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Potential uses of an infodemiology approach for health-care services for rheumatology

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Abstract

Objectives This is a demand-based infodemiology study using the Google Trends and AdWords tools to illustrate infodemiology's potential use in rheumatology. The study investigates three questions in North American countries: (1) What terms associated with "rheumatology" and "arthritis" do people search for on Google? (2) What is the search volume for disease-modifying antirheumatic drugs (DMARDs)? and (3) What is the search volume for the term "arthritis" compared with for "hepatitis C" and "breast cancer"?

Methods We conducted independent searches by country and search term for 2015–2017. Seventeen DMARDs were searched for 2015 through May 2018, with the turmeric remedy included for comparison. Data were exported to Excel for further analysis, adjusted by country population, and expressed as searches per 100,000 inhabitants (SpTh).

Results There were approximately 550 associated terms for "arthritis" in each country, and 5679 SpTh for DMARDs across the three countries. Searches for turmeric numbered slightly lower than for all DMARDs together in Canada and the USA, but were 70% higher in Mexico. Turmeric was also searched four times more than the most-searched biological DMARD in Canada and the USA, and 60 times more in Mexico. Arthritis was more commonly searched for in Canada than hepatitis C and breast cancer, but hepatitis C was highest in the USA and breast cancer in Mexico. Monthly trends did not show expected peaks associated with arthritis awareness campaigns.

Conclusion Infodemiology provides preliminary information that could help in generating hypotheses, assessing health-care interventions, or even in providing patient-centered care.

Keywords Arthritis · Breast cancer · Disease-modifying antirheumatic drugs · Hepatitis C · Infodemiology · Trending

Introduction

There are more than 430 million Internet users in North America (Canada, USA, and Mexico) [1, 2], and most have searched online for information about health-related issues, including specific diseases or treatments [3]. Internet users searching for health-related information also visit sites aimed at health professionals [4]. Most importantly in this behavior is that, in many cases, the information patients retrieve online directly affects their health-care decisions [5, 6].

The term "big data" is used for data sets so big and complex that traditional data-processing application software cannot adequately handle them. One form of big data is that which accumulates over the course of Internet search activity. Internet search data may therefore provide valuable insights into patterns of disease and population behavior. For instance, Eysenbach, in 2006, was the first to show a correlation between influenza-related searches on Google and influenza cases occurring during the following week in Canada [7]. Eysenbach labeled such studies "infodemiology," or if the primary aim is surveillance, "infoveillance," which is defined as "the science of distribution and determinants of information in an electronic medium, specifically the Internet, or in a

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population, with the ultimate aim to inform public health and public policy" [7].

Infodemiology-related publications have increased more than sevenfold from 2009 to 2017, studying health phenomena in a variety of topic domains, though mainly in infectious diseases, mental health, substance use, other non-communicable diseases, and general population behavior [8, 9]. Nevertheless, it seems that infodemiology has not garnered much interest in the field of rheumatology. We found only three related articles: two on seasonal trends in restless leg syndrome [10] and systemic lupus erythematosus (SLE) [11], and the third on volume trends of Internet searches regarding SLE [12]. However, owing to the chronicity, complexity, and the multidimensional impact of most rheumatic diseases, infodemiology seems a highly suitable initial approach for studying a broad range of topics in domains such as patient-centered care model, health-care research, and outcome determinants.

As the fields of big data and infodemiology are evolving with the creation of complex algorithms and programs to address new challenges and concerns [13, 14], their use outside specialized centers is also becoming more complex. However, in rheumatology it is possible to perform valuable infodemiology studies simply, inexpensively, in near-real time, and in office settings. Google Trends (GTr) and Google AdWords (GAd) are two useful tools for assessing demand-based infodemiology indicators.

This study aimed to demonstrate the use of GTr and GAd with regard to rheumatology, in an office setting and performed mostly by medical students. We posed three research questions assessing whether differences exist in the demand for information among North American countries, over a 3-year period. These questions were as follows: (1) What terms associated with "rheumatology" and "arthritis" do people search for on in Canada (CAN), the United States (USA), and Mexico (MEX) in Google? (2) What is the search volume for specific disease-modifying antirheumatic drugs (DMARDs) in CAN, USA, and MEX? and (3) What is the search volume for the term "arthritis" compared with that for "hepatitis C" and "breast cancer" in CAN, USA, and MEX?

