

# Public awareness of preventive measures against COVID-19: an infodemiology study

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## ABSTRACT

**Introduction:** The coronavirus disease 2019 (COVID-19) pandemic has led to an increase in global awareness of relevant public health preventive measures. This awareness can be explored using online search trends from major search engines, such as Google Trends. We investigated the relationship between public awareness of preventative measures and progression of the COVID-19 pandemic.

**Methods:** Search data for five queries ('mask', 'hand washing', 'social distancing', 'hand sanitizer', and 'disinfectant') were extracted from Google Trends in the form of relative search volume (RSV). Global incidence data for COVID-19 were obtained from 1 January to 30 June 2020. These data were analysed and illustrated using a global temporal RSV trend diagram, a geographical RSV distribution chart, scatter plots comparing geographical RSV with average number of daily cases, and heat maps comparing temporal trends of RSV with average number of daily cases.

**Results:** Global temporal trends revealed multiple increases in RSV, associated with specific COVID-19-related news events. The geographical distribution showed top regions of interest for various preventive measures. For the queries 'mask', 'hand washing', 'hand sanitizer', and 'disinfectant', heat maps demonstrated patterns of early RSV peaks in regions with lower average number of daily cases, when the temporal element was incorporated into the analysis.

**Conclusion:** Early public awareness of multiple preventive measures was observed in regions with lower average number of daily cases. Our findings indicate optimal public health communication regarding masks, hand washing, hand sanitiser, and disinfectant in the general population during early stages of the COVID-19 pandemic. Early public awareness may facilitate future disease control efforts by public health authorities.

Hong Kong Med J 2023;29:214–23

<https://doi.org/10.12809/hkmj219556>

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## New knowledge added by this study

- This study focused on the importance of early public awareness in controlling coronavirus disease 2019 (COVID-19); this effect was not extensively investigated in previous studies.
- Early awareness trends among regions with lower average number of daily cases were illustrated using heat maps for the queries 'mask', 'hand washing', 'hand sanitizer', and 'disinfectant'.
- In contrast to prior infodemiology studies, this study used a global online approach and focused on specific preventive measures recommended by the World Health Organization.

## Implications for clinical practice or policy

- This study revealed correlations between regions with low average number of daily cases of COVID-19 and early public awareness of multiple preventive measures (ie, 'mask', 'hand washing', 'hand sanitizer', and 'disinfectant'). Health policies should seek to promote these preventive measures among the general public, which could help to slow the spread of disease. Furthermore, early public awareness may help public health authorities to control future global public health crises.
- This study also investigated the effects of authorities, public figures, and social media on public health awareness. Future healthcare policies should consider these factors to effectively promote correct public health information among the general public.

## Introduction

Coronavirus disease 2019 (COVID-19) began in December 2019 in Wuhan, China, and became a public health crisis affecting millions of people worldwide.<sup>1</sup> On 11 March 2020, the World Health Organization (WHO) declared that COVID-19 constituted a pandemic<sup>2</sup>; by 1 September 2020, the total number of confirmed COVID-19 cases had exceeded 26 million, with over 800 000 deaths.<sup>3</sup>

Accordingly, the WHO issued recommendations to the general public with the goal of reducing community transmission of COVID-19. These recommended preventive measures included the use of masks in specific situations as well as hand washing, social distancing, and various other disease prevention strategies.<sup>4</sup> In the early and middle of 2020, there was no specific treatment to cure the aggressively spreading virus; thus, preventive measures and public awareness of such information had important roles in the formulation of public health policies.

Because of technological advancements in recent decades, the internet has become a convenient and effective channel for providing readily accessible and up-to-date public health information to members of the general public. In the era of big internet data, infodemiology—an emerging area of science that explores the distribution and determinants of information in electronic media—has been implemented in multiple areas of modern medicine.<sup>5</sup> The analysis of large amounts of internet data enables researchers to identify trends in online search behaviour; this information can be used to analyse relationships among public health communication, public awareness, and the progression of disease outbreaks. Indeed, search trends from major search engines (eg, Google) have been extensively used in infodemiology and intelligence studies focused on outbreak patterns and public awareness,<sup>6</sup> particularly with respect to the Ebola,<sup>7-9</sup> H1N1 influenza,<sup>10,11</sup> and Zika<sup>12-14</sup> viruses.

