Online queries as a criterion for evaluating epidemiological status and effectiveness of COVID-19 control measures in Russia: results from Yandex.Wordstat analysis

Kuvat Momynaliev, Dimash Khoroshun, Vasiliy Akimkin

ABSTRACT

Objectives Assessment of the significance of online queries regarding smell impairment to evaluate the epidemiological status and effectiveness of COVID-19 epidemic control measures using levofloxacin as an example.

Setting There are 81 regions of Russia and several large cities, such as Moscow, St. Petersburg and Nizhny Novgorod.

Methods Weekly online queries from Yandex Russian users regarding smell impairment and levofloxacin were analysed in regions and large cities of Russia from 16 March 2020 to 21 February 2021.

Results A strong positive direct correlation (r>0.7) was found between the number of smell-related queries in Yandex new cases of COVID-19 in 59 out of 85 Russian regions and large cities (70%). During the ‘first’ peak of COVID-19 incidence in Russia (April–May 2020), the increase in the number of smell-related queries outpaced the increase in new cases by 1–2 weeks in 23 out of 59 regions of Russia. During the ‘second’ peak of COVID-19 incidence in Russia (October–December 2020), the increase in the number of smell-related queries outpaced the increase in new cases by 1–2 weeks in 36 regions of Russia, including Moscow. It was found that the query/new case ratio increased by more than 100% compared with new infection cases during the ‘second’ peak of incidence demonstrated significantly higher search activity related to levofloxacin than the regions where the increase in queries was lower than 100% compared with the increase in new infection cases.

Conclusion The sudden interest in certain symptoms of COVID-19, such as smell impairment and the growing frequency of online queries among the population, can be used as an indicator of the spread of coronavirus infection among the population and for evaluation of the effectiveness of the COVID-19 epidemic control measures.

INTRODUCTION

In recent years, big data analytics have become increasingly integrated into studies conducted in public health informatics, and web data analysis has become a valuable tool for monitoring and population behavioural analysis in terms of health-related content. The term for using data from web-based sources to improve public health is known as ‘infodemiology’, a combination of the words ‘information’ and ‘epidemiology’. Infodemiology and infoveillance studies using different web-based sources, such as Google, Twitter, and other social media platforms, show the importance of real-time access to data when evaluating health status.

On the other hand, during the global COVID-19 pandemic, the scale of public interest in this disease has been unprecedented, suggesting that the trends demonstrated by web search traffic should remain steady and reliable. Changes in smell and taste are prominent symptoms of COVID-19 as has consistently been demonstrated in many countries (eg, Iran, Spain, France, Italy, Germany, and the UK). More critically, these chemosensory changes generally occur earlier than other symptoms and
may constitute more specific symptoms than fever or dry cough. Accordingly, web-based monitoring of changes in smell and taste can provide early and specific information on the spread of COVID-19 in the general population and support health system monitoring to evaluate the effectiveness of epidemic control measures taken by countries against COVID-19.

In a previous study, we demonstrated a strong correlation between the relative search volume (RSV) in Russia when using Google Trends to assess ‘smell’ queries and actual infection cases (r=0.81). The interest in the above queries increased along with the number of new cases from 16 March 2020 to 11 May 2020 and 27 August 2020 to 1 October 2020 (r=0.93 and 0.87, respectively). From 2 April 2020 to 12 April 2020, the increase in queries outpaced the increase in actual COVID-19 cases by 2–5 days. The increase in the smell-related queries ‘outpaced’ the increase in the new infection cases implies that smell-impaired patients tend to study the problem through a web search and only then opt for SARS-CoV-2 testing. We found that starting on 27 August 2020, the smell-related queries outnumbered the detected cases of infection as of 1 October 2020.