Material and methods

GTr and GAd were used in an outpatient rheumatology center under the supervision of experts in searching for trending online topics (GMA and SRG), with medical students performing the actual searches. Rheumatologists designed the concept and took part in the data analysis and interpretation. For the first research question, on terms people in CAN, USA, and MEX associated with rheumatology and arthritis, we conducted six different searches—one for each country, and one for each term—covering January 2015 to December 2017. The search was performed during 2 weeks in March 2018.

For the second question, on search volume for DMARDs, we analyzed 17 biological or targeted synthetic DMARDs approved for treating rheumatic diseases. To do this, we used a separate search on the drug name, as well as its brand name(s), by country, and covering January 2015 through May 2018 to see if similar tendencies remained during the first months of 2018. To gain perspective of the relative magnitude of the search results, we also included methotrexate and turmeric (curcuma) (both specifically in the context of arthritis treatment). The latter was selected because it is now the most popular non-conventional remedy in rheumatology. Searching was performed during the third week of July 2018.

For the third research question, on the search volume of the term "arthritis" compared with "hepatitis C" and "breast cancer," we performed nine different searches; one for each condition and country, covering January 2015 to December 2017. Searching was performed during March 2018.

Google Trends

GTr (https://trends.google.com/trends/) is one of the world's largest real-time datasets. The tool helps organize and visually display the billions of searches that take place on Google every month [15]. It is a Web-based, free tracking system of Google search volumes. Its algorithms normalize data for the overall number of searches on a scale from 0 (search volume < 1% of peak volume) to 100 (peak popularity), presenting them as relative search volumes. We used this platform for assessing monthly trends to select the currently popular remedy for arthritis treatment and high-volume searches on arthritis, hepatitis C and breast cancer that could be related to awareness campaigns. However, we had to additionally use GAd to obtain numbers of searches, rather than proportions.

Google AdWords

GAd is a Google's advertising system, in which advertisers bid on certain keywords for their clickable ads to appear in Google's search results [16]. Google processes around 40,000 searches per second [17]; all these data are stored and organized by Google and then, through the AdWords platform, are approximated for customer use. GAd enables tracking of how many times a keyword is searched worldwide on Google. This information is displayed in the platform and can be download. To gain access to the keyword function of the GAd platform, at least one ad should be created. This is a paid ad (usually around US$8).

To do this, we created an AdWords account at https://google.com/adwords/ and followed the instructions at the time of conducting the search; instructions for this tool change frequently [18, 19]. We used single terms for

searches for "arthritis," "rheumatology," "breast cancer," and "hepatitis C." However, we restricted the searches for turmeric and specific DMARDs to "treat arthritis" or "arthritis treatment" or "rheumatology," because, for instance, turmeric is a common cooking spice, and some DMARDs may be used for other non-rheumatic diseases. As some DMARDs have different brand names by country (e.g., rituximab and tocilizumab), we searched all brand names irrespective of country.

Statistical analysis

The resulting search volumes were exported to Excel for further analysis. The search volumes for questions 2 and 3 were adjusted by country population (searches per 100,000 habitants [SpTh]); CAN, 36,979,262; USA, 326,961,000; and MEX, 130,894,000 [20].

In this type of study, measures of central tendency and dispersion cannot be calculates, as the search volume is expressed as a one total value.

Results

For the first research question, the results showed when people searched for information on rheumatology in CAN and the USA, they used around 600 different terms, with 318 in MEX. In CAN, the most frequently entered terms, in order of frequency, were lupus, fibromyalgia, gout, and arthritis. In USA, they were lupus, fibromyalgia, dermatologist, and gout. In MEX, they were lupus, fibromyalgia, dermatologist, physiotherapy, and rheumatoid arthritis. However, when people searched for "arthritis," there were around 550 associated terms in all three countries. The most frequent terms in CAN were rheumatoid arthritis, arthritis pain, psoriatic arthritis symptoms, and arthritis symptoms. In the USA, they were rheumatologist, spondylosis, rheumatology, temporal arteritis, joint pain, and rheumatism. In MEX, they were rheumatoid arthritis, osteoarthritis, knee pain, rheumatism, and rheumatoid factor.

