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'Dr. Google, I have a stomach ache' – seasonal variations in abdominal pain: a 4-year retrospective data analysis from Google Ads keywords planner

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Abstract

Background: Internet traffic may reflect the prevalence of real-world ailments. The aim of this study was to analyse queries associated with abdominal pain and to investigate seasonal frequency and trends of searches in Poland.

Methods: We analysed mean search volume from March 2015 to February 2019 of keywords associated with 'abdominal pain' in the Polish language generated from the Google Ads Planner. Keywords were categorised by location, feature or type of pain, concurrent symptoms, frequency and patient groups, etc. We compared differences in search volumes across seasons and years.

Results: Overall, 24,673,430 queries were associated with abdominal pain in the period analysed. The number of searches associated with abdominal pain in winter increased by ~30% compared with queries searched in summer. There were significantly more searches related to abdominal pain located in the epigastric, umbilical, hypogastrium, left lumbar, left iliac and right iliac regions combined with vomiting or fever, and acute or burning sensation in cold months. We did not observe any specific patterns of pain in the right lumbar or left hypochondrium region, co-presence of flatulence, acute, cramping or persistent/chronic or strong abdominal pain.

Conclusion: Internet queries associated with abdominal pain and related factors have increased in the past 4 years and present a seasonal pattern. Google Ads may be a valuable tool to assess the prevalence of complaints in under-researched regions. The observed trends in queries related to abdominal pain merely reflect the scale of the problem. The reported pattern should be verified in epidemiological studies.

Keywords: abdominal pain, AdWords, gastrointestinal health, Google, Poland

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Introduction

Abdominal pain is one of the most common complaints, with an estimated prevalence of 2.8% in general practice and 5–10% in emergency departments.[1–3] Moreover, a third of the general adult population fulfils the diagnostic criteria for a Rome IV functional gastrointestinal disorder, and in a third of this subset multiple gastrointestinal areas are involved.[4] This overlap is associated with increased abdominal pain and health impairment.[4] Additionally, many people face difficulties in accessing healthcare due to multiple inequalities.[5] Therefore, these symptomatic individuals and people in need turn for help to Dr. Google, rather than to real-life medical consultations.[6,7]

It is estimated that 27.4 million (72%) Polish citizens use the Internet.[8] Approximately 65–90% of

Web users look for health-related information.[9] Individuals searching the Internet for health purposes appreciate immediate access to the desired information, and approximately 80% perceive the Web as a reliable source of information.[10] It has been suggested that Internet traffic may mirror the health issues of population.[11] The data assessing trends of searches related to abdominal pain may reveal the prevalence of this complaint beyond the walls of the medical office.[12] It is likely that individuals who seek health information on the Web may not be willing to unravel embarrassing problems accompanying pain such as diarrhoea, constipation, flatulence or possible underlying stress at the time of the face-to-face visit.[13] Moreover, the simplicity of Internet-based self-management may be associated with the comfort of not disclosing emotional problems or with a lack of trust in local healthcare systems.

Infodemiology (information epidemiology) is an approach of investigating data from an electronic medium for epidemiological purposes.[14] Infodemiology analyses information unavailable in classic epidemiological studies. For instance, data from Web sources is often easy to collect as well as containing a massive amount of information. Moreover, people may experience a moderate ailment and search for relief on the Internet, which may be explained by a reluctance to seek help for minor ailments in a professional healthcare office. For this reason, analysis of Internet data may reveal poorly investigated relationships. Infodemiological studies process data from Internet forums,[15] Wikipedia,[16] social media and search engines.[17–18]

Google is the most popular search engine, with a local market share from 93.8% to 98.5% in 2016–2019.[19,20] Google Ads Keywords Planner, initially designed for e-commerce campaigns, has been used recently as a tool for the recruitment of Google users to clinical trials.[21,22] This tool may also serve as an epidemiological data source and enables both qualitative and quantitative analysis of a large number of keywords associated with the given phrases in the chosen language, location and timeframe.[23] These properties were used in a study on a series of dermatological studies,[23–27] as well as in paper on heartburn-related searches across six Western countries.[28]

Epidemiological data on the prevalence of abdominal pain among people in Poland are scarce. Therefore, we aimed to analyse yearly trends and seasonal frequency of searches associated with abdominal pain and its localisation, types and features, concomitant symptoms, associated factors, groups of patients, time of day, causes and treatment in the Google search engine in the Polish language over the last 4 years.