Our work aimed to determine the significance of web queries related to smell impairment to evaluate the epidemiological status and effectiveness of COVID-19 epidemic control measures using the example of levofloxacin. In this study, we analysed smell-related queries (hereafter ‘smell queries’) from Yandex Russian users in regions and large cities of Russia from 16 March 2020 to 21 February 2021 (49 weeks) and compared them with new cases of infection. In contrast to Google Trends, the Yandex.Wordstat service provides absolute rather than relative data, thus making it possible to compare queries with actual cases in absolute quantities, for example, coronavirus infection or drug consumption. We assume that certain internet queries such as smell impairment can be markers of the spread of SARS-CoV-2 infection and can be used as a supplementary tool for evaluating the effectiveness of COVID-19 epidemic control measures.

**MATERIALS AND METHODS**

**Study period**

The study period lasted from 16 March 2020 to 21 February 2021 and was broken down into weeks.

**Databases**

The data on new (confirmed) cases reported weekly in regions, and large cities of Russia were obtained from https://стопкоронавирус.рф (https://stopcoronavirus.rf) resources and Yandex and Johns Hopkins University services. The data (when required) were normalised on a scale from 0 to 100 by the maximum number of new (confirmed) cases per week during the study period.

**Databases of search queries**

Yandex.Wordstat is the service providing information about queries made by Yandex users. For example, it helps determine the monthly number of people looking for a certain phrase and find queries similar in meaning to the entered phrase. The Yandex.Wordstat query statistics show how frequently users entered their search-term-containing queries into the search box (the number of impressions). Our study estimated the number of users’ queries in Russia that included the words ‘smell’ and ‘levofloxacin’. According to Yandex, the most popular keyword combinations in which the words ‘smell’ and ‘levofloxacin’ occur are shown in online supplemental table 1.

The data on the web-based smell query were received in absolute weekly values from 16 March 2020–22 March 2020 to 15 February 2021–21 February 2021.

The strength of the relationship between the daily increase in the number of cases of COVID-19 and the number of queries associated with changes in the smell was then tested using Spearman’s rank correlation since it is known that data were not normally distributed. For all correlations, statistical significance was determined.

**Estimated time gaps between queries related to smell and new cases of COVID-19**

For this purpose, weekly queries and new cases of infection were normalised by the maximum number of queries and a maximum number of new cases of infection per week over the entire observation period, respectively. Then, we estimated the weekly increase in queries and new cases of infection by finding the difference between the number of queries (new cases of infection) per week and the number of queries (new cases of infection) during the previous week. The increase or decrease was considered significant if it was more than 2% and if the subsequent dataset had an upward or a downward trend. The analysis included only the regions that demonstrated a significant correlation (r>0.5) between smell-related queries and confirmed cases of infection.

**Patient and public involvement**

This research was done without patient and public involvement.

**RESULTS**

**Dynamics of smell-related queries in the studied regions**

Figure 1 and online supplemental movie 1 show changes in smell-related web queries from the 12th week of 2020 (16 March 2020 to 22 March 2020) to the 7th week of 2021 (15 February 2021 to 21 February 2021) (the total observation period consists of 49 weeks) in regions and large cities of Russia (85 regions). The maximum number of smell-related queries was recorded in most of the regions during the pandemic’s second wave in October to November, for example, in the Ivanovo, Kaluga, Moscow and Ryazan regions from 2 November 2020 to 8
November 2020 and in Moscow from 23 November 2020 to 29 November 2020. The highest activity was observed during the first wave in several regions, including Dagestan, Ingushetia, and North Ossetia from 27 April 2020 to 3 May 2020, Chechnya from 11 May 2020 to 17 May 2020 and Tyva from 22 June 2020 to 28 June 2020.

As expected, the number of queries strongly correlates ($r>0.99$) with the population in the respective areas. When the smell-related queries (online supplemental table 2) were normalised, the largest number of queries per population was found in Moscow (0.11 queries/person), St. Petersburg (0.10 queries/person), Nizhny Novgorod (0.09 queries/person), Moscow, Novosibirsk, and Sverdlovsk regions (0.08 queries/person). At the same time, Moscow, the Magadan Region, and the Altai Republic had the highest coronavirus infection incidence per person (>0.08). The smallest number of queries/person (0.01) was found in the Chechen Republic, the Republic of Ingushetia, and the Republic of Dagestan.