In the context of COVID-19, various infodemiology investigations have been conducted, ranging from the impacts of COVID-19 on domestic abuse<sup>15</sup> and psychological distress,<sup>16,17</sup> to its impacts on social media discourse.<sup>18</sup> In particular, previous infodemiology studies used Google data to examine public awareness of COVID-19 in various countries.<sup>19-23</sup> Analyses of other popular websites, such as Wikipedia, revealed an increase in public awareness of health-related topics during the COVID-19 pandemic.<sup>24</sup> However, previous regional studies did not utilise extensive datasets with respect to time period, number of countries, and all five WHO-recommended preventive measures that were selected in this study. Additionally, previous studies did not explore how early public awareness of preventive measures is related to lower average

## 新冠疫情預防措施的公眾意識：訊息流行病學研究

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**簡介：**2019新冠疫情提高了全球對相關公共衛生預防措施的意識，而這意識可透過主要搜尋引擎（例如Google Trends）的網上搜尋趨勢探索。我們調查了預防措施的公眾意識與新冠疫情發展之間的關係。

**方法：**我們在Google Trends以相對搜尋量的形式提取了五個搜尋字詞‘mask’（口罩）、‘hand washing’（洗手）、‘social distancing’（社交距離）、‘hand sanitizer’（消毒潔手液）及‘disinfectant’（消毒劑）的搜尋數據，以及獲取了於2020年1月1日至6月30日期間新冠疫情的全球發病率數據。我們使用全球時間性相對搜尋量趨勢圖、地理相對搜尋量分布圖、比較地理相對搜尋量與平均每日個案數目的散點圖及比較時間性相對搜尋量趨勢與平均每日個案數目的熱圖。

**結果：**全球時間性趨勢顯示相對搜尋量因應特定的新冠疫情相關新聞而倍增，地理分布則顯示了對各項預防措施最感興趣的地區。就搜尋字詞‘mask’、‘hand washing’、‘hand sanitizer’及‘disinfectant’來說，當在分析結合時間性元素時，熱圖顯示平均每日個案數目較少的地區在早期出現相對搜尋量高峰的模式。

**結論：**平均每日個案數目較少的地區對多項預防措施的公眾意識較早出現。我們的研究結果表明新冠疫情爆發初期一般市民就口罩、洗手、消毒潔手液及消毒劑的最佳公共衛生傳播。及早出現公眾意識有助公共衛生當局日後的疾病控制工作。

number of daily cases in specific countries.

This study was conducted to explore relationships between early public awareness of preventative measures and the progression of the COVID-19 pandemic through the interpretation of Google searches regarding multiple public health preventive measures. The results are expected to provide guidance for future public health communication and policy decisions.

## Methods

### Overview of Google Trends and global incidence data

To explore the relationship between public awareness of specific preventive measures against COVID-19 and the progression of COVID-19 pandemic, search data were extracted from Google Trends (GT) and compared with global incidence data for COVID-19. The global incidence data, measured in number of cases, were retrieved from the COVID-19 Data Repository by the Centre for Systems Science and Engineering at Johns Hopkins University of the US.<sup>3</sup> Next, the average number of daily cases in each country/region was calculated based on the total number of cases in that country/region between the date of the first locally reported case and 30 June 2020.<sup>3</sup> Google Trends provides quantitative information regarding actual search

requests on Google for specific terms, in the form of relative search volume (RSV). The RSV is the volume of a search query for a specified location and period of time, normalised both geographically and temporally. The data are expressed using a range from 0 to 100, depending on the ratio of searches for that topic to all searches for all topics on Google.<sup>25,26</sup> When conducting an infodemiology study using GT data, accurate keyword, region, and period selections must be made according to the study aims.<sup>25,26</sup>

### Keyword, region, and period selections

Based on WHO recommendations<sup>27</sup> and top-ranked Google search queries related to COVID-19, we selected 'mask', 'hand washing', 'social distancing', 'hand sanitizer', and 'disinfectant' as keywords that represented public interest in preventive measures against COVID-19. For each keyword, data were retrieved from GT according to 'search topic' (where available), which allowed simultaneous analysis of five queries.<sup>28</sup> In contrast to the 'search term' option, 'search topic' is a 'group of terms that share the same concept in any language.'<sup>26</sup> By analysing GT data in the form of search topics, we were able to accommodate differences in language, translation, terminology, and spelling of the same concept.

