Use of Google Trends to investigate loss-of-smell–related searches during the COVID-19 outbreak

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Background: **Initial reports describing coronavirus 2019 (COVID-19) were dominated by the presence of cough, breathlessness, and fever; anecdotal reports suggested anosmia may also be a manifestation. We used Google Trends (GT) to investigate whether there was a surge in individuals searching for information related to smell loss during the COVID-19 epidemic in Italy, Spain, the United Kingdom, the United States, Germany, France, Iran, and The Netherlands.**

Methods: **GT was used to explore internet activity related to loss of smell in the 8 aforementioned countries. Spearman rank analysis was performed to correlate loss-of-smell–relative search volumes (RSVs), with the increases of daily confirmed cases of COVID-19 and deaths attributed to disease. As a control event, we also performed analysis of smell-related searches during the last UK influenza epidemic of 2009.**

Results: **In all 8 countries, we observed strong correlations between daily RSVs related to loss of smell, increases of daily COVID-19$^+$ cases and deaths ranging from 0.633 to 0.952. All correlations were statistically significant ($p < 0.05$).**

Conclusion: **There is a strong correlation between the frequency of searches for smell-related information and the onset of COVID-19 infection in Italy, Spain, UK, USA, Germany, France, Iran, and The Netherlands. We hypothesize this may relate to a previously underrecognized symptom.** © 2020 ARS-AAOA, LLC.

Key Words:
coronavirus; COVID-19; Google Trends; loss of smell; symptom variation

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Health-care systems across the world have been strained to the limit by coronavirus. Emanating from Hubei Province, coronavirus 2019 (COVID-19) has spread globally with devastating consequences. Public health responses have been hamstrung by the limited information available on the typical presentation and symptomology of the virus; each new piece of information must be fitted into a jigsaw puzzle when we cannot see the larger picture.

One of the first articles published from the COVID-19 outbreak described the neurologic sequelae of infection.[1] The authors performed a retrospective case review of 214 patients admitted to the hospital in Wuhan and found that 6% had "hyposmia" charted as a symptom at admission. Given that hyposmia is an item often overlooked during standard medical history-taking, this is not an insignificant proportion of patients who volunteered the change in smell perception as a symptom. However, initial reports were dominated by the more dramatic symptoms of fever, cough, and breathlessness, and these symptoms remain the guidance for the UK government advice calling for prompt self-isolation.[2]

However, as cases became more prevalent worldwide, there were anecdotal reports of social media chatter regarding a sudden increase in anosmia in otherwise well patients. Rhinologists reported seeing a sudden increase in anosmic patients without nasal blockage, runny nose, fever, cough, or any other symptoms that would be used to justify self-isolation. The coincidental timing with the COVID-19 pandemic leads naturally to a hypothesis: Could a loss in sense of smell be a symptom of coronavirus infection?

A fast-moving pandemic requires equally agile research techniques using real-time data collection. The power of Google Trends (GT) as an epidemiologic surveillance tool has been demonstrated in previous studies of influenza,[3] and specifically in rhinology.[4] We sought to harness GT to

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investigate trends in searches regarding smell and anosmia and to track these search engine terms against the coronavirus outbreak in Italy, Spain, the United Kingdom (UK), the United States (USA), Germany, France, Iran, and The Netherlands.

Materials and methods

GT, an online tracking system of internet hit-search volumes that recently merged with its sister project, Google Insights for Search (Google, Inc), was used to explore internet activity related to the COVID-19 epidemic. The portal determines the proportion of searches for user-specified terms among all searches performed using Google. It then provides a relative search volume (RSV), which is the query share of a particular term for a given location and time period, normalized by the highest query share of that term over the time series and presented on a scale from 0 to 100. Each point of the graph generated by GT is divided by the highest point, which is conventionally set at 100.

The following terms were used: "smell," "loss of smell," "anosmia," "hyposmia," "olfaction," "taste," "loss of taste," and "dysguesia" (disease, topic, and term). This process was repeated with manual translation of those search terms into Spanish, Italian, Persian, German, French, and Dutch. In Spanish, the term "olfato" was the primary term used, in Italian "olfatto," in Persian "بویایی," in German "Geruchsverlust," in French "anosmie," and in Dutch "reuk." GT automatically translates disease and topic searches, and thus the process was repeated with "anosmia," "hyposmia," and "dysgeusia." In the UK, German, and USA, the search term "loss of smell" demonstrated the most responsive variation in the specified study time. By comparison, the manual translation of the simple term "smell" into Spanish, Dutch, Persian, and Italian (respectively "olfato," "بویایی," "reuk," and "olfatto") offered better results than the translations of "loss of smell." Thus, "olfato," "بویایی," "reuk," and "olfatto" were selected for further analysis only in Spain, The Netherlands, Iran, and Italy. Unfortunately, it was not possible to analyze search trends from China due to restrictions in the country that limit access.[5]

Estimations of the incidence of coronavirus has been hampered by limited availability and reliability of testing. This has led to concerns that confirmed case numbers vastly underestimate the reservoir of disease present in a population. Testing has generally been reserved for the most severe cases, and, as such, we also used deaths confirmed secondary to coronavirus as a proxy for disease prevalence within a country and plotted the frequency of smell-related search terms to the number of coronavirus deaths in each country. Information regarding coronavirus cases and deaths for Italy, Spain, UK, USA, Germany, France, Iran, and The Netherlands was gathered from official government documentation and the US Centers for Disease Control & Prevention website.[6-9]