Materials and methods

Search strategy for data extraction

We extracted the search volume for the phrase 'abdominal pain' (pl. ból brzucha) from March 2015 to February 2019 using Google Ads Keywords Planner. Data were generated for the region: Poland and for the language: Polish. The Planner generated a list of proposed terms associated with 'abdominal pain' and search volume for each keyword expressed as an exponent of 10. Since the Keywords Planner may propose keywords not associated with abdominal pain, we excluded all keywords without this term (e.g. 'metatarsal pain'). Two authors (M.K., I.Ł.) independently analysed the generated list of keywords and created the final lists. Any inconsistencies in the lists were referred to the senior author (W.M.). Additionally, each keyword was characterised by localisation, type, pain characteristics, concurrent symptoms, frequency, associated factors, patient group, time of day, a question about causes, symptoms and/or treatment and queries about the provocation of abdominal pain. The term 'category' refers to the characterisation of the keyword. The keyword (incorrect and incorrect orthographical variations) could have multiple categories (e.g. keyword 'treatment abdominal pain child' – categories: treatment, child), and keyword category may also consist of multiple keywords (e.g. category 'diarrhoea': 'diarrhoea abdominal pain at night', 'diarrhoea fever abdominal pain'). A screenshot of the keywords search engine is presented in Supplemental Figure S1. To assess potential influences of seasonal migration of Polish citizens on searches fluctuation, we collected data from the same period and in the Polish language from $n = 11$ countries that are the most frequent destinations for both holidays (Bulgaria, Egypt, Greece, Spain, Turkey) and seasonal or permanent work abroad (France, Germany, Ireland, Italy, the Netherlands, the United Kingdom) of Polish citizens.[29,30] Both groups of countries comprised 75–80% of the total number of migrations to holiday places

abroad or seasonal and permanent workplaces in the years 2015–2018.[29,30]

Statistical analysis and data presentation

We calculated the arithmetical mean monthly research volume for all categories of keywords and for all countries and performed descriptive analyses for the queries over time and for different characteristics. The data are presented as the total number of queries in the analysed period and as a percentage of the total number of searches in the Polish version of the search engine. The number of queries made during each season and year is presented as median (interquartile range). To compare the search volume in each season and year, the Kruskal–Wallis test with a *post hoc* pair-wise Mann–Whitney *U* test were performed. A p value < 0.05 was considered as a significant difference. For the comparison, we included all categories of keywords associated with abdominal pain with a median of at least 1000 searches per month in the analysed period. The considered seasons were: spring (March, April, May), summer (June, July, August), autumn (September, October, November) and winter (December, January, February), and the analysed years were divided into first (March 2015–February 2016), second (March 2016–February 2017), third (March 2017–February 2018), and fourth (March 2018–February 2019). We visualised the time course of all queries related to abdominal pain in Polish in Poland and the chosen countries. Moreover, we visualised categories related to abdominal pain with total volume searches in the analysed period of at least 100,000. Plots were generated using *ggplot2* and *ggthemes2* packages of R 3.6.1 (R Foundation, Vienna, Austria).[31]

Results

Google Ads Keywords Planner generated 1,393 keywords for the phrase 'abdominal pain'. After evaluation of each keyword, we included 1,294 in the final investigation. There were a total of 24,673,430 queries associated with abdominal pain in the analysed period. The total number of searches was 2,325,500 in holiday destination countries and $n = 9,132,125$ in countries of permanent or seasonal work of Polish citizens. All categories of keywords associated with abdominal pain (with translation from Polish to English) are presented in Supplemental Table S1.