For the second research question, on DMARDs, there were 28,104,730 searches in the three countries during the study period of 41 months, amounting to 5679 SpTh (494,834,000 inhabitants in total). Table 1 shows the biologicals with more searches, given by country and adjusted for SpTh. Searches of all included DMARDs were similar in CAN and the USA. However, in MEX, they were around 12 times less. Methotrexate was the most commonly searched in CAN and the USA during the 41-month study period, with a slight increase over time. However, in MEX, depending on the year, it was between the seventh- and eighth-most searched. The brand name of adalimumab was ranked top among biological agents in the three countries during the entire study period. A

bid of change in search volume was observed for the brand names of secukinumab, tofacitinib, and ixekizumab.

Table 1 also shows the searches on the non-conventional turmeric (curcuma) remedy. The search volumes of all DMARDs together compared with turmeric were slightly higher; by 18% in CAN and the USA in 2015; 8% (CAN) and 5% (USA) in 2016; 8% (CAN) and 4.5% (USA) in 2017, and 16% (CAN) and 14% (USA) for the 5 months of 2018. The opposite occurred in MEX, where searches for turmeric exceeded those for DMARDs by 66% in 2015, and around 76% for the period 2016–2018. Searches for turmeric were also around 3.5 times more than those for methotrexate in the USA and CAN, and between 107 and 189 times more in MEX. Search volumes for turmeric were also greater than for the brand name of adalimumab; around four times more in CAN and the USA, and 60 times more in MEX, reaching their highest throughout 2016 in all three countries.

For the third research question, on the search volume of the term "arthritis" compared with "hepatitis C" and "breast cancer," overall, there were 10,810,000 (2185 SpTh) searches in the three countries during the 3-year period for arthritis, 15,193,700 (3070 SpTh) for hepatitis C, and 7,646,600 (1545 SpTh) for breast cancer. However, the frequency distributions for search terms show different patterns by country (Fig. 1). In CAN, arthritis was the highest, with 800, 826, and 826 SpTh for 2015, 2016, and 2017, respectively. Hepatitis C followed, slightly lower at 776, 765, and 714 SpTh for the same years. Breast cancer had 48% fewer searches than arthritis: 450.5, 426, and 403 SpTh. The opposite occurred in the USA, where hepatitis C was highest, with 1355, 1420, and 1436 SpTh. Arthritis was the second, 32% lower than hepatitis C: 765, 987, and 1104 SpTh. Breast cancer was the third, with 42% fewer searches than for hepatitis C: 404, 495.5, and 629 SpTh. Mexico has also its own unique pattern. The search volumes for each term were much less than for CAN and the USA, and breast cancer was highest, with 541, 520, and 602 SpTh. Arthritis and hepatitis C had similar results, with both around 74% less than for breast cancer.

The monthly search trends by topic showed different patterns by country (Fig. 2). Searches on arthritis in CAN were steady in January–May and dropped 18% from June to September and also in December in each study year. In the USA, searches on arthritis increased by 28% in 2016 and 12% in 2017, mainly from January to July in both years; there were no monthly variations during 2017. In MEX, searches were almost the same in the 3-year period, with just an 8% increase in 2017, while July and December had the lowest numbers of searches.

Searches on hepatitis C in CAN were highest in the months of November 2015 and 2016. However, the overall searches dropped in 2017, mainly in the months of July (18%), August (18%), and November (32%). In the USA, the overall searches remained almost the same throughout the 3-year period;

Table 1 Disease-modifying antirheumatic drugs (DMARDs) with more searches in Canada, the USA, and Mexico