We examined smell-related search terms from December 1, 2019 to March 25, 2020 for the terms identified earlier in Italy, Spain, UK, USA, Germany, France, Iran, and The Netherlands. We then plotted the trajectories of these search term trends against the number of cases and deaths related to coronavirus identified in each country. The data were examined graphically and then tested formally by Kolgomorov-Smirnov test. This confirmed the data were not normally distributed, and therefore the Spearman rank correlation was used to test the strength of the association between the RSVs for loss of smell and the number of cases of coronavirus and the number of deaths attributed to coronavirus in Spain, Italy, and UK. GT also demonstrates RSVs by location and can offer data at a regional level. To illustrate the utility of this function, we chose Spain as the test country due to its rapidly increasing number of cases. We then plotted the number of smell-related search terms by region in Spain.

To our knowledge, the first formal note of anosmia as a likely symptom of COVID-19 was the British Rhinologic Society (BRS) report by on of the present authors (C.H., March 20, 2020).[10] To investigate this potential confounding effect of publicity, we restricted our GT analysis to the time period ending March 19 and retested the relationship in the UK, Spain, and Italy.[11]

We sought to determine dates of statistically significant increase in RSV linear trends before the COVID-19 outbreak. We analyzed a period between January 1 and January 25, March 2020, and plotted the trajectory of RSVs for each country. We performed the linear regression and found no statistically significant trend between February 1 and March 1, 2020 for Italy, Spain, UK, USA, Germany, France, and The Netherlands. In case of Iran, we found no statistically significant trend between January 1 and February 1, 2020. We identified means from this period and set the 95% confidence level (upper bound) as the threshold for a significant trend.

Subsequently, we analyzed following period ending on March 25 per country and identified the day when RSV trajectory gained a significant trend. Significance was confirmed by linear regression.

We sought to test our hypothesis using the last recorded epidemic in the UK, caused by the swine flu by H1N1 in 2009. There is no reported association between anosmia and H1N1 and, as such, we sought to use this epidemic as a control to the current coronavirus pandemic. We analyzed a period between April 27 and July 3, 2009, when the Health Protection Agency announced that a containment approach to reduce spread was no longer appropriate, and would be replaced by a treatment phase in which everyone presenting symptoms would be treated, if necessary without laboratory confirmation. Daily reports of confirmed cases are no longer being published.[12,13]

Moreover, because several studies have shown that postviral olfactory loss occurs in general peaks in March, we analyzed a matching period (Italy, Spain, and UK) in 2019 and performed a correlation analysis.[14-16]

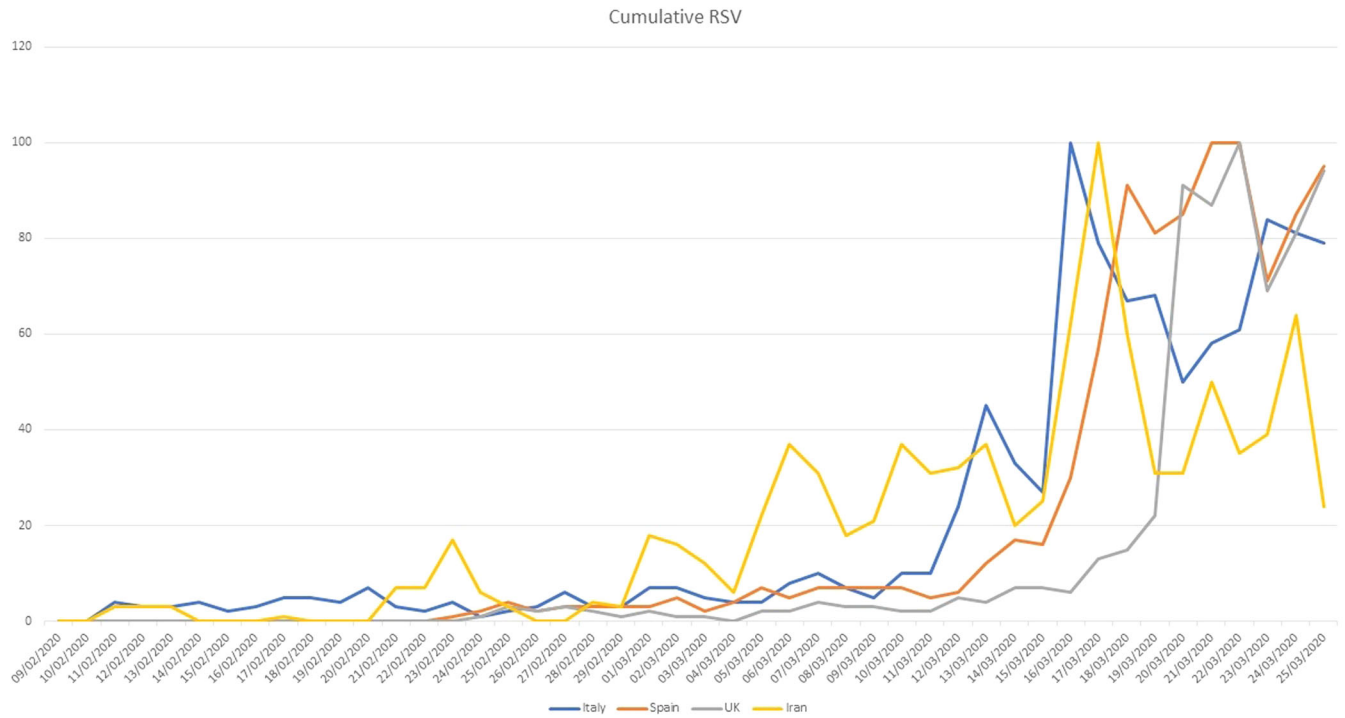

FIGURE 1. Cumulative trends of RSVs in Italy, Spain, and UK between February 3 and March 25, 2020. COVID-19 = coronavirus 2019; RSV = relative search volume.