The obtained data can imply specific behavioural patterns typical of populations in different regions of Russia during the coronavirus infection pandemic in terms of information search regarding one of the COVID-19 symptoms: smell impairment.

**Correlations between the number of queries and new COVID-19 cases**

We analysed correlations between the number of queries and new COVID-19 cases in regions and large cities of Russia (online supplemental table 3, figure 2). The presented data show that Moscow was characterised by a very high correlation between queries and new cases. 

![Figure 1](https://example.com/figure1.png) 

**Figure 1** Heat map of changes in the number of smell-related queries when using the Yandex search engine from the 12th week of 2020 (16 March 2020–22 March 2020) to the seventh week of 2021 (15 February 2021–21 February 2021) in Russia.
of infection ($r=0.96$). The average ($0.5<r<0.7$) correlation between smell-related queries and new COVID-19 cases was detected for 25 regions ($p<0.05$). Thirty-three regions of Russia, including St. Petersburg, demonstrated a strong correlation ($0.7<r<0.9$) between the number of smell-related queries and new COVID-19 cases in the studied regions ($p<0.05$). For 26 regions, the correlation coefficient was less than 0.5 or $p>0.05$. Thus, in total, 70% of the regions and large cities of Russia (59 out of 85 regions) demonstrated a significantly strong correlation ($r>0.7$) between smell-related queries and confirmed COVID-19 cases; these data suggest a strong relationship between the information search for one of the COVID-19 symptoms, smell impairment, and the confirmed cases of coronavirus infection.

The increase/decrease in the number of smell-related online queries precedes the increase/decrease in the number of new COVID-19 cases

We attempted to estimate the time gap between the online search of smell-related information by population and new cases of coronavirus infection in different regions of Russia. For example, see figure 3; the number of smell-related queries and the number of new cases of infection before and after the data were normalised for Moscow and the Moscow and Vladimir Regions as a visual illustration of the obtained data.

The analysis results are shown in table 1 and online supplemental table 4. During the first peak of coronavirus infection incidence in Russia, smell-related queries outpaced the increase in the number of new cases of infection by 1–2 weeks in 23 out of 59 regions of Russia. Such a relationship was not observed for the other regions.

During the second peak of coronavirus infection incidence in Russia, the increase in the number of smell-related queries outpaced the increase in the number of new cases of infection by 1–2 weeks in 36 regions of Russia, including Moscow. In 14 regions, queries outnumbered new cases of infection, and they were ahead by more than 2 weeks. Two regions of Russia did not demonstrate such patterns during the first and second waves.

**Relationship between queries and new infection cases as a supplementary tool for the evaluation of the effectiveness of COVID-19 epidemic control measures**

Since the Yandex.Wordstat provides queries in absolute rather than relative numbers, we estimated the increase in the number of queries during the second peak of coronavirus infection incidence as the effectiveness indicator for COVID-19 epidemic control measures in regions of Russia. For this purpose, we compared the relationships between smell-related queries and new COVID-19 cases between two periods: when the number of new infections in the studied regions was minimal for several weeks (the plateau period from 6 July 2020 (28th week)–12 July 2020 to 14 September 2020–20 September 2020 (38th week)) and when the number of infections had an upward trend, rising to the maximum number (the peak period from 21 September 2020–27 September 2020 (39th week) to 30 November 2020–6 December 2020 (49th week)).
Figure 4 and table 2 show the results of the query/new infection case ratio calculation for 45 regions between the peak and plateau periods. The obtained data show that, except for Moscow, St. Petersburg, and the Tver Region, the ratio of queries to the number of new cases of infection increased during the second peak of coronavirus infection incidence compared with the plateau period; in 24 regions, the increase in queries was more than 100%.

Furthermore, in these regions, we assessed the popularity of queries related to levofloxacin, an antibiotic mentioned in the Ministry of Health of Russia guidelines as an agent administered to treat bacterial infections in patients with COVID-19 (online supplemental table 5). We can point out two groups where the ratio of levofloxacin-related queries to the total number of new cases of infection was less than one or larger than one. The first group includes Moscow and St. Petersburg, where the ratio of queries to the number of new cases of infection decreased during the peak period compared with the plateau period.