Trends over time

We analysed the time course of all queries made in the analysed period in Poland (Figure 1A, Tables 1 and 2). The search volume grew from ~360,000 to ~710,000 per month during the years 2015–2019. The median number of searches per month grew from year to year. *Post hoc* testing showed there was a higher number of searches between the fourth and third years in comparison with the first and second years. Differences were observed in the number of searches between each season: winter and autumn were the highest, and were higher than spring and summer by ~30%.

A growing number of queries each year was associated with abdominal pain in holiday destinations countries for Polish citizens, but only the difference between the first and fourth year was significant (Figure 1B, Table 1). Moreover, the median number of searches per month in summer and fall was higher than that in winter and in spring (Table 1).

The median number of searches per month in foreign countries associated with the place of employment of Polish people increased during the first 3 years of observation and in the fourth year this growth stopped (Figure 1C, Table 1). The number of searches in the second, third and fourth years was higher in comparison with the first year of observation. Furthermore, we observed a significantly higher number of queries made in winter *versus* summer (Table 2). The plots for different countries analysed are presented in Supplemental Figures S2–S3).

Localisation

We identified a total of 14,450,210 (59%) searches using different keywords associated with abdominal symptoms, which allowed us to assign the localisation of the abdominal pain (Figure 2, and see Table S2 for the frequency abdominal pain terms from Google queries in Poland from March 2015 to February 2019). We identified the hypogastrium, epigastric and the left lumbar regions of the abdomen as the most common localisation of pain. The interest of Google users in abdominal pain increased over the 4-year period for all locations excluding the right iliac region. However, *post hoc* analysis showed that significant differences occurred between the first *versus* third and first *versus* fourth year (Figure S4A and S4B; Table S2a). For all locations, excluding the left hypochondrium and right

Table 1. Comparison between the number of searches per month in the Google search engine associated with abdominal pain in Poland and holiday destination abroad and work-associated countries in each season. Data are presented as median (interquartile range).

Keywords	Spring (Sp)	Summer (Su)	Fall (F)	Winter (W)	Differences between seasons	*Post hoc* test
All, PL	485,113 (405,998–504,153)	421,418 (396,323–486,641)	519,085 (480,319–604,540)	604,850 (542,902–686,138)	$H(3) = 17.58$; $p < 0.001$	Sp *versus* W: $p = 0.01$; Su *versus* F: $p = 0.03$; Su *versus* W: $p < 0.001$
All, holiday countries	45,150 (43,388–46,688)	52,625 (49,763–57,763)	47,450 (46,338–52,625)	44,725 (44,575–45,600)	$H(3) = 22.20$; $p < 0.001$	Sp *versus* Su: $p < 0.001$; Sp *versus* F: $p = 0.03$; Su *versus* W: $p < 0.001$; A *versus* W: $p = 0.008$
All, work countries	190,797 (183,136–193,332)	185,300 (177,838–188,979)	197,130 (189,481–199,228)	194,673 (191,663–203,378)	$H(3) = 13.28$; $p = 0.004$	Su *versus* W: $p = 0.003$; Su *versus* F: $p = 0.01$

PL, Poland.

Table 2. Comparison between the number of searches per month in the Google search engine associated with abdominal pain in Poland and holiday destination abroad and work-associated countries in each year (1b). Data are presented as median (interquartile range).