Computation was done using SPSS version 21.0.0 (IBM Corp, Armonk, NY).

Results

Using the search terms appropriate for each country, trajectories for the frequency of smell-related search items were examined from February 1 to March 25, 2020. From January 1 until January 31, the frequency of smell-related search terms did not deviate significantly from the baseline values for each country. Figure 1 shows cumulative RSVs between February 3 and March 25, 2020.

We therefore narrowed our analysis to the 10-day time period specifically preceding the first coronavirus death within each country: March 5 in the UK; February 21 in Italy; March 4 in Spain; February 29 in the USA; March 9 in Germany; February 25 in France; February 19 in Iran; and March 6 in The Netherlands. Dates of statistically significant increases in RSV linear trends were identified as March 7 in Italy, March 13 in Spain, March 13 in the UK, February 24 in Iran, March 18 in the USA, March 15 in Germany, March 17 in France, and March 19 in The Netherlands. The trajectories representing daily increases in cases, deaths, and RSVs for each country in these time frames are illustrated in Figure 2.

The strengths of the associations between daily increase of cases, deaths, and RSVs were then tested using the Spearman rank correlation. We observed strong correlations ranging from 0.633 to 0.952. All correlations were statistically significant ($p < 0.001$) (Table 1).

Next, we investigated the potential confounding effect of the BRS statement. Spearman rank correlation analysis for daily increase of cases, deaths, and RSVs was restricted to the time period ending on March 19. Analysis again showed strong correlations for Spain, Italy, and the UK, ranging from 0.836 to 0.936 ($p < 0.001$), and no difference when compared with correlations of the 10-day time period preceding the first coronavirus death within each country to March 25, 2020.

We then tested the correlation of smell-related search terms with a previous epidemic of swine flu secondary to H1N1 between April 27 and July 3, 2009. This relationship is illustrated in Figure 3. No correlation was observed between daily increase of $H1N1^+$ cases and RSVs. We also compared RSVs of the current COVID-19 outbreak with a matching period in 2019 for each country. We did not observe a similar trend and no correlation was identified (Fig. 4).

Finally, to assess GT output offering "hotspots" of search items at the regional level, we identified the region of Spain with the highest frequency of smell-related search items and retested the relationship. Spearman correlation analysis between daily increase of COVID-19^+ cases and RSV on a single day (March 20, 2020) revealed a strong correlation (0.91, $p < 0.001$). These data are presented in Figure 5.

Discussion

These data illustrate a clear correlation between the use of search terms regarding "smell" and the number of