No significant relationship was found between the increase in smell-related queries during the peak period with the cut-off point set at 100% and the increase in levofloxacin-related queries compared with the number of new cases of infection (p=0.1690). However, when the cut-off point was set at 160%, a significant relationship (p=0.0216) was found between the increase in smell-related queries during the peak period and the increase in levofloxacin-related search activity. In other words, in the regions where the increase in queries compared with the number of new cases of infection during the second peak of coronavirus infection incidence increased by more than 160%, the levofloxacin-related search activity was significantly higher than in regions where the number of queries increased by less than 160% compared with the number of new cases of infection.
DISCUSSION

In response to the pandemic, numerous studies have attempted to identify the causes and symptoms of COVID-19 disease. The cumulative estimate for the prevalence of loss of smell was 77% when assessed using objective measures (95% CI 61.4% to 89.2%) and 44% when measured by subjective measures (95% CI 32.2% to 57.0%).20 21

Our study demonstrated a strong correlation (r>0.7) between the number of smell-related queries in Yandex and new COVID-19 cases in 59 regions and 85 large cities of Russia (70%). The obtained results are consistent with our previous data that revealed a strong correlation between smell queries and new infection cases (r=0.81) in Russia using Google Trends.18 Higgins et al22 also pointed out that worldwide search queries related to shortness of breath, anosmia, dysgeusia and ageusia, headache, chest pain, and sneezing had a strong correlation (r>0.60; p<0.001) both with daily new confirmed cases and with the number of deaths caused by COVID-19. Similar results were obtained by Walker et al19 who found a strong correlation between daily RSV associated with loss of smell, the daily increase in COVID-19 cases, and deaths ranging from 0.633 to 0.952 (p<0.05) in several countries.

In addition, the obtained data showed that during the first peak of the coronavirus infection incidence in Russia, the increase in smell-related queries outpaced the increase in new infection cases by 1–2 weeks in 23 out of 59 regions. During the second peak of the coronavirus infection incidence in Russia, the increase in the number of smell-related queries outpaced the increase in new infection cases by 1–2 weeks in 36 regions of Russia, including Moscow. In 14 regions, the increase in queries

| Region of Russian Federation | 13–22 weeks | 34–40 weeks |
|-----------------------------|-------------|-------------|
| Altai Territory             | 1           |             |
| Amursk Region               | 1           |             |
| Arkhangelsk Region          | 1           | 1           |
| Bryansk Region              |             |             |
| Vladimir Region             | 2           | 2           |
| Volgograd Region            | 2           | 3           |
| Voronezh Region             | 1           | 3           |
| Ivanovo Region              | 2           |             |
| Kaliningrad Region          | 1           |             |
| Kaluga Region               | 2           |             |
| Karachay-Cherkess Republic  | 2           |             |
| Kemerovo Territory          | 1           |             |
| Kirov Region                | 3           |             |
| Kostroma Region             | 3           |             |
| Krasnodar Territory         | 1           | 3           |
| Krasnoyarsk Territory       | 1           | 2           |
| Republic of Crimea          |             |             |
| Kurgan Region               | 1           |             |
| Kursk Region                | 1           |             |
| Leningrad Region            | 1           |             |
| Magadan Region              | 1           |             |
| Moscow                      | 1           | 2           |
| Moscow Region               | 5           | 4           |
| Murmansk Region             | 2           |             |
| Nenets Autonomous District  | 2           | 2           |
| Nizhny Novgorod Region      | 1           |             |
| Novgorod Region             | 3           |             |
| Novosibirsk Region          | 1           |             |
| Omsk Region                 | 2           |             |
| Orenburg Region             | 1           |             |
| Oryol Region                | 1           |             |
| Penza Region                | 4           |             |
| Primorsky Territory         | 4           |             |
| Republic of Altai           | 1           |             |
| Republic of Kalmykia        |             |             |
| Republic of Karelia         | 2           |             |
| Mari El Republic            | 1           |             |
| Republic of Mordovia        | 1           |             |
| Republic of Sakha (Yakutia) | 2           | 2           |
| Republic of North Ossetia-Alania | 2     | 6           |
| Republic of Tyva            | 5           | 2           |
| Rostov Region               | 1           |             |
| Ryazan Region               | 2           |             |