Keywords	1st year	2nd year	3rd year	4th year	Differences between years	*Post hoc* test
All, PL	396,260 (384,405–484,553)	449,562 (416,480–540,228)	535,795 (492,532–594,604)	618,683 (499,511–675,854)	$H(3) = 18.88$; $p < 0.001$	1st *versus* 4th: $P<0.001$; 1st *versus* 3rd: $P=0.004$; 2nd *versus* 4th: $P=0.02$
All, holiday countries	44,800 (43,613–46,075)	46,175 (44,238–48,113)	47,700 (45,300–52,163)	49,575 (46,663–55,700)	$H(3) = 10.21$; $p = 0.02$	1st *versus* 4th: $P=0.02$
All, work countries	178,268 (173,341–182,360)	190,453 (184,281–198,426)	194,820 (192,655–201,041)	191,845 (188,515–198,808)	$H(3) = 18.68$; $p < 0.001$	1st *versus* 2nd: $P=0.002$; 1st *versus* 3rd: $P<0.001$; 1st *versus* 4th: $P=0.001$

PL, Poland.

lumbar region, interest in abdominal pain was higher during winter than during spring or summer, and higher during autumn than summer in most cases (Table S2a).

Description of pain

We identified a total of 2,682,510 (10.9%) searches with a description of pain. Most frequently, Google users described abdominal pain as 'crampy', 'stabbing', 'acute' and 'strong'. We observed that queries with a description of abdominal pain were significantly higher in the fourth year than in the first year (Figure 3, Table S2b). Moreover, pain described as 'acute' and 'cramping' was also significantly higher in the fourth year than in the second and third years. The number of searches for menstrual-like pain was higher in the second, third and fourth years than in the first year. We observed seasonal