In terms of region selection, GT normalises data differently according to geographical level.<sup>26</sup> In this study, we retrieved both global- and country-level data depending on the analysis; global-level data were used to analyse general trends in public interest and geographical distribution, whereas country-level data were used to analyse correlations. Global incidence data for 190 countries/regions worldwide are available from the aforementioned Johns Hopkins University database. To clarify the terminology used in this study, 'geographical RSV' data were normalised according to search volume in individual regions over a fixed period of time through analyses of 'interest by region' in worldwide searches. In contrast, 'temporal RSV' data were normalised according to daily search volume over time, either globally or regionally, through analyses of 'interest over time' in either worldwide or regional searches.

Furthermore, global incidence data and GT-based RSV data were collected for the period from 1 January to 30 June 2020. The period selected for GT data completely matched the study period, consistent with published guidance.<sup>26</sup> As mentioned above, a primary goal of this study was the examination of global public awareness during early stages of the COVID-19 pandemic. To examine awareness before local outbreaks, a universal start date was selected, rather than the date of the first reported case in each country/region (used in the aforementioned calculation of average number of daily cases). According to the timeline of WHO's response to

COVID-19,<sup>29</sup> the first event involving all three levels of the WHO (headquarters, regional, country) occurred on 1 January 2020; accordingly, this date was selected as the start date for this study. Because GT data are proportional to all searches for all topics over time, it is important to note that the GT data used in this study were last retrieved on 7 November 2020.<sup>26</sup>

### Data analysis

To illustrate the global temporal RSV trends for each query throughout the study period, global RSV data for each search topic were extracted and plotted on line graphs, where RSV was proportional to worldwide temporal search volume. Moreover, for each individual query, the geographical distribution of RSV was analysed and summarised in a table listing the top 20 regions of interest.

We analysed correlations between geographical RSV trends for each query and average number of daily cases in each country/region, whereby RSV was normalised according to overall regional search volume throughout the study period. Correlations were presented using scatter plots, and Pearson correlation coefficients were calculated. To avoid pre-analytical errors, we used the default GT setting of excluding regions with low search volume.

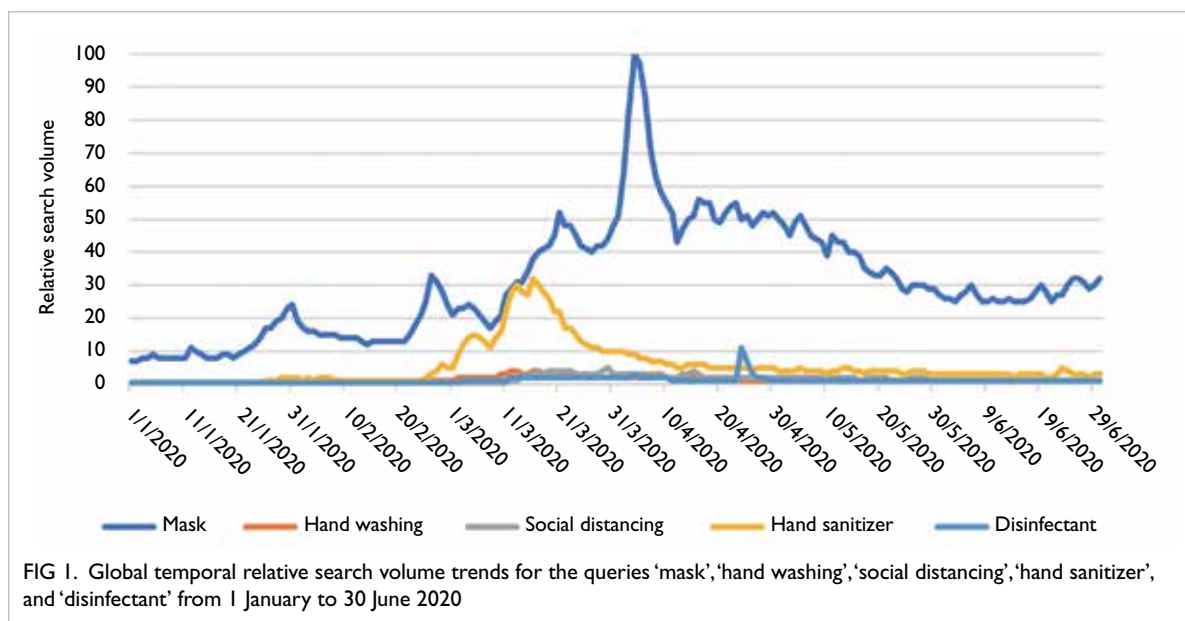
The temporal element of RSV trends in each country/region is necessary to illustrate the importance of early awareness. Therefore, temporal RSV trends in each region were extracted separately for each query; the RSV for each region was normalised according to the search volume of individual days in that region. Temporal RSV trends were then plotted against the lists of regions (excluding regions with low search volume) on five individual heat maps. In each heat map, the y-axis depicts the region list sorted from highest to lowest average number of daily cases, whereas the x-axis represents the timeline from 1 January to 30 June 2020. A three-colour scale of green, yellow, and red was used to represent low, medium, and high RSV, respectively.