Table 1

| Region of Russian Federation | 13–22 weeks | 34–40 weeks |
|-----------------------------|-------------|-------------|
| St. Petersburg              | 2           | 4           |
| Saratov Region              | 1           |             |
| Sakhalin Region             | 3           |             |
| Sverdlovsk Region           | 5           |             |
| Sevastopol                  | 1           | 2           |
| Smolensk Region             | 2           |             |
| Stavropol Territory         | 2           |             |
| Tambov Region               | 1           |             |
| Tver Region                 | 8           | 8           |
| Tomsk Region                | 2           |             |
| Tula Region                 | 1           | 1           |
| Ulyanovsk Region            | 2           |             |
| Khanty-Mansi Autonomous Area| 1           |             |
| Chuvash Republic            | 1           |             |
| Yamal-Nenets Autonomous District | 1    |             |
| Yaroslavl Region            | 1           |             |

Table 1 Continued
outpaced the increase in new infection cases by more than 2 weeks. A previous study also showed the time interval between the onset of COVID-19-associated symptoms and their actual detection.23

An important question raised in our study is whether the smell-related queries are primarily attributed to the queries from users with COVID-19 or they can be explained by other time-related reasons, such as seasonal diseases, allergies, or an infodemic (a rapid spread of information) when users who do not experience COVID-19 symptoms, including loss of smell, try to find more information about the disease.22 23
Table 2  The ratio of smell-related queries to new cases of COVID-19 between two periods of plateau and peak