| Years	Adjusted searchers per one-hundred thousand country's population											
	2015			2016			2017			January–May 2018		
	CAN	USA	MEX	CAN	USA	MEX	CAN	USA	MEX	CAN	USA	MEX
Turmeric remedy	1190	1219	749	1666	1944	1422	1649	2152	440	34.5	978	729
All DMARDs searches	1734	1785	53	1962	2162	174	1937	2357	203	1016	1286	106
Top DMARDs, rank, and searches												
Methotrexate	1st, 422	1st, 398	8th, 7	1st, 466	1st, 480	8th, 7.5	1st, 498	1st, 505	7th, 8	1st, 218	1st, 234	7th, 4
Adalimumab®	2nd, 257	2nd, 303	2nd, 15	2nd, 282	2nd, 362	2nd, 17	2nd, 287	2nd, 341	2nd, 21	2nd, 134	2nd, 168	2nd, 12
Infliximab®	3rd, 218	3rd, 165	9th, 6	3rd, 239	3rd, 179	9th, 5.5	3rd, 223	3rd, 182	10th, 5	3rd, 89	3rd, 79	–
Etanercept®	4th, 113	4th, 160	3rd, 14	4th, 111	4th, 171	3rd, 13	6th, 98	4th, 171	5th, 13	6th, 39	4th, 76	6th, 6
Rituximab	5th, 86	7th, 76	1st, 25	5th, 95	8th, 90	1st, 28.5	5th, 103.5	9th, 100	1st, 35	4th, 49	8th, 48	1st, 22
Ustekinumab®	6th, 70	6th, 84	–	6th, 77	7th, 91	–	4th, 106	6th, 118	–	5th, 47	6th, 51	–
Infliximab	7th, 47	10th, 45	5th, 10	*8th, 52	10th, 52	5th, 12	*8th, 53	11th, 59	3rd, 14	8th, 23	10th, 29	3rd, 7
Rituximab®	8th, 44	5th, 99	7th, 8	9th, 47	5th, 112	7th, 8	10th, 48	5th, 120	7th, 8	10th, 22	7th, 49	7th, 4
Golimumab®	9th, 41	–	–	10th, 43	–	–	*11th, 45	–	–	11th, 18	–	–
Adalimumab	10th, 28	–	6th, 9	*11th, 31.5	*13th, 40	6th, 10	*12th, 36	–	5th, 13	13th, 15	–	3rd, 7
Tofacitinib®	–	8th 69	–	–	9th, 83	–	*9th, 49	8th, 101	5th, 13	*8th, 23	9th, 45	*10th, 5
Abatacept®	–	9th 50	–	–	11th, 48	–	–	12th, 50	–	–	12th, 23	–
Certolizumab®	–	11th 44	–	–	12th, 46	–	–	–	–	–	12th, 23	–
Etanercept	–	–	4th, 11	–	–	3rd, 13	–	–	3rd, 14	*12th, 17	–	3rd, 7
Tocilizumab	–	–	10th, 4	–	–	9th, 5.5	–	–	9th, 5.5	–	–	9th, 3
Secukinumab®	–	–	–	*7th, 66	*6th, 96	–	*7th, 77	*7th, 110	–	*7th, 35	*5th, 57	10th, 2.5
Ixekizumab®	–	–	–	–	–	–	–	*10th, 70	–	–	11th, 25	–

®Brand name. *Bid change from 2015
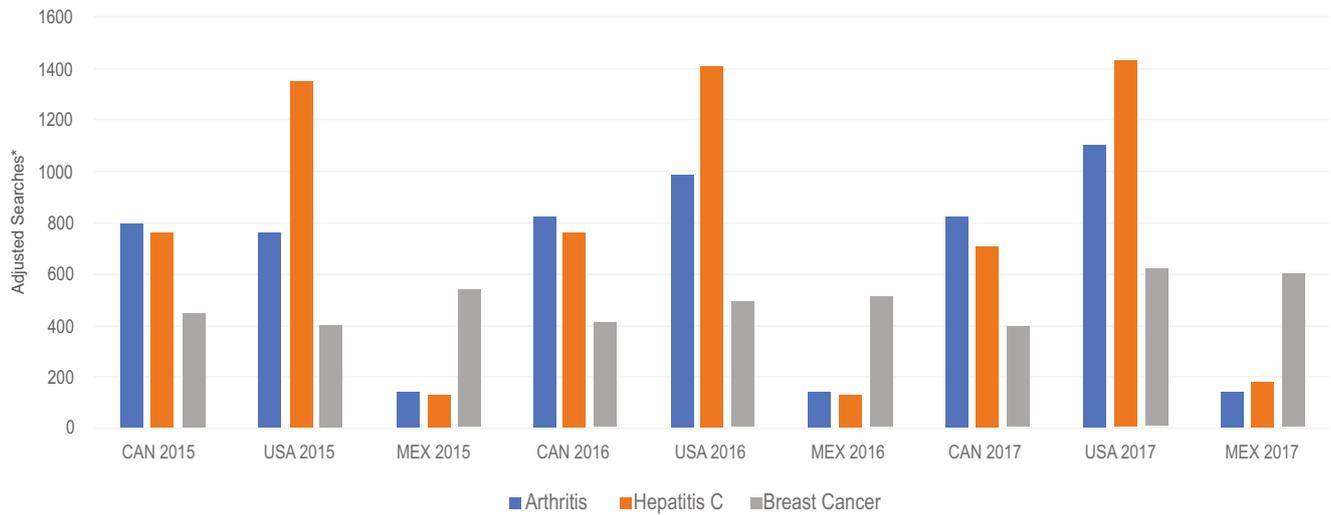
Fig. 1 Search volume of arthritis, hepatitis C, and breast cancer, by year and country. *Adjusted searches per 100,000 habitants

