of performed Nuss procedures increases, but the exact number for the whole world is difficult to determine, particularly for countries or areas of the Southern Hemisphere (18). It is also possible that the Google search engine cannot identify "Nuss procedure" records in some languages, for example, Chinese.

In addition, the Ravitch procedure is not recognized at all by GT as a topic. There can be several explanations for this observation. Firstly, this topic refers to a small branch of medicine, which is used only by specialists and is not popular among potential patients. Secondly, the Ravitch procedure may lose interest due to the increasing popularity of non-operative or minimally-invasive methods such as the Dynamic Compressor System or Abramson technique (5,22).

The results are interesting and demand further more detailed studies. The decent quality content on PE and PC may be crucial. Good quality content expands the

coverage of given topics. Users eagerly discuss, link, or simply share data, once well-written articles are available. Texts that are precisely tailored to readers' needs to solve specific problems and correspond to users' intentions when entering the phrase in the search engine. GT helps investigate unknown seasonal relationships—in this case, seasonal variability and changing interest in PC and PE. These are little-known phenomena, which can be logically explained. It is further seen that there are still many places where people are interested in PE, while the Nuss method receives a much lower degree of interest. Finally, our data reveal that people use GT; therefore, high-quality internet content is required to make these concepts accessible and better understood.

The authors acknowledge several limitations of this study. Firstly, GT does not provide a precise number of searches and only selects the data for the whole world or a whole country. It is also not possible to choose other macroregions (e.g., the continent). However, RSV is adjusted to the number of Google users in the given region and time. Therefore, the index is useful in analyzing the dynamics of discourse. Secondly, the RSV of the topics could often be dependent on media attention, which could be the reason for a high amplitude of irregularity in some countries or areas (39).

Moreover, the topics with a lower search volume are particularly at risk of irregular variation. This also applies to the analysis of search trends in minor countries or areas. Therefore, investigation of the analyzed topics in Argentina and Australia is limited due to the vulnerability of the trends to irregular variations. Another problem is the inability to confront the internet interest with relevant epidemiology or the exact number of Nuss procedures in the individual countries or areas. Generally, there is not enough data on the epidemiology of both deformities in individual countries or areas and the number of Nuss procedures performed annually. Therefore, confrontation and more detailed discussion are limited. Also, GT does not record data concerning Google users such as gender, age, education, etc., which are the domain of epidemiological research. Finally, Google is not a search engine used by all internet users on the market. The differences can be seen in Europe, the USA, or Japan, where the percentage of Google users is higher, while in countries or areas like Russia or China, it is significantly lower (40). For example, Google's share in the search engine market decreased from 95% in 2009 to about 3% in 2019. At the moment, Baidu is the most popular search engine in China, shares 68.66% of the market.

Conclusions

Globally, interest in PE is higher than the interest in PC that might reflect real-world prevalence. The Internet is an important source of information on chest wall deformities. Further studies should focus on the quality of websites on PE or PC. GT is an easy-to-use tool that explores the global interest in medical topics, which may provide background for further real-world studies.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/jtd-20-2924>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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