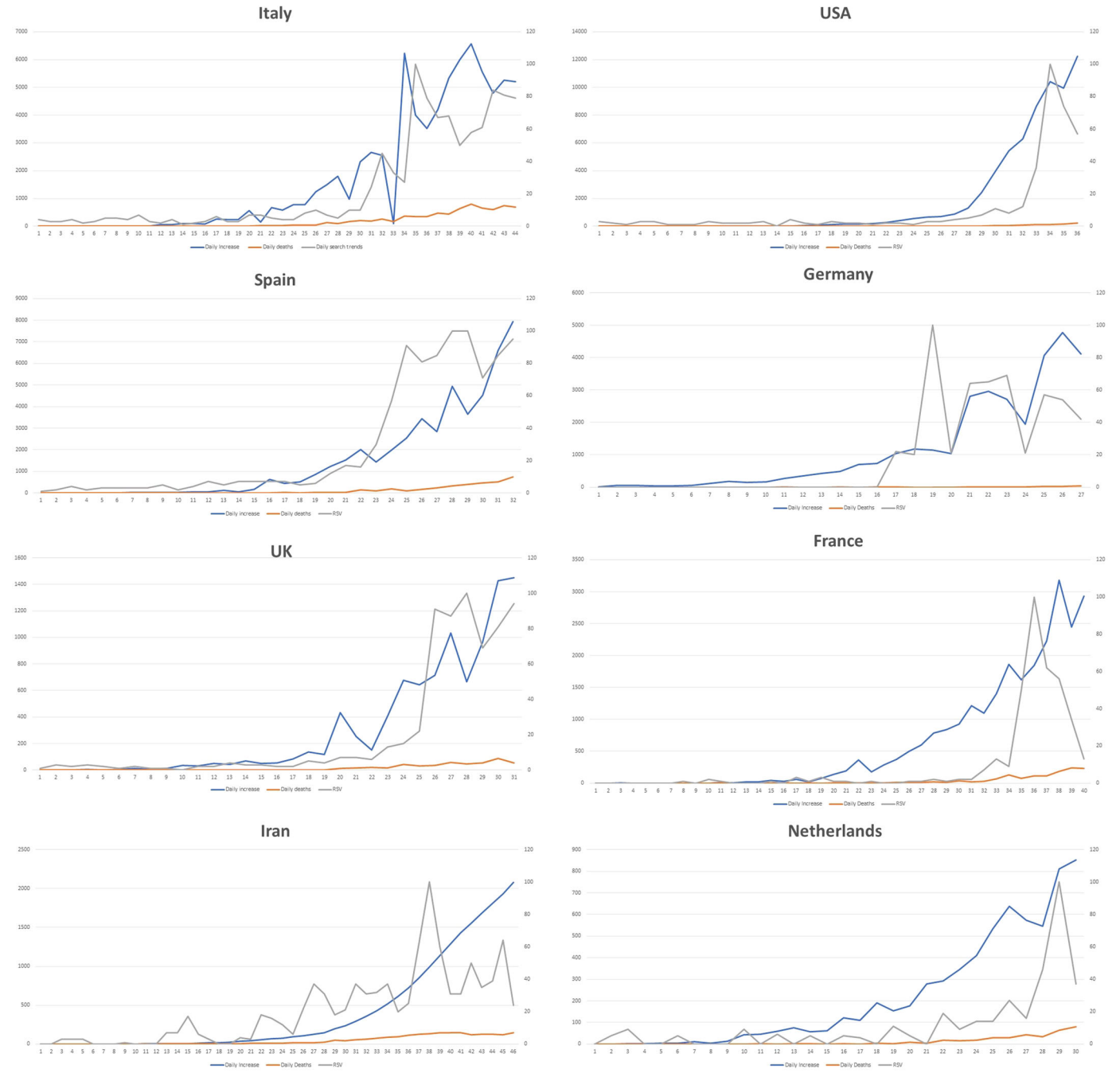

FIGURE 2. Daily increases of COVID-19^{+} cases, deaths and RSVs trajectories for Italy, Spain, the UK, the USA, Germany, France, Iran, and The Netherlands. Italy: day 1 = February 11, 2020 (10 days before first death), day 44 = March 25, 2020; Spain: day 1 = February 23, 2020 (10 days before first death), day 31 = March 25, 2020; UK: day 1 = February 24, 2020 (10 days before first death), day 30 = March 25, 2020; Iran: day 1 = February 9, 2020 (10 days before first death), day 46 = 25th of March 2020; USA: day 1 = February 19, 2020 (10 days before first death), day 36 = March 25, 2020; Germany: day 1 = February 28, 2020 (10 days before first death), day 27 = March 25, 2020; France: day 1 = February 15, 2020 (10 days before first death), day 40 = March 25, 2020; The Netherlands: day 1 = February 25, 2020 (10 days before first death), day 30 = March 25, 2020. Daily increase = daily increases of COVID-19^{+} cases. Daily deaths = daily increases of confirmed deaths secondary to COVID-19^{+}. COVID-19 = coronavirus 2019; RSV = relative search volume.

coronavirus cases and deaths. This correlation is present across Italy, Spain, UK, USA, Germany, France, Iran, and The Netherlands and is remarkably consistent in temporal relationship to the outbreak in each country when monitored against the first death secondary to coronavirus. This suggests that there may be an increase in frequency among members of the public searching for information regarding their sense of smell in the same time-frame as coronavirus has manifested in their country. Given that anosmia has been identified in at least 6% of coronavirus patients, this could either represent an enormous reservoir of disease within each country; a larger proportion of coronavirus