| Region of Russian Federation | Queries/cases (total) | Queries/cases (plateau) | Queries/ cases (peak) | Peak/plateau |
|------------------------------|-----------------------|-------------------------|-----------------------|--------------|
| Moscow                       | 1.7±0.6               | 2.4±0.3                 | 1.5±0.3               | 63%          |
| St. Petersburg               | 3±1.8                 | 3±0.8                   | 2.9±1.4               | 97%          |
| Tver Region                  | 2.9±1.8               | 2.5±0.4                 | 2.5±0.3               | 100%         |
| Republic of North Ossetia-Alania | 1.6±0.8         | 1.8±0.9                 | 2±0.7                 | 111%         |
| Leningrad Region             | 3.2±1.8               | 2.5±0.5                 | 3±0.5                 | 120%         |
| Arkhangelsk Region           | 1.8±0.7               | 1.6±0.4                 | 2±0.4                 | 125%         |
| Novgorod Region              | 1.4±0.7               | 1.3±0.4                 | 1.8±0.3               | 138%         |
| Kaliningrad Region           | 1.6±1                 | 1.6±0.3                 | 2.4±0.8               | 150%         |
| Mari El Republic             | 2.4±1.1               | 2.6±0.4                 | 3.9±0.8               | 150%         |
| Altai Territory              | 16.8±55.9             | 5.1±1.3                 | 7.7±4                 | 151%         |
| Stavropol Territory          | 2.6±1.6               | 1.9±0.3                 | 2.9±0.6               | 153%         |
| Moscow Region                | 3.6±1.8               | 3.9±0.8                 | 6±1.4                 | 154%         |
| Nenets Autonomous District   | 3.4±5.4               | 2.2±3.4                 | 3.4±1.2               | 155%         |
| Smolensk Region              | 2.4±1.2               | 2.2±0.9                 | 3.6±0.5               | 164%         |
| Bryansk Region               | 2.5±1.2               | 2.4±0.7                 | 4±0.6                 | 167%         |
| Vladimir Region              | 4±1.7                 | 3.5±0.8                 | 6±0.6                 | 171%         |
| Ryazan Region                | 2.9±1.2               | 2.3±0.5                 | 4.1±0.6               | 178%         |
| Nizhny Novgorod Region       | 3.2±1.5               | 3±0.6                   | 5.4±0.7               | 180%         |
| Krasnodar Territory          | 7.5±4.1               | 6.8±1.5                 | 12.3±1.9              | 181%         |
| Penza Region                 | 2.7±1.6               | 2.1±0.4                 | 3.8±1                 | 181%         |
| Chuvash Republic             | 3.2±1.6               | 2.6±0.5                 | 5±1.3                 | 192%         |
| Ulyanovsk Region             | 1.8±1.2               | 1.3±0.3                 | 2.6±0.7               | 200%         |
| Kirov Region                 | 2.2±1.5               | 1.9±0.7                 | 3.9±1.9               | 205%         |
| Kaluga Region                | 2.3±1.1               | 1.8±0.5                 | 3.8±0.9               | 211%         |
| Volgograd Region             | 3±2.9                 | 2.3±0.6                 | 4.9±1.9               | 213%         |
| Kostroma Region              | 2.0±1.3               | 1.3±0.6                 | 2.8±0.8               | 215%         |
| Tambov Region                | 2.5±1.4               | 2±0.5                   | 4.4±1.3               | 220%         |
| Oryol Region                 | 1.7±0.9               | 1.3±0.3                 | 2.9±0.4               | 223%         |
| Tula Region                  | 3.3±1.7               | 2.6±0.8                 | 5.9±0.9               | 227%         |
| Yaroslavl Region             | 2.9±1.6               | 2.2±0.5                 | 5.1±1.1               | 232%         |
| Ivanovo Region               | 2±1.3                 | 1.5±0.4                 | 3.5±0.8               | 233%         |
| Kursk Region                 | 10.3±15.5             | 2.4±1                   | 5.6±1.6               | 233%         |
| Khanty-Mansi Autonomous Area | 2.1±1.6               | 1.2±0.4                 | 2.9±1.1               | 242%         |
| Saratov Region               | 3.2±2.8               | 2.2±0.4                 | 5.5±2.1               | 250%         |
| Kemerovo Territory           | 6.4±11.1              | 2.3±0.6                 | 5.8±2.8               | 252%         |
| Orenburg Region              | 2.7±2.1               | 2.8±0.8                 | 5.1±2.5               | 255%         |
| Amur Region                  | 1.9±2.6               | 0.9±0.3                 | 2.3±0.6               | 256%         |
| Voronezh Region              | 2.7±2.2               | 1.6±0.6                 | 4.1±1.8               | 256%         |
| Primorsky Territory          | 1.9±1.7               | 1.2±0.4                 | 3.1±0.7               | 258%         |
| Sverdlovsk Region            | 5.4±6.6               | 3.2±0.9                 | 8.6±2                 | 269%         |
| Tomsk Region                 | 1.6±2.1               | 0.7±0.2                 | 1.9±0.6               | 271%         |
| Republic of Mordovia          | 2.8±1.4               | 1.6±0.3                 | 4.4±1.2               | 275%         |

When analysing the Yandex.Wordstat data, we did not observe such peaks in queries related to smell impairment during the respective period in previous years. The assumption that symptom-free occasional users are interested in COVID-19 symptoms can be challenged by several arguments. For example, a comparative study conducted in Israel24 showed that patients suspected of having COVID-19 and having positive COVID-19 results (68%) demonstrated changes in smell almost 10 times as frequently as patients with negative COVID-19 (8%) results. Our study did not detect any increase in queries compared with new cases of infection during the second wave of infection in Moscow, St. Petersburg, and the Tver Region, the total population of which accounts for 50% of the population of 24 regions; there was a 100%–250% increase in the number of queries compared with the number of new cases of infection. In addition, for Moscow, the ratio of queries to new cases of infection decreased from 2.4±0.3 to 1.5±0.3, while for St. Petersburg and the Tver Region, the ratio of queries to new cases of infection remained unchanged. Moreover, from 16 November 2020–22 November 2020 to 25 January 2021–31 January 2021, in Moscow, the number of queries exceeded the number of new cases of infection by only 10%–20% (figure 3). Therefore, it is quite probable that smell-related queries are generated by people suffering from loss of smell, which is primarily associated with COVID-19.

