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**‘Googling’ Gout: Exploring perceptions about gout through a linguistic analysis of online search activities**

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## Abstract

**Aims:** To understand what terms people seeking information about gout use most frequently in online searches and explore the psychological and emotional tone of these searches.

**Methods:** A large de-identified dataset of search histories from major search engines was analyzed. Participants who searched for gout (n=1,117), arthritis (arthritis search control group, n=2,036, age and sex-matched), and a random set of age and sex-matched participants (general control group, n=2,150) were included. Searches were analyzed using Meaning Extraction Helper and Linguistic Inquiry and Word Count.

**Results:** The most frequent unique searches in the gout search group included gout-related and food-related terms. Those who searched for gout were most likely to search for words related to eating or avoidance. In contrast, those who searched for arthritis were more likely to search for disease or health-related words. Compared with the general control group, higher information seeking was observed for the gout and arthritis search groups. Compared with the general control group, both the gout and arthritis search groups searched for more food-related words, and fewer leisure and sexual words. The searches of both the gout and arthritis search groups were lower in positivity and higher in sadness words.

**Conclusion:** The perception of gout as a condition managed by dietary strategies aligns with online information-seeking about the disease and its management. In contrast, people searching about arthritis focus more on medical strategies. Linguistic analyses reflect greater disability in social and leisure activities and lower positive emotion for those searching for gout or arthritis.

## Significance and Innovations

- Linguistic analysis of online search behaviour can be used to understand how people might perceive health conditions
- People searching about gout or arthritis engage in high levels of information seeking
- The perception of gout as an illness that is primarily managed by dietary strategies aligns with online information-seeking about the disease and its management
- Linguistic analyses reflects greater disability in social and leisure activities and lower positive emotion for those searching for gout or arthritis than controls

Gout is a common form of inflammatory arthritis, with increasing prevalence worldwide (1). The central cause of gout is chronic deposition of monosodium urate crystals (2). Although effective long-term management of gout is available, many studies have shown low levels of prescription and adherence to urate-lowering therapy (3-5). In addition to dietary risk factors, there are many biological factors that contribute to development of gout, such as genetic risk factors, kidney disease and medications (1, 6). However, gout is perceived by patients, the general public and many health care professionals as a self-inflicted condition that is caused primarily by dietary indiscretion (7-10). These perceptions have been present within popular culture for centuries (11, 12), and are reflected in contemporary media depictions of the condition (13). These portrayals of the disease may contribute to stigma and a reduced willingness of patients to seek medical attention for gout management because of embarrassment about the condition (9).

Analysis of language has been used to understand and predict both physical and mental health. In the domain of mental health, the words people use have been found to be related to and predictive of outcomes such as depression (14, 15), coping with trauma (16, 17), and

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manic episodes (18). Analysis of online search behaviour can be used to track and predict physical health issues such as pregnancy (19), breast cancer (20), and pancreatic cancer (21). Furthermore, the language people use and their online behaviour can provide insights into how people perceive health issues. For example, analysis of language use in blogs and newspapers along with Wikipedia visits during a swine flu outbreak showed a rapid, short-term increase in information-seeking on Wikipedia following the outbreak, an increase in anxiety and negative emotion in those talking about the outbreak, and greater concern with health and death (22). Collectively, previous research demonstrates the potential of language and online behaviour to help researchers understand how people respond to health threats .

Building on this prior research and the high prevalence of online health information-seeking (23), online search behaviour can be explored to understand how people might perceive health conditions and the management of these conditions. The aim of this study was to understand what terms are used most frequently by people seeking information about gout in their online searches, and to explore the psychological and emotional tone of these searches using a linguistic analysis of search histories.

### **Materials and Methods**

In cooperation with Microsoft Research, a large de-identified dataset of search histories from 200,000 consenting individuals was obtained from ComScore, a web analytics company, covering a two year period (2011 to 2013). In exchange for incentives such as cash and software, the company installed software on participants' computers to passively monitor online search activities. Time-stamped search terms were logged from major search engines (Google, Bing, Yahoo, Ask). Basic demographics (gender, age, income, geographic region) were provided by the analytics company based on user self-reports. The data were de-

identified by replacing names, addresses, number strings (e.g., phone numbers, zipcodes, social security numbers), and urls with anonymizing codes. For example, a zip code such as “55111” was replaced with “zipcode” or a first name such as Jane was replaced with “fname”. All characters were translated into machine-readable characters. Common misspellings were corrected. Once the texts were cleaned, search terms were aggregated by participant over the entire period.