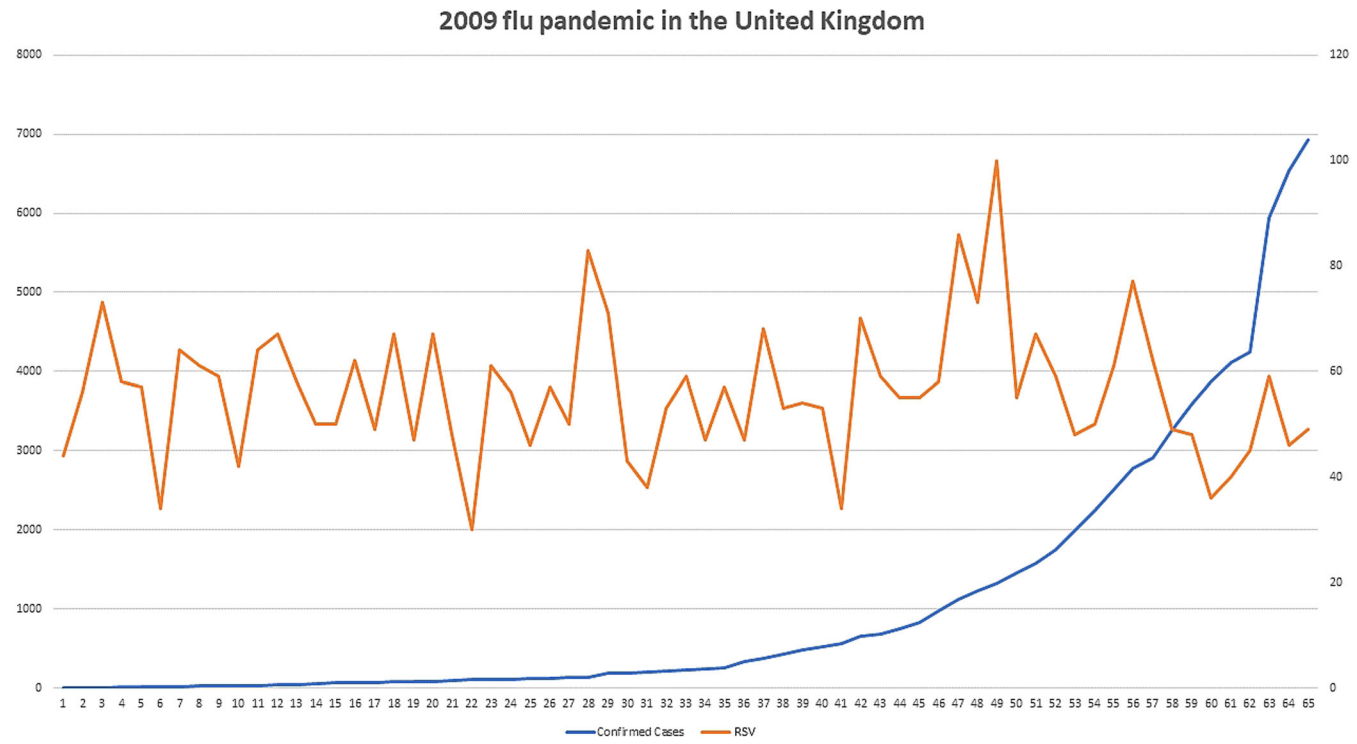

FIGURE 3. Daily increase of influenza-positive cases and RSV trajectories for UK. Day 1 = April 27, 2009, day 32 = July 2, 2009 (testing of influenza discontinued next day).

patients with anosmia; or an as-yet undetected coincidental factor confounding results. Given the strength and consistency of the correlation we would favor an association with coronavirus and smell but acknowledge the limitations in the data, as discussed in what follows.

We have attempted to be pragmatic with our study and, in particular, to be flexible in the chosen search terms. Direct translation of a term from one language to another can result in lost nuances of meaning and overlay, and thus we aimed to select terms that were responsive to the coronavirus pandemic. This is not to say that there was no relationship when using other terms—for example, "anosmia," instead of "smell," but the smaller number of searches using infrequently used search terms leads to a small sample size and difficulty in detection of trends. Ultimately, the inference of this study is to detect local trends and spikes in search strings that may alert epidemiologists to infection hotspots and tailoring of search terms to local phraseology would be more likely to detect change than a rigid "one-size-fits-all" translation.

Our hypothesis suggests that members of the public have identified that they have had a change in their sense of smell and have been compelled to search for information. This may have (rightly or wrongly) made the link of causality with coronavirus due to its dominance of the international news agenda. This seems to be a phenomenon particular to coronavirus, and we failed to find a similar pattern in the most recent epidemic recorded in the UK, caused by swine flu. Taking these findings together, we hypothesize that this may represent a subset of the population who have had anosmia in association with coronavirus infection or carriage. Taking this hypothesis one step further, it may be inferred that the GT data could be monitored in real time to detect occurrence of symptoms that have been hitherto unrecognized as a disease manifestation. In the context of a global pandemic, this offers a tantalizing glimpse into the potential use of a tool such as GT to monitor a broad spectrum of physical symptom search terms and identify spikes of activity. These could help to identify not only symptoms that should be further investigated for association with disease, but also a subset of the population who are well other than having a minor symptom that is sufficiently irritating to prompt them to search for information but insufficiently serious to seek medical attention. In short, it could be used to identify a population with minor symptoms or asymptomatic carriage who would never have come to the attention of traditional health-care channels. Although this is merely a hypothesis, it is a potential tool for identifying reservoirs of infection within a population leading to real-time action aimed at its containment.

Although "big data" such as that collected by GT may be of much value, it should be interpreted with caution as it is not possible to accurately define the population contributing to the data sample. Sudden increases in searches can be driven by a news agenda; for example, there was a spike in searches around thunderstorm-induced asthma in 2016[17] when it was highlighted in several news pieces.

TABLE 1. Spearman rank correlation analysis for daily increases in COVID-19^{+} cases, deaths, and smell searches