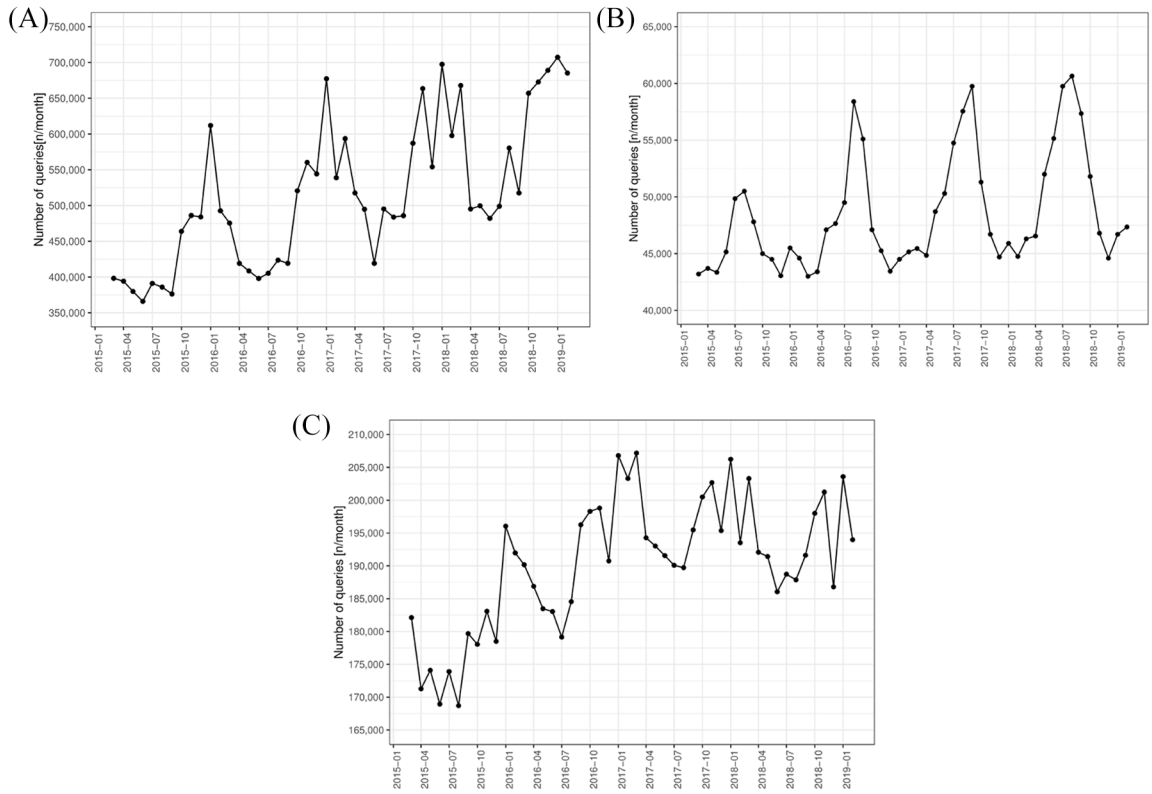

Figure 1. The number of Google queries associated with abdominal pain from March 2015 to February 2019 in different countries. (A) Poland, (B) Bulgaria, Egypt, Greece, Spain, and Turkey (holiday countries), and (C) France, Germany, Ireland, Italy, Netherlands, and the United Kingdom (countries associated with Polish workers).

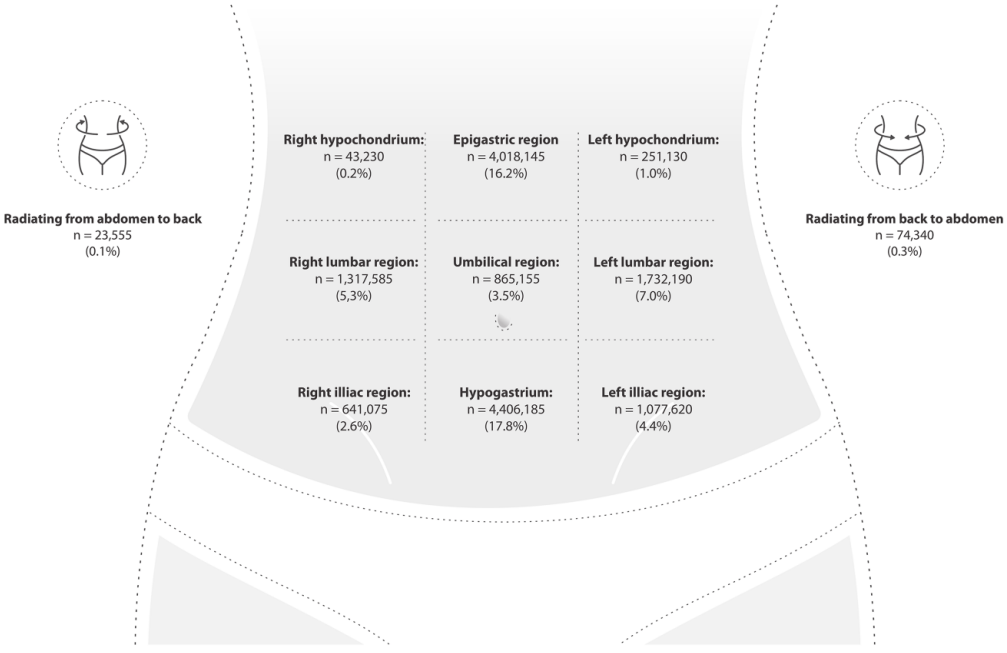

Figure 2. The total number and frequency of Google searches of abdominal pain with localised for Poland from March 2015 to February 2019.