## Results

### Global temporal trends

Figure 1 shows the global temporal RSV trends of the five queries in this study, namely, 'mask', 'hand washing', 'social distancing', 'hand sanitizer', and 'disinfectant'. 'Mask' was the query that consistently demonstrated the greatest global RSV throughout the study period; at its peak, it exceeded the peak of the second highest query, 'hand sanitizer', by more than threefold.

With respect to the query 'mask', the greatest peak occurred on 4 April 2020, and three other peaks were identified (31 January 2020, 26 February



2020, and 21 March 2020). In particular, the peak on 4 April 2020 (RSV=100) corresponded to the WHO's announcement of 1 000 000 cases worldwide.<sup>30</sup> The peak on 31 January 2020 (RSV=24) corresponded to the WHO Director-General's Statement regarding the International Health Regulations Emergency Committee on 30 January 2020, in which COVID-19 was declared a 'Public Health Emergency of International Concern'.<sup>31</sup> Similarly, the peak on 26 February 2020 (RSV=33) corresponded to the WHO release of guidelines entitled 'Rational use of personal protective equipment for coronavirus disease',<sup>32</sup> which detailed preventative measures such as hand hygiene (soap/alcohol sanitiser), use of masks, and social distancing.

The RSV peak for the query 'hand sanitizer' on 13 March 2020 (RSV=30) corresponded to the WHO's press release declaring that COVID-19 was a pandemic, during a media briefing on 11 March 2020.<sup>2</sup> This peak was also accompanied by an article in *The New York Times* describing a shortage of hand sanitiser.<sup>33</sup>

Another major peak, visible without extensive data analysis, was recorded for the query 'disinfectant' on 24 April 2020. Unlike the other peaks, which gradually increased, the query 'disinfectant' increased from an RSV of 1/100 on 23 April 2020 to 11/100 on the following day; this 11-fold increase is visible in Figure 1.

### Geographical distribution

With respect to country-level interest in the query 'mask' (online supplementary Table), the highest RSV was observed in Hong Kong (100), followed by Singapore (87) and France (75). The highest country-

level RSV values for 'hand washing' were observed in Indonesia (100), Vietnam (100), and Hong Kong (88), while that for 'social distancing' were recorded in Canada (100), Indonesia (95), and Singapore (92). For 'hand sanitizer', the highest country-level RSV values were recorded in Hong Kong (100), Singapore (96), and Denmark (91). For 'disinfectant', the highest country-level RSV values were observed in the US (100), the Philippines (88), and Singapore (79). The full list of geographical distributions showing all countries/regions is included in the online supplementary Table.

### Correlations between geographical relative search volume trends and average number of daily cases

Figure 2 shows the correlation between the average number of daily cases for each country/region and the LogRSV of each respective search query from 1 January to 30 June 2020. 'Hand washing' and 'social distancing' were the only queries with mild correlations, with Pearson correlations ( $r$  values) of -0.44 ('hand washing') and -0.38 ('social distancing'). No strong correlations were observed for the other three terms 'mask' ( $r=0.03$ ), 'hand sanitizer' ( $r=0.00$ ), and 'disinfectant' ( $r=-0.06$ ).