	Italy			Spain			UK			Iran		
	Cases	Deaths	RSV	Cases	Deaths	RSV	Cases	Deaths	RSV	Cases	Deaths	RSV
Italy												
Cases	1	0.982[a]	0.831[a]	0.982[a]	0.982[a]	0.947[a]	0.976[a]	0.961[a]	0.906[a]	0.976[a]	0.981[a]	0.835[a]
p value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Deaths	0.982[a]	1	0.833[a]	0.957[a]	0.977[a]	0.941[a]	0.949[a]	0.974[a]	0.882[a]	0.982[a]	0.990[a]	0.844[a]
p value	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
RSV	0.831[a]	0.833[a]	1	0.655[a]	0.596[a]	0.559[a]	0.607[a]	0.558[a]	0.518[a]	0.865[a]	0.859[a]	0.782[a]
p value	<0.001	<0.001		<0.001	<0.001	0.001	<0.001	0.001	0.003	<0.001	<0.001	<0.001
Spain												
Cases	0.982[a]	0.957[a]	0.655[a]	1	0.976[a]	0.952[a]	0.973[a]	0.950[a]	0.864[a]	0.950[a]	0.962[a]	0.611[a]
p value	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Deaths	0.982[a]	0.977[a]	0.596[a]	0.976[a]	1	0.936[a]	0.967[a]	0.968[a]	0.891[a]	0.964[a]	0.975[a]	0.650[a]
p value	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
RSV	0.947[a]	0.941[a]	0.559[a]	0.952[a]	0.936[a]	1	0.926[a]	0.935[a]	0.850[a]	0.907[a]	0.924[a]	0.582[a]
p value	<0.001	<0.001	0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
UK												
Cases	0.976[a]	0.949[a]	0.607[a]	0.973[a]	0.967[a]	0.926[a]	1	0.942[a]	0.861[a]	0.943[a]	0.950[a]	0.591[a]
p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001
Deaths	0.961[a]	0.974[a]	0.558[a]	0.950[a]	0.968[a]	0.935[a]	0.942[a]	1	0.871[a]	0.929[a]	0.962[a]	0.588[a]
p value	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	0.001
RSV	0.906[a]	0.882[a]	0.518[a]	0.864[a]	0.891[a]	0.850[a]	0.861[a]	0.871[a]	1	0.885[a]	0.897[a]	0.538[a]
p value	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	0.002
Iran												
Cases	0.976[a]	0.982[a]	0.865[a]	0.950[a]	0.964[a]	0.907[a]	0.943[a]	0.929[a]	0.885[a]	1	0.965[a]	0.878[a]
p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001
Deaths	0.981[a]	0.990[a]	0.859[a]	0.962[a]	0.975[a]	0.924[a]	0.950[a]	0.962[a]	0.897[a]	0.965[a]	1	0.899[a]
p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001
RSV	0.835[a]	0.844[a]	0.782[a]	0.611[a]	0.650[a]	0.582[a]	0.591[a]	0.588[a]	0.538[a]	0.878[a]	0.899[a]	1
p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	.001	0.002	<0.001	<0.001	
	USA			Germany			France			The Netherlands		
	Cases	Deaths	RSV	Cases	Deaths	RSV	Cases	Deaths	RSV	Cases	Deaths	RSV
USA												
Cases	1	0.960[a]	0.636[a]	0.885[a]	0.798[a]	0.784[a]	0.969[a]	0.886[a]	0.680[a]	0.871[a]	0.909[a]	0.659[a]
p value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Deaths	0.960[a]	1	0.633[a]	0.975[a]	0.823[a]	0.836[a]	0.984[a]	0.933[a]	0.721[a]	0.927[a]	0.979[a]	0.723[a]
p value	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
RSV	0.636[a]	0.633[a]	1	0.092	.059	0.025	0.646[a]	0.690[a]	0.550[a]	0.423[b]	0.391[b]	0.233
p value	<0.001	<0.001		0.647	0.771	0.903	<0.001	<0.001	0.001	0.020	0.033	0.215

(*Continued*)

TABLE 1. Continued

	USA			Germany			France			The Netherlands		
	Cases	Deaths	RSV	Cases	Deaths	RSV	Cases	Deaths	RSV	Cases	Deaths	RSV
Germany												
Cases	0.885[a]	0.975[a]	0.092	1	0.829[a]	0.836[a]	0.947[a]	0.817[a]	0.426[b]	0.874[a]	0.975[a]	0.565[a]
p value	<0.001	<0.001	0.647		<0.001	<0.001	<0.001	<0.001	0.027	<0.001	<0.001	0.002
Deaths	0.798[a]	0.823[a]	0.059	0.829[a]	1	0.663[a]	0.823[a]	0.820[a]	0.151	0.818[a]	0.817[a]	0.487[a]
p value	<0.001	<0.001	0.771	<0.001		<0.001	<0.001	<0.001	0.452	<0.001	<0.001	0.010
RSV	0.784[a]	0.836[a]	0.025	0.836[a]	0.663[a]	1	0.833[a]	0.713[a]	0.458[b]	0.774[a]	0.810[a]	0.565[a]
p value	<0.001	<0.001	0.903	<0.001	<0.001		<0.001	<0.001	0.016	<0.001	<0.001	0.002
France												
Cases	0.969[a]	0.984[a]	0.646[a]	0.947[a]	0.823[a]	0.833[a]	1	0.948[a]	0.768[a]	0.918[a]	0.957[a]	0.715[a]
p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001
Deaths	0.886[a]	0.933[a]	0.690[a]	0.817[a]	0.820[a]	0.713[a]	0.948[a]	1	0.726[a]	0.933[a]	0.883[a]	0.677[a]
p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001
RSV	0.680[a]	0.721[a]	0.550[a]	0.426[b]	0.151	0.458[b]	0.768[a]	0.726[a]	1	0.342	0.479[a]	0.272
p value	<0.001	<0.001	0.001	0.027	0.452	0.016	<0.001	<0.001		0.064	0.007	0.146
The Netherlands												
Cases	0.871[a]	0.927[a]	0.423[b]	0.874[a]	0.818[a]	0.774[a]	0.918[a]	0.933[a]	0.342	1	0.925[a]	0.693[a]
p value	<0.001	<0.001	0.020	<0.001	<0.001	<0.001	<0.001	<0.001	0.064		<0.001	<0.001
Deaths	0.909[a]	0.979[a]	0.391[b]	0.975[a]	0.817[a]	0.810[a]	0.957[a]	0.883[a]	0.479[a]	0.925[a]	1	0.676[a]
p value	<0.001	<0.001	0.033	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<0.001		<0.001
RSV	0.659[a]	0.723[a]	0.233	0.565[a]	0.487[a]	0.565[a]	0.715[a]	0.677[a]	0.272	0.693[a]	0.676[a]	1
p value	<0.001	<0.001	0.215	0.002	0.010	0.002	<0.001	<0.001	0.146	<0.001	<0.001	