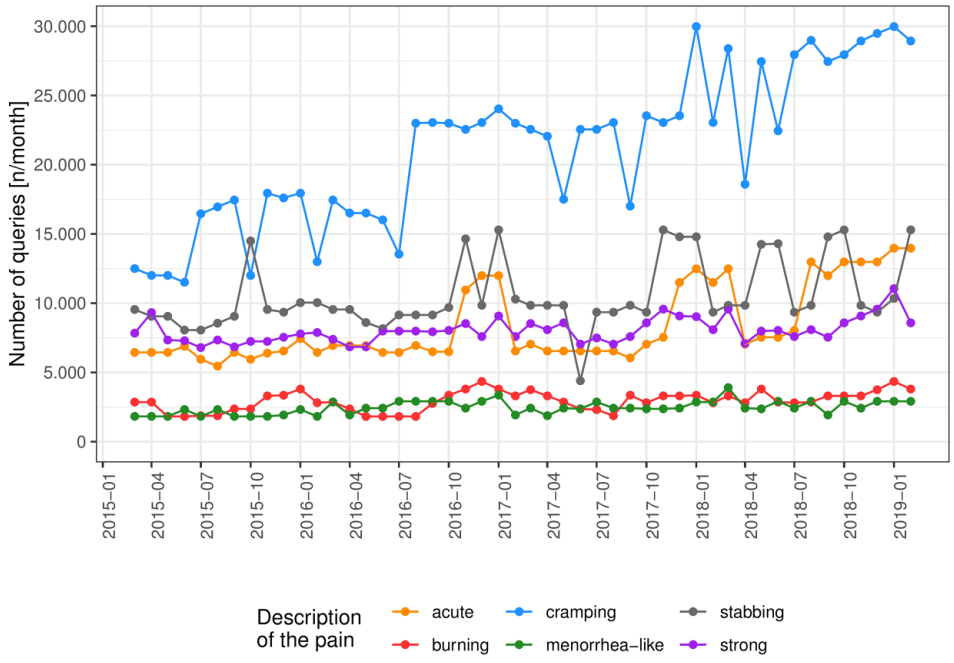

Figure 3. The number of Google queries with the most frequent descriptions of abdominal pain in Poland from March 2015 to February 2019.

(winter and autumn) patterns of interest of pain described as 'burning', 'stabbing' and 'frequent'.

Concomitant symptoms

There were a total of 1,723,455 (7.0%) searches of abdominal pain combined with another symptom. The term 'abdominal pain' was most frequently linked with the following gastrointestinal tract symptoms: 'flatulence', 'diarrhoea', 'fever' and 'vomiting'. Interest in symptoms such as diarrhoea and flatulence was higher in the second to fourth years than in the first year. Furthermore, queries of abdominal pain with fever were more frequent in the third and fourth years than in the first year (Figure 4 and Table S2c). We observed that abdominal pain with diarrhoea or vomiting was searched more frequently during winter than in spring (for symptoms of 'vomiting', the number of searches during the winter was also higher than in summer). 'Abdominal pain fever' was more frequently searched during the winter than in other seasons. We did not find any seasonal patterns of queries associated with flatulence.

Frequency

We found a total of 347,165 (1.4%) queries regarding abdominal pain combined with a description of its frequency. Abdominal pain was described mostly as follows: 'persistent/chronic' and 'frequent'. Searches for 'frequent abdominal pain' were more prevalent in the winter than in summer, whereas there was no specific pattern for 'persistent/chronic' queries (Table S2c; Figure S5).

Associated factors

Some of the searches included information about circumstances associated with abdominal pain. There were a total of 529,580 (2.1%) such queries. Users most frequently searched for information about 'abdominal pain after a meal'. Interestingly, the keyword 'abdominal pain after a meal' was the main search term every year in November (Figure S6). However, the number of searches for the terms 'abdominal pain after a meal' did not differ between seasons (Table S2d).

Group of patients

The Keywords Planner provided keywords associated with a specific group of patients. In the analysed period, there were a total 3,152,735 (12.8%) of these queries. The most frequent searches specifying the type of patients referred to pregnant women. The interest in abdominal pain