however, in 2017, a 22% increase was seen in January, March, May to June, and August, and a decrease of 33% during

November and December. In MEX, the overall numbers of searches increased slightly each year, by 36% from 2015 to
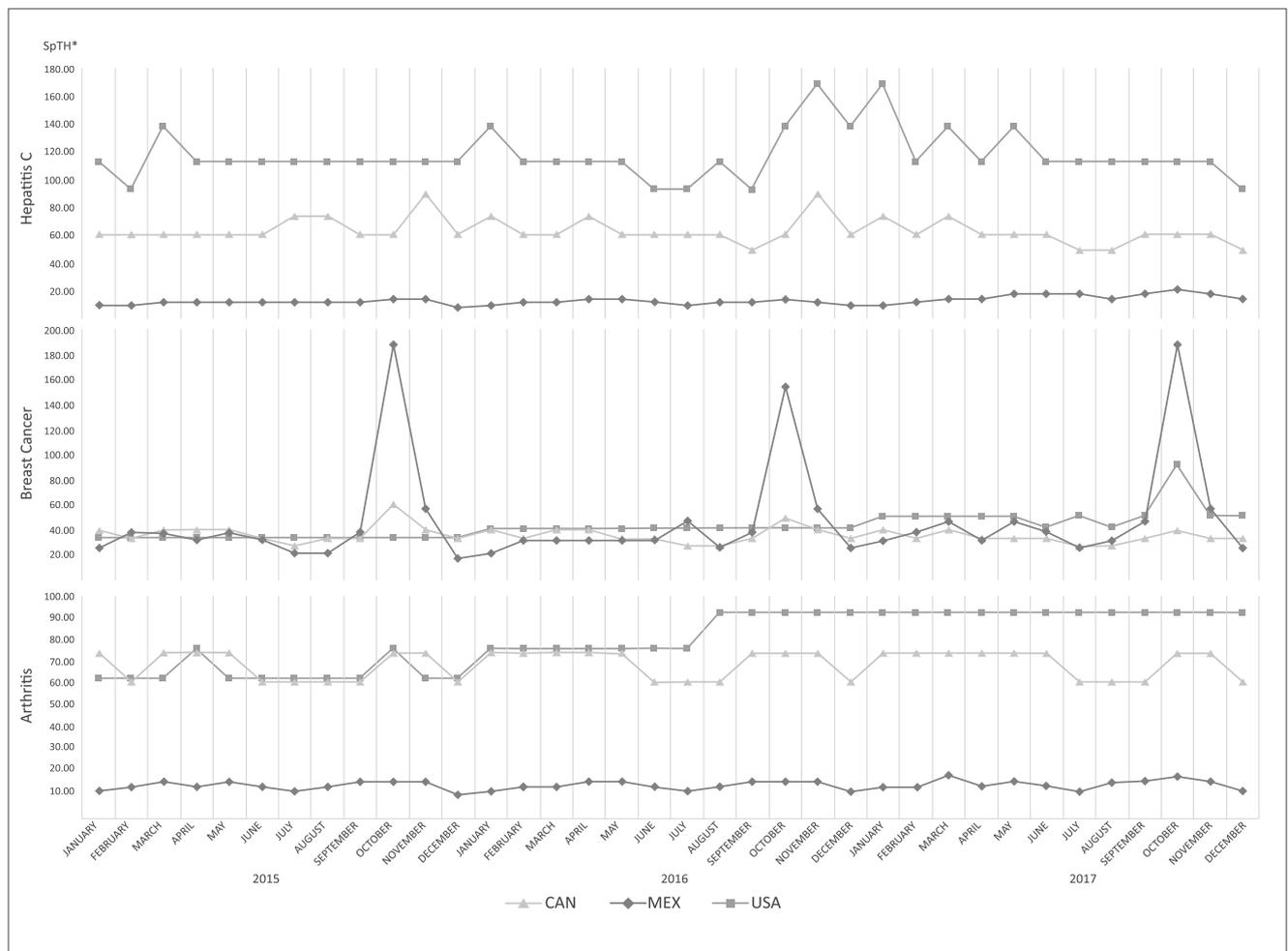
Fig. 2 Monthly trends in arthritis, hepatitis C, and breast cancer searches, by country and year. *SpTHh, adjusted searches per 100,000 habitants; CAN, Canada; USA, the United States of America; MEX, Mexico