Cases are daily increases of COVID-19$^+$ cases. Deaths are daily increases of confirmed deaths secondary to COVID-19$^+$.
[a]Correlation significant at 0.01 level (2-tailed).
[b]Correlation significant at 0.05 level (2-tailed).
COVID-19 = coronavirus 2019; RSV = relative search volume.

One cannot be certain if an individual is searching for information due to having the symptom, or only through curiosity.

At the time of writing the ENT-UK statement (March 20, 2020), the authors searched the published literature and social media but were surprised by the paucity of reports connecting COVID-19 infection and anosmia outside of closed physician discussion boards, at least in English language–based sites. At that time, anosmia was not recognized as a potential symptom by the World Health Organization, any national diagnostic criteria, or widely promoted symptom trackers, which was one of the major drivers to issue ENT-UK press release. We performed another search for purposes of this article and identified only one report, from Iran, on loss of sense of smell coinciding with the COVID-19 epidemic among Iranians, dated March 9, 2020.[18] There has undoubtedly been an increase in anosmia in the days since the ENT-UK press release, the AAO-HNS (Anosmia, Hyposmia, and Dysgeusia Symptoms of Coronavirus Disease) statement, which followed on March 22, as the international press reported a potential new symptom of COVID infection.[19] Therefore, correlations were repeated using data up to March 19.

It is likely that many of the searches performed in the UK after March 20 were in part driven by the inclusion in the mainstream media of the BRS report by Professor Hopkins regarding anosmia in coronavirus.[10] To investigate this potential confounding effect of publicity in driving Google searches, we restricted our analysis to the time period ending March 19 and retested the relationship in the UK. The correlation coefficient for case incidence on retesting remained similar in all 3 countries. Similarly, trends in Spain and Italy predate this press release, which is, to our understanding, the first time that a formal note of this