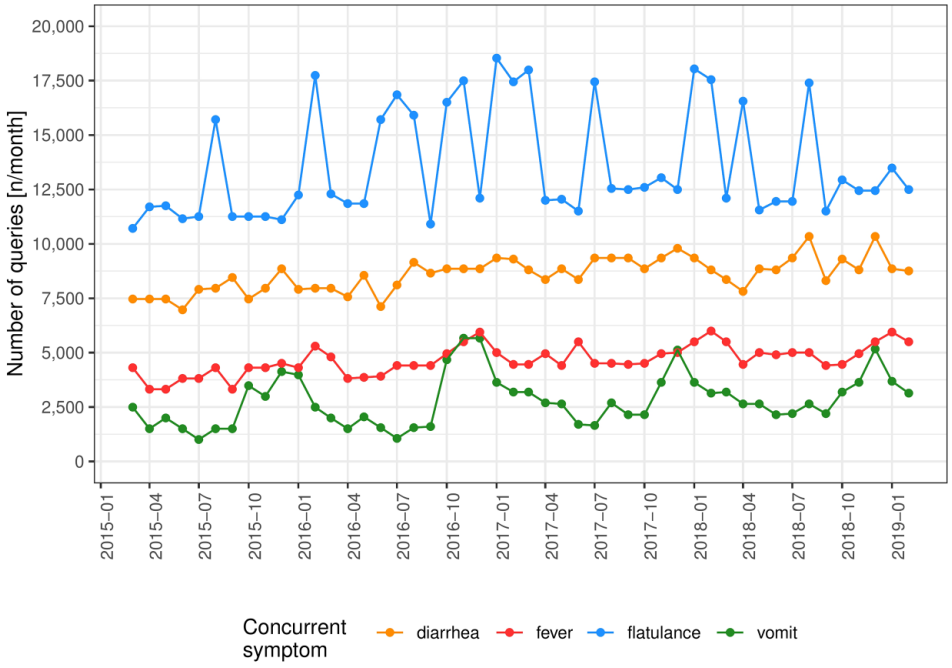

Figure 4. The number of Google queries with the most frequent concomitant symptoms with abdominal pain in Poland from March 2015 to February 2019.

during pregnancy was higher in the second to fourth years than in the first year. Furthermore, we did not observe any specific seasonal pattern (Figure S7; Table S2d). Conversely, searches associated with abdominal pain in children did not differ between years but were more most frequent in winter followed by autumn, than in summer (Figure S7; Table S2d). The number of searches for the keyword categories 'abdominal pain men' was significantly higher in winter than in summer (Figure 6; Table S2d).

Time of day

Approximately 187,095 (0.8%) searches involved queries about the time of the day of the abdominal pain episode. The queries about 'abdominal pain in the night' were the most frequent, followed by 'abdominal pain in the morning' and 'abdominal pain in the evening' (Table S2d).

Causes and symptoms

We identified a total of 375,250 (1.5%) queries regarding 'abdominal pain causes'. The number of searches related to 'causes' of abdominal pain was higher during the third and fourth year than in the first or second year and was higher in the second year than in the first year (Table S2d; Figure, S8). However, the number of searches did not differ between seasons.

Treatment

There were 1,129,535 (4.6%) queries characterised as 'abdominal pain treatment'. The number of searches monthly ranged from 12,500 to 37,500 and increased steadily during the periods analysed: queries in the fourth year were higher than in the first and second years, and higher in the third than in the first year (Table S2d; Figure S9). We observed a higher interest in abdominal pain treatment during the winter in comparison with other seasons.

Provocation of abdominal pain

We noted queries 'abdominal pain how to induce'. Interestingly, the peaks of the queries were present in April 2015; January, February and October 2016; October and November 2017; January, April and November 2018 and in January 2019.

Discussion

The present study was the first of its kind to explore Google data in order to analyse seasonal trends in abdominal pain for a specific population.

We found that the number of queries related to abdominal pain and different factors associated with abdominal pain increased during the yearly periods analysed. First, this growth could be explained by increased access to the Internet[19]; second, a higher trust placed on health information provided by the Web; and third, by an increase in the prevalence of abdominal pain or limited access to relative to information or treatment available in the real world. We cannot clearly conclude which of these rationales could explain the observed trends. The role of 'Dr. Google' in searching for information related to abdominal pain is increasing, and this phenomenon should be noted by healthcare regulators and policymakers as well as medical professionals.