From the larger dataset, three groups were identified: participants who searched for gout at least once ( $n = 1,117$ ), participants who searched for arthritis (arthritis search control group,  $n = 2,036$ , matched to the gout search group on age and sex), and a random set of participants matched on age and sex who had not searched for gout or arthritis (general control group,  $n = 2,150$ ). The general control group size was chosen to roughly match the size of the arthritis search group. Additionally, the general control group was chosen to match on the age and gender composition of both the gout and arthritis search groups. For the analyzed dataset with the gout, arthritis, and general control groups, the total number of search words was 25,000,811. All participants included in the analysis were 18 years or over. The Office of Research Support at University of Texas at Austin reviewed the study protocol and advised that IRB review and oversight was not required as the study involved secondary use of a de-identified dataset with no direct links to identifiers.

Meaning Extraction Helper, a word frequency software, was used to calculate search term frequencies from each participant’s search history (Boyd, R.L. 2017 <http://meh.ryanb.cc>, version 1.4.15). Search terms were also analyzed using Linguistic Inquiry and Word Count (LIWC), a psychological text analysis software from which psychological processes can be inferred from the words people use (Pennebaker, Boyd, Jordan, & Blackburn, 2015

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<http://liwc.wpengine.com>) (24). Search group membership was dummy-coded with the general control search group as the comparison group. Search group membership was correlated with individual word frequencies using Spearman correlations using the psych package for R (Revelle, W. 2017 psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, USA, <https://CRAN.R-project.org/package=psych> Version = 1.7.8). One-way analysis of variance (ANOVA) with Tukey *post hoc* tests was used for LIWC categories to examine differences between the three search groups (gout search, arthritis search, general control search) in terms of how they are searching for information using SPSS (v22.0, IBM Corp, Armonk, NY).

## Results

The demographic features of participants are shown in Table 1. Just under half of the participants were men, with a range of income and ages. Table 2 includes examples from the dataset to show what people searched for when they searched for gout.

Analysis of the fifty most frequent unique searches showed gout-related terms (such as uric, purine, kidneys) and food-related terms (eg. meats, atkins, mash) in the group searching for gout (Table 3). For the group searching for arthritis, there were no food-related terms in fifty most frequent unique searches, but medical terms were commonly observed (eg. fibromyalgia, inflammatory, psoriatic, crohns, hospitalized).

Table 4 shows the Spearman correlations between search group membership and individual word frequencies, with the ten most correlated words. The majority of the words most correlated with gout search group membership related to food or avoidance (eg. food, diet, avoid, recipe, eat). In contrast, although some food words were correlated with the arthritis

searchgroup (eg. food, diet, recipe, eat), stronger correlations were observed with the arthritis search group for disease or health-related words (eg. rheumatoid, pain, disease, symptom).

All of the words most correlated with the arthritis search group membership were disease or health-related.

In the LIWC analysis, compared with the general control search group, total word count was higher for the gout and arthritis search groups, indicating higher information seeking in both groups (Figure 1 and Supplementary Table 1). Insight words (e.g., know, learn, and means) were also used more often in both the gout and arthritis search groups compared with the general control group. Although both the gout search group and the arthritis search group searched for more health-related words than the general control search group, health-related words were lower for the gout search group than the arthritis search group. Compared with the general control search group, both the gout and arthritis search groups searched more for ingestion-related (mainly food-related terms like dish, eat, pizza) words.

Compared with the general control search group, the groups of people searching for gout and arthritis searched for fewer leisure (e.g., cook, chat, movie) and sexual (e.g. love, sex) words (Figure 2 and Supplementary Table 1). There were also fewer social words (e.g. family, talk, they) in the arthritis search group, with a similar trend for the gout search group (Tukey  $P=0.052$  compared with general control group). The searches of both the gout and arthritis search groups were less positive in emotional tone (lower in positivity and higher in sadness words).

Overall, there were very few differences between the gout and arthritis search groups in the LIWC analysis, with the exception of higher total word count and use of health words by the arthritis search group, and higher use of insight words (e.g., know, learn, and means) by the gout search group (Figures 1 and 2, and Supplementary Table 1).

## **Discussion**

This linguistic analysis of online search activities has shown that people searching about gout or arthritis engage in high levels of information seeking. Consistent with prior research examining patient and community perceptions of disease (7, 9, 13, 25), unique searches in the gout search group included more food-related words, and words related to food and dietary strategies were correlated with membership of the gout search group. Although similar strength of correlations were observed between food-related words and the arthritis search group, much stronger correlations were observed between medical-related words and the arthritis search group. The perception of gout as an illness managed by dietary strategies aligns with online information-seeking about the disease and its management. In contrast, people searching about arthritis are more focused on searching about medical strategies.

The LIWC analysis indicates that the emotional experiences of people searching for gout or arthritis were similar, with lower positive emotion tone and higher sadness words compared with the general control participants. Our linguistic analyses reflect greater disability in social and leisure activities and lower positive emotion for those searching for medical conditions such as gout or arthritis, compared to people who do not search for these conditions. Although it cannot be assumed that all participants searching for gout had the condition, these findings align with prior studies which have shown higher rates of depression (26), and reduced social participation in people with gout (27).