The existing difference (100%–250%) between the number of queries and confirmed COVID-19 cases during the second peak of coronavirus infection incidence can be explained by the fact that some of the users who suffered from loss of smell and who searched the internet for information did not see a doctor in healthcare facilities. In this case, patients can opt for self-treatment and look for information about methods of treatment of coronavirus infection. One of these antibiotics is levofloxacin, which was mentioned in the Ministry of Health of Russia guidelines as an agent to treat bacterial infections in patients with COVID-19. A shortage of this antibiotic was reported in the Ministry of Health of Russia guide-
with the number of new cases of infection during the second wave, the levofloxacin-related search activity was also significantly higher than in regions where the number of queries increased by less than 160% compared with the number of new cases of infection.

Our study shows the analysis of search queries in Yandex.Wordstat confirms the timewise relationship: internet users first look for information about their initial COVID-19 symptoms (smell impairment) and then confirm their disease. The presented data demonstrate that the increase (decrease) in the number of smell-related queries precedes the increase (decrease) in the number of infections by several weeks. Therefore, the ratio of queries to new cases of infection can be used to estimate the actual number of patients with recent coronavirus infections. For example, from 16 November 2020–22 November 2020 to 25 January 2021–31 January 2021, the queries in Moscow outnumbered the new infections by only 10%–20%. This suggests an effective policy targeted at COVID-19 epidemic control measures in Moscow when all the people affected by COVID-19 were detected promptly.

It should be noted that our results should be interpreted with caution due to many limitations. First, the design of our study does not allow us to conclude at the individual patient level. The increase in the number of queries may, at least in part, be due to an increase in the presence of related topics in the media and not to individual situations. In addition, looking for symptoms may be related to more than just COVID-19. However, given the high prevalence of COVID-19 in Russia and the significant correlation with confirmed cases of COVID-19, it is reasonable to assume that the increase in related searches is due to COVID-19. Although we tried to select terms that would cover the largest percentage of related terms, this could reduce the specificity of the search. For example, the search topic is ‘levofloxacin’ and not ‘levofloxacin in the treatment of COVID-19’ or ‘how to use levofloxacin in COVID-19 complications’. Like this, we can cover all intended search queries with high sensitivity; although this reduces the specificity of the search since queries related to the use of levofloxacin in urological diseases will also fall into the statistics, for example, ‘fourth generation fluoroquinolones in urology’ or ‘urological antibiotics for men’, as follows from the analysis of search queries.

CONCLUSION

We assume that the increase in the sudden interest in some symptoms of COVID-19, such as smell impairment, can be used as a valuable, minimally invasive indicator of coronavirus spread among populations and a tool for evaluating the effectiveness of COVID-19 epidemic control measures.