Analysis of Internet traffic may serve as an interesting epidemiologic tool. In the current study, we found there was an association between seasonal migration (work, holidays) of Polish individuals and the search volume of Internet queries related to abdominal pain, which can reflect the epidemiological value of such analysis. Interest in abdominal pain in Poland was relatively lower than the previously described frequency of abdominal pain in this population and that of Polish populations in the countries analysed.[32–34] The latter may reflect the proportion of individuals who actively use the Internet to find health-related information about abdominal pain. However, data from Google Ads are estimations and thus may only reveal the magnitude of complaints regarding abdominal pain. Moreover, these epidemiological studies may also be biased by the limited period of observation.[32–34]

We found that the number of searches associated with abdominal pain and most factors related to this symptom increased in autumn and winter. Interestingly, we observed a decrease in the number of queries in December in 'work emigration countries', which can be explained by frequent returns to the homeland for Christmas. Whereas the number of queries associated with abdominal pain decreases in the summer in Poland, it increases in countries of holiday destinations, which confirms the epidemiological value of Google Ads.

Increased interest in abdominal pain in autumn and winter among Internet users could be a consequence of spending more time online browsing websites. However, we could not find any reliable data to support this hypothesis. The interest in acute, strong, menstrual and cramping abdominal pain has no seasonal pattern. Perhaps in such cases, individuals look to Dr. Google for immediate help when these symptoms occur. The peak in searches for the terms 'abdominal pain after a meal' in November is in agreement with Piotrowicz *et al.* who documented that functional dyspepsia patients in Poland mostly reported an aggravation of the ailments in autumn and winter.[35] Of interest, we found that Google users were also looking for methods capable of triggering abdominal pain, most likely to find an excuse to avoid school or work.

Google Ads may be a universal source of infodemiological data for countries with high popularity of the Google search engine. Analysis of the keywords provides context (localisation, other symptoms) of searches on a specific ailment. These properties are valuable to characterise the most common localisation of the complaint as well as the needs of Google users.[23,27,28] To our best knowledge, this is a first study mapping the frequency of abdominal pain in different localisation using data from the search engine. Data from Google Ads may be confronted with real-world information to seek for under-researched associations.[25] Therefore, we encourage readers in their investigations using Google Ads. This method is also very useful in case of the lack of real epidemiological data.

The authors acknowledge several limitations of this study associated with the data obtained from Google Ads Keywords Planner. Google Ads does not present an exact number of searches but only the ranges. Moreover, the company does not publish the methodology of the search volume calculations, thus limiting confidence in outcomes.[23] The Keywords Planner may not recognise some colloquialisms, and synonyms for certain ailments, particularly if these phrases are rarely used. Fortunately, the term 'abdominal pain' (pl. ból brzucha) in the Polish language does not have many synonyms, and all the popular phrases were presented in the list generated from Google Ads. The time period was restricted to only 4 years.[23] Another limitation is a lack of epidemiological data of the users, that is, information relative to sex and age and a detailed history of symptoms and other comorbidities. Previous studies have reported that women look for health information more often on the Internet

than men.[36,37] Furthermore, the number of searches may only reflect the magnitude of the actual quantity of queries. Finally, we could not predict the etiology of the complaints. Since Google Ads generated only a limited number of keywords that may reflect the presence of alerting symptoms, we could not perform detailed analyses of these queries.

In conclusion, Internet queries related to abdominal pain and related factors have increased in the past 4 years and indicate a seasonal pattern. Google Ads may be a valuable tool for the assessment of the prevalence of complaints experienced in under-researched regions. The observed trends of queries related to abdominal pain may merely reflect the scale of the problem. The reported pattern should be verified in epidemiological studies.

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Author contributions

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Conflict of interest statement

IŁ and WM are foundation shareholders of Sanprobi, manufacturer and distributor of probiotics

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Supplemental material

Supplemental material for this article is available online.

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