2017. The lowest numbers of searches occurred in January and December of each year (Fig. 2).

Searches on breast cancer in CAN decreased slightly each year, most notably in April, October, and November 2017. In the USA, overall searches increased 23% in 2017 and 55% in 2017 compared with 2015. The monthly search volumes did not change during 2015 and 2016; however, October 2017 showed an increase of 174%, and 50% for November and December 2017 when compared with the same months in 2015. In MEX, overall searches were almost the same in 2015 and 2016, with a slight increase (11%) in 2017. However, around 31% of all searches occurred in October of each year (Fig. 2).

Discussion

In this study, we posed and investigated three research questions to demonstrate the value of an infodemiology approach for rheumatology, using the GTr and GAd tools. The first question, on associated terms, may be used to select suitable terms when planning extension of a research question. The second question, on DMARDs, may be useful in different areas, such as identifying information gaps that rheumatology organizations must fill, infoveillance as a complement to post-marketing surveillance strategies, and awareness of trending unconventional remedies that may need to be discussed with patients. Such remedies may pose health risks [21], such as in the former cases of drug interactions (e.g., cyclosporine and amitriptyline) with St. John's wort [22], or salmonella arizona arthritis associated with rattlesnake ingestion [23]. For the third question, on relative search volume, we deemed breast cancer would be a good "competitor" to compare with arthritis because there are public policies on its detection, and it has similar incidence to rheumatoid arthritis. We chose hepatitis C because it has similar prevalence and because of recent advertising of new treatments. This information could assist in ways such as planning and assessing the effectiveness of awareness campaigns, identifying people's information needs, and seeking and allocation of resources.

Big data, such as that which accumulates in the course of Internet search activities and is available through tools such as GTr and GAd, helps generate hypotheses. It can, however, in no way serve as a substitute for conventional data collection and analysis; instead, it can function as a complement. With this dimension, the results of the first research question show the myriad of associated terms used to seek information on rheumatology. The numbers of terms were similar in CAN and the USA, but even though these countries both communicate in English, the most commonly searched terms vary. This suggests sociocultural differences and/or perceived knowledge on the topic. Interestingly, in MEX, the associated terms for rheumatology numbered almost half those in CAN and the

USA, though the numbers were similar for arthritis. This could be because rheumatology is much less commonly known in MEX, as the top associated terms suggest, and because arthritis is more widely known and, therefore, people in MEX use the same diversity of associated terms, although different ones from those in CAN and the USA. It would be interesting for rheumatologists in MEX to assess perceptions of people regarding who the experts are for treating arthritis and rheumatic diseases. This could be done through means such as an ethnographic study. A recent study using qualitative design explored needs for information in 71 rheumatoid arthritis patients from four Spanish-speaking countries [24]. Questions prioritized by patients in this study were similar to the "arthritis"-associated terms that we are reporting in our study.