Although gout occurs more frequently in men than women, it is notable that less than half the participants searching for gout were male. These findings are consistent with prior research which has demonstrated that although men and women have equal access to the internet in the US, women are more likely to gather health-related information online (23). It is possible that women with gout searched for this condition more because available education resources are of limited relevance to women with gout (28). However, it is also possible that women may also have searched for gout due to contact with a family member, friend or acquaintance who was affected by gout, or for some unrelated reason.

A previous qualitative study reported that gout is not considered a form of arthritis, but may be viewed as a different kind of rheumatic disease (7). The observation in our study that people searching for arthritis search for more medical words raises the possibility that including the word arthritis in a disease label, or in information provided about gout may have an impact on understanding effective management strategies for gout. A recent study by our group has shown that supermarket shoppers view the condition 'urate crystal arthritis' as a more chronic and serious condition that requires long term medications, whereas, the same condition labeled as 'gout' is viewed as a condition caused by poor diet, over-consumption of alcohol, and requiring dietary management (25).

The key limitation to this study is that very little personal information about participants is available, and it is not possible to determine whether participants in the gout or arthritis search groups had the condition, were searching about the condition due to concerns about a relative or friend, due to curiosity, or for information gathering as a student/health care professional. Furthermore, searching for a disease does not necessarily equate to a medical diagnosis. For example, prior research has shown that relative Google search volume correlates with incidence and mortality rates of some, but not all, cancers (29). Despite these limitations, the search patterns found in this study provide novel information about

perceptions of gout and its management. The results are consistent with the popular perception that gout is a condition that is primarily managed by dietary restrictions.

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#### **Conflicts of interest statement**

Nicola Dalbeth declares receipt of consultancy, honoraria or speaker fees from Takeda (<\$10,000), ArdeaBiosciences/AstraZeneca (<\$10,000), Kowa (<\$10,000), Abbvie (<\$10,000), Janssen (<\$10,000) and Horizon (<\$10,000), outside the submitted work. The other authors declare no conflicts of interest.

#### **Authorship contribution statement**

Kayla N. Jordan: 1a, 1b, 1c, 2, 3

James W. Pennebaker: 1a, 1b, 1c, 2, 3

Keith J Petrie: 1a, 1c, 2, 3

Nicola Dalbeth: 1a, 1c, 2, 3

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**Table 1. Demographics by group.** Percentage of group sample size is shown.

	<b>Gout search group</b>	<b>Arthritis search group</b>	<b>General control group</b>
<b>N</b>	1117	2036	2150
<b>Age</b>			
18-24	18.35	21.91	16.98
25-34	16.03	18.66	18.37
35-44	15.67	15.37	20.70
45-54	20.68	16.55	15.16
55+	22.56	20.92	28.79
<b>Gender</b>			
Unknown	0.45	0.44	0.00
Female	54.97	56.53	50.37
Male	44.58	43.03	49.63
<b>Annual income (USD)</b>			
Less than 15000	11.28	9.38	8.93
15,000-24,999	6.45	5.75	6.00
25,000-39,999	10.03	9.58	8.65
40,000-59,999	16.03	19.94	17.12
60,000-74,999	27.39	22.30	24.51
75,000-99,999	12.35	12.43	12.05
100000+	8.59	10.76	10.37

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**Table 2. Examples of searches in the group of participants who searched for gout.** Each bullet point shows a different individual's searches on a given day.

- *vw volkswagen beetle 2012 gout home treatment medications home remedies for gout pain home remedies for gout pain relief*
- *youtube craigslist ebay black spider helicopter youube ebay amazon allopurinol side effects gout diet free gout diet foods that help lower uric acid omeprazole*
- *horse trailer gout diet low purine diet xname bow reviews gun shows gun town*
- *list of gout food cause urid acid in the body opusbank*
- *female naked pics craigslist female naked pics female naked pics female naked pics gahout gaout gout symptoms and causes*
- *what causes gout what populations are susceptible to gout anti reject drugs for organ transplants anti reject drugs for organ transplants gout gout*
- *truth or fiction truth or fiction snopes truth or fiction snopes com truth or fiction snopes pledge of allegiance pledge of allegiance by obama and what causes hiccups what causes gout what causes fog what causes gurgling in sewer what causes gurgling in sewer lines*