### Correlations between temporal relative search volume trends in each region and average number of daily cases

The online supplementary Figure shows heat maps for the five search queries. In online supplementary Figure a, a divergence pattern was observed for the search query 'mask', which tended to display an earlier RSV peak in countries/regions with lower

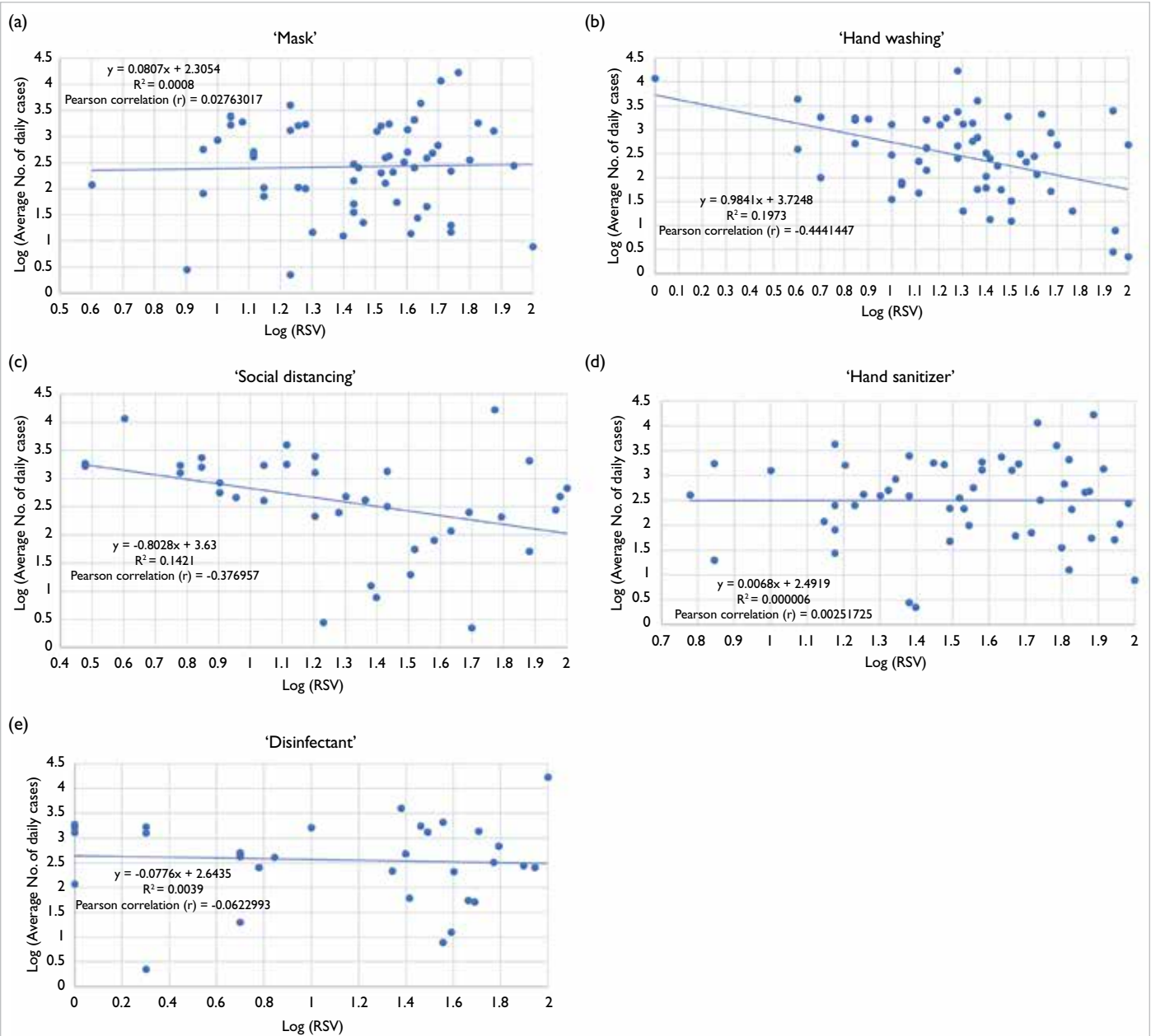


FIG 2. Correlation between country-specific geographical relative search volume (RSV) trend and average number of daily cases for the queries (a) 'mask', (b) 'hand washing', (c) 'social distancing', (d) 'hand sanitizer', and (e) 'disinfectant'. Dots represent countries/regions