Following in the same dimension, the second research question, on DMARDs, warrants several comments. The brand name of adalimumab is most commonly searched among all biological or targeted synthetic DMARDs, including the oldest and newest, in all three countries. This could be related to marketing in a bidirectional way; it is the one that evokes either more interest or more uncertainty. Additionally, the search volume for all included DMARDs was substantially lower in MEX. This could be explained by lower Internet penetration in MEX (67%) than in CAN (90%) and the USA (96%) [2], and by the different pattern of Internet use behavior, where in MEX, social networks such as Facebook appear to be preferred sources of information-seeking as compared with search engines such as Google, which is different from behavior in CAN and the USA. Furthermore, despite the substantial investment the pharmaceutical industry makes in commercializing a specific biological product, to specific countries, the non-conventional remedy, turmeric, has far more searches in all three countries. Searches on turmeric even have volume near that of the collective searches for all biologicals, with no sign of decrease in 2018. Spread of information by word of mouth evidently has potentially more impact than specialized marketing strategies. It may be a valuable pursuit for rheumatology organizations to acquire knowledge of marketing concepts, such as the power of word of mouth, influencers, and so-called market mavens [25], to achieve a more effective impact on influencing desirable lifestyle changes in rheumatic patients.

Positioning, as defined here, regards the place a disease occupies in the mind of the general population. The third research question can be used as a surrogate for evaluating the positioning of the term "arthritis" compared with two non-rheumatic diseases. It is intriguing that arthritis, as a generic term for various diseases, is better positioned in CAN, though hepatitis C is in the USA and breast cancer in MEX. Furthermore, monthly trends in searches on arthritis showed no apparent peaks in the three countries during the years studied. This is relevant if we consider that there are periodic

annual public awareness campaigns, such as World Arthritis Day in October, arthritis and rheumatoid campaigns in February and May in the USA, arthritis awareness month in September in CAN, and "el Día del Paciente Reumático" (Rheumatic Patient's Day) in September or November in MEX. This is in contrast with searches on breast cancer, where peaks are evident coinciding with the October 2017 breast cancer awareness campaign in the USA, and each October in MEX. CAN showed no peaks in this regard. Monthly searches on hepatitis C showed no particular trends, as would be expected owing to the influence of commercialization of new treatments; the first in July 2015 and the last in August 2017.

There are several plausible explanations for the above findings. These include inequity of individual countries' public policies regarding illness, differentiated penetration of public awareness campaigns by medical associations, and the countries' cultural perceptions of the meaning of "seriousness" or "importance" of a disease. Meanwhile, the rheumatology associations of CAN, the USA, and MEX may use the present findings as areas of opportunity for future research to confirm these data and, if necessary, improve the importance ascribed to rheumatic diseases, as well as public awareness campaigns, in their communities.

The strengths of this study that lend weight to our inferences are the use of GAd as well as GTr to acquire actual search volumes, that the findings were adjusted to numbers of countries' inhabitants, and that the study was designed to use simple procedures performable in an office setting. Nonetheless, several limitations should be noted. First, Google is a business; in improving its services, it continually changes its data-generating processes and search algorithms [13, 18, 19]; therefore, GAd and GTr are not designed for health research, and results may not be reproducible if searches are performed on different dates. Second, there are other platforms with big data for social media analytics, such as Facebook Insights and Twitter Analytics. Although each one has different profiles of users and contents, and were created for business, they can also be used in Infodemiology. New projects have also been developed that automated coding specific health issues from news media, such as International Crisis Early Warning System (ICEWS) and Global Data on Events Language and Tone (GDELT) [14]. In 2012, the rheumatology group in Edomonton, Canada, developed a webpage named "Ask the Rheumatologist" where patients could submit their questions with answers provided by rheumatologist posted online; between 2012 and 2015, this webpage received 7985 views from 53 countries and 227 questions [26]. In our study, we limited the analysis of the information demand to the Google tools for its accessibility and ease of use. Third, the study subject is the searches themselves, not the people who do them. Consequently, it is not possible to know the number of individuals who perform the

searches, or their sociodemographic characteristics. Furthermore, this type of study precludes statements on causality or associations; data interpretation is limited to assumptions.

In summary, GTr and GAd are easy-to-use tools that provide useful and near-real-time information about a population's behavior in its demand for information. Our results show the myriad of terms associated with arthritis and rheumatology, that a non-conventional remedy garners more interest than any DMARD in North America, and that both the positioning of arthritis and the penetration of awareness campaigns can be improved. Finally, the results generate hypotheses, but in are no way a substitute, but rather a complement, to conventional data collection and analysis.

Compliance with ethical standards

Disclosures   None.

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