**Table 3. Most frequent unique searches in the gout search group and the arthritis**

**search group**

<b>Gout search group</b>		<b>Arthritis search group</b>	
<b>Word</b>	<b>% of people searching</b>	<b>Word</b>	<b>% of people searching</b>
uric	6.27	fibromyalgia	6.53
sid	3.76	jwoww	4.52
meats	3.58	supposed	4.52
amusement	3.40	inflammatory	4.47
verdict	3.40	penney	4.42
wraps	3.40	psoriatic	4.42
reply	3.31	epilepsy	4.37
hoes	3.31	hoax	4.32
scams	3.31	brett	4.32
hates	3.31	asleep	4.27
vac	3.22	dvds	4.22
purine	3.22	controlled	4.17
mustard	3.13	feelings	4.17
hourly	3.13	equivalent	4.08
ache	3.13	outbreak	4.08
tsa	3.13	mitt	4.08
herman	3.13	weakness	4.03
erase	3.13	cds	4.03
renee	3.13	enjoy	4.03
rodman	3.13	ripa	3.98
atkins	3.13	kicked	3.98
comm	3.04	hugo	3.93
bananas	3.04	collision	3.93
hometown	3.04	andrea	3.93
directionsxnumber	3.04	mowry	3.88
airfare	3.04	addicted	3.88
herbs	3.04	crohn's	3.88
ego	2.95	postage	3.83
mash	2.95	began	3.83
arabia	2.95	patricia	3.83
bees	2.95	slams	3.83
buckle	2.95	sq	3.78
combs	2.95	menstrual	3.78
candidates	2.95	latifah	3.78
caroline	2.95	stains	3.78
jonah	2.95	shoppe	3.78
courtney	2.86	flexible	3.73

kidneys	2.86	popping	3.73
coop	2.86	hospitalized	3.73
dew	2.86	byxnumber	3.68
plow	2.86	transcript	3.68
keira	2.86	attempt	3.68
knightley	2.86	radius	3.68
coaches	2.86	criteria	3.68
martinez	2.86	expectancy	3.68
blur	2.86	sightings	3.68
strawberries	2.86	organized	3.63
verification	2.86	miscarriage	3.63
jovovich	2.86	levi	3.63
gellar	2.86	jackman	3.63
pans	2.86	adjust	3.63
cinnamon	2.86	cries	3.63
doug	2.86	appears	3.63
		attacked	3.63

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**Table 4. Search group membership correlated with individual word frequencies.** In this analysis, different forms of the same word were combined (i.e. recipe, recipes). Spearman correlations were calculated and the ten words most correlated with each search group are shown.  $P < 0.0001$  for bolded correlations.

Word	Highest individual word frequencies correlations with gout search group		Word	Highest individual word frequencies correlations with arthritis search group	
	R for gout search group	R for arthritis search group		R for arthritis search group	R for gout search group
food	<b>0.16</b>	<b>0.14</b>	rheumatoid	<b>0.40</b>	<b>-0.12</b>
diet	<b>0.14</b>	<b>0.11</b>	pain	<b>0.29</b>	0.07
symptom	<b>0.13</b>	<b>0.24</b>	disease	<b>0.25</b>	0.06
avoid	<b>0.13</b>	0.04	symptom	<b>0.24</b>	<b>0.13</b>
acid	<b>0.11</b>	<b>0.10</b>	treatment	<b>0.22</b>	<b>0.08</b>
recipe	<b>0.10</b>	<b>0.14</b>	medical	<b>0.21</b>	<b>0.08</b>
county	<b>0.10</b>	<b>0.11</b>	knee	<b>0.20</b>	0.02
map	<b>0.10</b>	0.07	blood	<b>0.20</b>	<b>0.09</b>
lawn	<b>0.10</b>	0.06	cancer	<b>0.20</b>	0.06
eat	<b>0.10</b>	<b>0.14</b>	syndrome	<b>0.20</b>	0.05

## Figure legends

**Figure 1. LIWC analysis for information seeking, and insight, health-related and ingestion words.** Information seeking (WC) is a measure of word count. All other categories represent the % of word count comprising words in that category. Data are shown as mean (95% CI) for the group who did not search for gout or arthritis (Control), the group of participants who searched for arthritis (Arthritis), and the group of participants who searched for gout (Gout). \*\* $P < 0.01$ , \*\*\* $P < 0.001$  compared with general control group, # $P < 0.05$  compared with the group of participants searching for arthritis, ### $P < 0.001$  compared with the group of participants searching for arthritis, using Tukey post hoc test.

**Figure 2. LIWC analysis for social, leisure and sexual words, and emotional time.** Tone is a standardized difference of positive and negative emotion words ranging from 0 to 100. All other categories represent the % of word count comprising words in that category. Data are shown as mean (95% CI) for the group who did not search for gout or arthritis (Control), the group of participants who searched for arthritis (Arthritis), and the group of participants who searched for gout (Gout). \* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$  compared with general control group, using Tukey post hoc test.