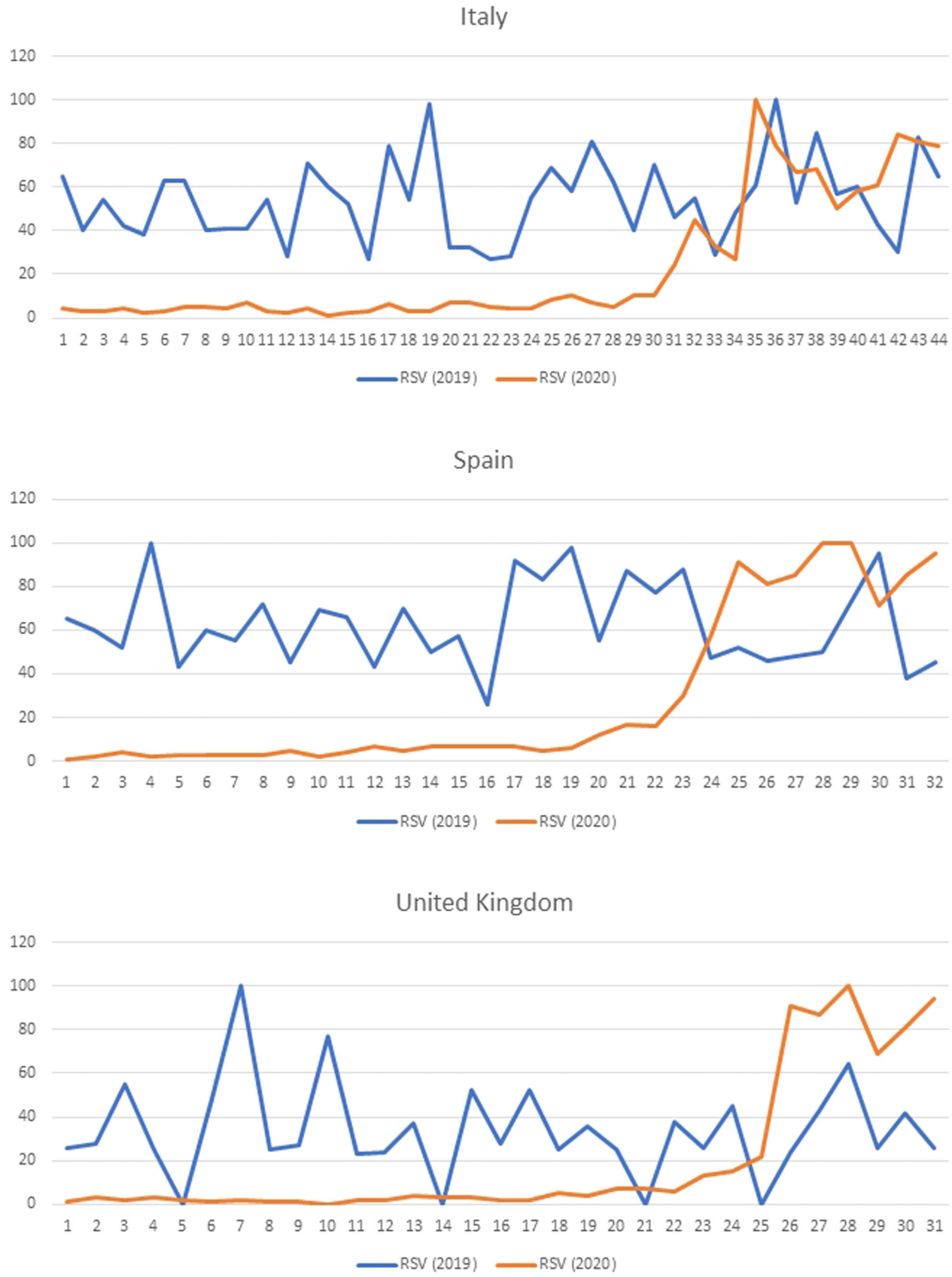

FIGURE 4. Comparison of RSV trend during current COVID-19 outbreak and matching period in 2019. RSV = relative search volume. Italy: day 1 = February 11, day 44 = March 25; Spain: day 1 = February 23, day 31 = March 25; UK: day 1 = February 24, day 30 = March 25. RSV = relative search volume. COVID-19 = coronavirus 2019.

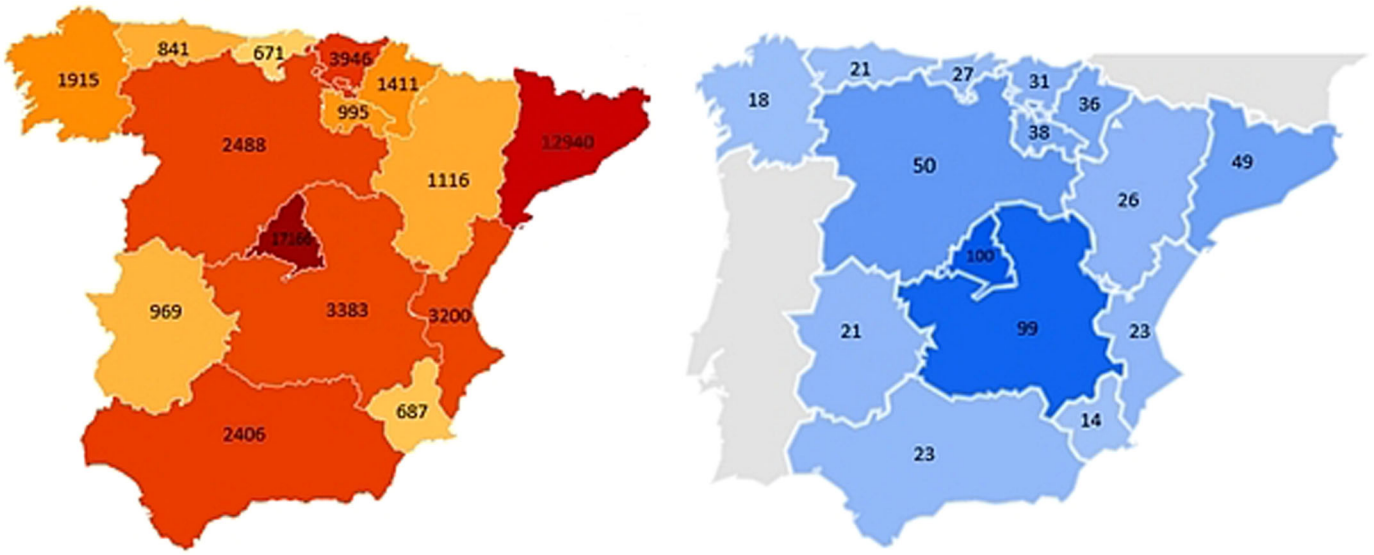

FIGURE 5. Heatmap of Spain showing the new cases of COVID-19$^+$ cases (left) and RSV (right) on March 3, 2020. COVID-19 = coronavirus 2019.

association was published in the mainstream media regarding a potential link between COVID-19 and anosmia.

The second important confounder is a well-described seasonal variation in postviral olfactory loss related to upper respiratory tract infections. Several studies have shown that postviral olfactory loss occurs in general peaks in March.[14-16] We compared RSVs of the current COVID-19 outbreak with a matching period in 2019, but our analysis did not reveal a similar trend.

Any data analysis based on RSV must acknowledge the inherent bias that it is a population sample selected specifically from those who are literate, with sufficient income to access the internet, and whose chosen search engine is Google.

Conclusion

There is a strong correlation between the frequency of searches for smell-related information and the onset of COVID-19 infection in Italy, Spain, the UK, the USA, Germany, France, Iran, and The Netherlands. Despite all our efforts to control confounders, our findings must be interpreted with caution. It is difficult to define the population that contributes to the data sample and a sudden increase in searches can be driven by a news agenda. Therefore, our findings require validation from epidemiologic studies analyzing rates of anosmia in COVID-19$^+$ patients but support the call from ENT-UK and the American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNSF) to include anosmia in the list of possible symptoms.

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