average number of daily cases and a later RSV peak in countries/regions with higher average number of daily cases. Among the countries/regions with an early RSV peak and low average number of daily cases, Hong Kong had an early RSV peak (100) on 29 January 2020 and an average number of daily case count of 7.75. Other notable examples include Taiwan (early RSV peak on 3 February 2020 and average number of daily case count of 2.79) and Vietnam (early RSV peak on 31 January 2020 and average number of daily case count of 2.23). In contrast, countries/regions with a late RSV peak and

high average number of daily cases included the US (late RSV peak on 4 April 2020 and average number of daily case count of 16789.11), Brazil (late RSV peak on 3 April 2020 and average number of daily case count of 11590.02), and Russia (late RSV peak on 30 March 2020 and average number of daily case count of 4327.68).

Similarly, online supplementary Figures b, d, and e show heat maps for the search queries of 'hand washing', 'hand sanitizer', and 'disinfectant', respectively. Earlier increases in RSV tended to occur in countries/regions with lower average number

of daily cases. However, the heat map of 'social distancing' did not display such a clear pattern; it showed a sudden global increase in late March 2020 (online supplementary Fig c).

## Discussion

### Principal findings

#### Overview

The rapid and aggressive infectivity of COVID-19 requires the general public to be vigilant about preventive measures. Although prevention is generally preferred over curative treatment, the effect of each preventive measure on COVID-19 transmission was unclear during early stages of the pandemic. For example, during early stages of the pandemic, there was controversy regarding the importance of wearing masks to prevent COVID-19 transmission via droplets.<sup>34</sup> Indeed, the routine use of medical masks by normal healthy individuals had not been recommended by the WHO at the start of data collection.<sup>35</sup> This controversy led to confusion regarding public health policies, as well as the stigmatisation of individuals who practised specific preventive measures. Thus, the present study retrospectively compared public awareness of the five aforementioned preventive measures with the progression of COVID-19; this analysis was intended to provide guidance regarding public health communication and policy decisions.

#### *Early awareness in regions with low average number of daily cases*

The heat maps (online supplementary Figs a-d) show a pattern of early awareness among countries/regions with lower average number of daily cases, according to analyses of the queries 'mask', 'hand washing', 'hand sanitizer', and 'disinfectant'. These findings suggested that such queries were associated with the prevention of COVID-19 progression. Despite these positive findings, we did not find strong correlations between average number of daily cases in specific countries/regions and the overall geographical RSV trend throughout the study period (Fig 2). This negative result highlighted the importance of temporal element in the prevention of COVID-19 transmission, implying that increased public awareness in an earlier stage of the pandemic was superior to an increase in the overall volume of public awareness. Notably, a similar GT-based study of mask awareness conducted earlier in May 2020 demonstrated a significant correlation (Kendall rank correlation coefficient [ $\tau$ ] of -0.47) between mask awareness and average RSV data during a very early stage of the pandemic (21 January to 11 March 2020).<sup>36</sup>

Our positive findings regarding mask, hand

washing, hand sanitiser, and disinfectant queries are consistent with the current understanding of COVID-19 transmission. The major routes of COVID-19 transmission include contact, droplets, and aerosols<sup>37</sup>; importantly, animate and inanimate surfaces participate in COVID-19 transmission. Face masks may slow the spread of COVID-19 by reducing aerosol and respiratory droplet transmission.<sup>36</sup> Systematic reviews and meta-analyses have increasingly shown that mask usage in community or healthcare settings reduces COVID-19 transmission.<sup>38-43</sup> In contrast, a Danish randomised controlled trial of mask usage in the general population suggested little to no evidence that facemask usage alone could prevent transmission of severe acute respiratory syndrome coronavirus 2, the virus causing COVID-19.<sup>44</sup> Retrospective cohort studies and case-control studies have provided some evidence of the preventive effects of mask usage in communities such as Beijing and Thailand.<sup>45,46</sup> Additional randomised controlled trials are needed to conclusively determine the benefits of mask usage in the general population.<sup>47</sup> Importantly, the routine maintenance of good hand hygiene can reduce contact transmission. The use of an alcohol-based hand sanitiser can disrupt COVID-19 transmission via surface protein precipitation.<sup>37</sup> Our findings regarding mask and hand washing queries were also consistent with previous regional infodemiology studies, including a Taiwanese GT-based study focused on masks and hand washing.<sup>22</sup> In support of the regional results, the present study illustrated the importance of early awareness on a global scale.