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ORCID iD

Kuvat Momynaliev http://orcid.org/0000-0003-4656-1025

REFERENCES

1. Eysenbach G. Infodemiology and infoveillance: framework for an emerging set of public health informatics methods to analyze search, communication and publication behavior on the Internet. J Med Internet Res 2009;11:e11.
2. Mollena L, Harmsen IA, Broekhuizen E, et al. Disease detection or public opinion reflection? Content analysis of tweets, other social media, and online newspapers during the measles outbreak in the Netherlands in 2013. J Med Internet Res 2015;17:e128.
3. Chen Y, Zhang Y, Xu Z, et al. Avian influenza A (H7N9) and related Internet search query data in China. Sci Rep 2019;9:10434.
4. Nurul Azmawati M, Hariz MS, Mohd Dzulkhairi MR. Attitude and practice on bats-borne diseases among village residents: a pilot study. Med & Health 2018;13:48–57.
5. Zeraatkhar K, Ahmadi M. Trends of infodemiology studies: a scoping review. Health Info Libr J 2018;35:91–120.
6. Tang L, Bie B, Park S-E, et al. Social media and outbreaks of emerging infectious diseases: a systematic review of literature. Am J Infect Control 2018;46:962–72.
7. Eysenbach G. SARS and population health technology. J Med Internet Res 2003;5:e14.
8. Menni C, Valdes AM, Freidin MB, et al. Real-time tracking of self-reported symptoms to predict potential COVID-19. Nat Med 2020;26:1037–40.
9. Eliezer M, Hautefort C, Hamel A-L, et al. Sudden and complete olfactory loss of function as a possible symptom of COVID-19. Jama Otolaryngol Head Neck Surg 2020;146:674–5.
10. Gautier J-F, Ravussin Y. A new symptom of COVID-19: loss of taste and smell. Obesity 2020;28:848.
11. Pellegrino R, Cooper KW, Di Pizio A, et al. Coronaviruses and the chemical senses: past, present, and future. Chem Senses 2020;45:415–22.
12 Bagheri SH, Asghari A, Farhadi M, et al. Coincidence of COVID-19 epidemic and olfactory dysfunction outbreak in Iran. Med J Islam Repub Iran 2020;34:446–52.

13 Beltrán-Corbellini Á, Chico-García JL, Martinez-Poles J, et al. Acute-onset smell and taste disorders in the context of COVID-19: a pilot multicentre polymerase chain reaction based case-control study. Eur J Neurol 2020;27:1738–41.

14 Bénédicte F, Le Turnier P, Declerck C, et al. Utility of hyposmia and hypogeusia for the diagnosis of COVID-19. Lancet Infect Dis 2020;20:1014–5.

15 Giacomelli A, Pezzati L, Conti F. Self-reported olfactory and taste disorders in SARS-CoV-2 patients: a cross-sectional study. Clin Infect Dis 2020;71:889–90.

16 Haehner A, Draf J, Dräger S, et al. Predictive value of sudden olfactory loss in the diagnosis of COVID-19. J Otorhinolaryngol Relat Spec 2020;82:175–80.

17 Yan CH, Faraji F, Prajapati DP, et al. Self-reported olfactory loss associates with outpatient clinical course in COVID-19. Int Forum Allergy Rhinol 2020;10:821–31.

18 Momynaliev KT, Akimkin VG. Analysis of Google trends queries in Russia during the coronavirus infection pandemic as a tool for epidemiological surveillance. Epidemiologiya i infektsionnye bolezni Aktual'nye voprosy 2020;10:33–7.

19 Walker A, Hopkins C, Surda P. Use of Google trends to investigate loss-of-smell-related searches during the COVID-19 outbreak. Int Forum Allergy Rhinol 2020;10:839–47.

20 Hannum ME, Ramirez VA, Lipson SJ, et al. Objective sensory testing methods reveal a higher prevalence of olfactory loss in COVID-19–positive patients compared to subjective methods: a systematic review and meta-analysis. Chem Senses 2020;45:865–74.

21 Pang KW, Chee J, Subramaniam S, et al. Frequency and clinical utility of olfactory dysfunction in COVID-19: a systematic review and meta-analysis. Curr Allergy Asthma Rep 2020;20:76.

22 Higgins TS, Wu AW, Sharma D, et al. Correlations of online search engine trends with coronavirus disease (COVID-19) incidence: Infodemiology study. JMIR Public Health Surveill 2020;6:e19702.

23 Pierron D, Pereda-Loth V, Mantel M, et al. Smell and taste changes are early indicators of the COVID-19 pandemic and political decision effectiveness. Nat Commun 2020;11:5152.

24 Karni N, Klein H, Asseo K, et al. Self-rated smell ability enables highly specific predictors of COVID-19 status: a case-control study in Israel. Open Forum Infect Dis 2021;8:eofaa389.

25 Ahmad S, Sohail A, Shahid Chishti MA, et al. How common are taste and smell abnormalities in COVID-19? A systematic review and meta-analysis. J Taibah Univ Med Sci 2022;17:174–85.