Despite the lack of a clear pattern of early awareness concerning the search topic 'social distancing', a meta-analysis has confirmed that social distancing of  $\geq 1$  m reduces COVID-19 transmission.<sup>38</sup> Therefore, the lack of positive findings regarding 'social distancing' in the present study does not necessarily indicate a lack of effectiveness. Instead, it suggests inadequate public awareness. Careful analysis of temporal RSV trends for all five queries (Fig 1) revealed that a lower overall volume of searches for 'social distancing'. Although public awareness of the topics 'mask', 'hand sanitizer', and 'disinfectant' may spontaneously increase because of various other factors, such as a market shortage, social distancing during the COVID-19 pandemic was often implemented via governmental policy, rather than public awareness.<sup>48,49</sup> This lack of public awareness was demonstrated by the decrease in confirmed COVID-19 cases in the US after government-imposed social distancing measures had been implemented.<sup>50</sup> Despite their proven efficacies, specific preventive measures such as hand washing were often implemented via public health initiatives, rather than law enforcement.<sup>48,49</sup> Future studies should seek to identify specific preventive

measures beyond public awareness that can guide public health policy decisions regarding the COVID-19 pandemic.

Preventive measures against COVID-19 transmission are only effective if the majority of the general public acknowledge and practise them with the correct timing and knowledge. In addition to the determination of whether a preventive measure is effective, patterns of early public awareness should be explored to enhance the preventive effects of public health communication on COVID-19 transmission.

**Effects of authorities, public figures, and social media on public awareness**

As mentioned above, there were multiple instances of a sudden surge in public awareness. One of the most prominent patterns was the surge in ‘disinfectant’ queries on 24 April 2020. A substantial increase in global awareness of disinfectant occurred within a single day, leading to questions regarding the underlying cause and whether that cause can provide any insights concerning effective public health communication. Further investigation revealed a possible key event related to the timing and content of the surge in ‘disinfectant’ queries: a speech made by US President Donald Trump on 23 April 2020, in which he claimed that disinfectant ‘knocks it [severe acute respiratory syndrome coronavirus 2] out in a minute’ and suggested that scientists should conduct further research in this area.<sup>51</sup> Although the scientific legitimacy of the contents of Trump’s speech was questionable, the speech itself had a substantial impact on public awareness, as demonstrated by the massive number of Google searches in such a short period of time.

The example above was not the only surge pattern evident in this study. Buried under the

overwhelming search volumes of other queries, the RSV magnitude of ‘social distancing’ appears to be relatively negligible (Fig 1). However, closer inspection of the temporal RSV trend of ‘social distancing’ reveals an obvious surge from 10 March 2020 to 20 March 2020 (Fig 3). Over an interval of 10 days, the RSV of ‘social distancing’ increased from 3 to 86. Similar to Trump’s speech, a key event in early March was associated with the surge in ‘social distancing’ queries. A sentiment of ‘staying home’ was reportedly coined by Florian Reifschneider, a German engineer; it soon became a trend on social media and was heavily promoted by prominent celebrities.<sup>52-55</sup> Although ‘staying home’ and ‘social distancing’ are distinct key terms, an approximately overlapping rise and fall pattern is evident upon comparison of both RSV trends (Fig 4). Notably, the RSV of ‘staying home’ overlapped with the RSV of ‘social distancing’, but the magnitude of the RSV of ‘staying home’ exceeded the magnitude of the RSV of ‘social distancing’ by more than 50%; this finding implies that the public response to social distancing may have been greater if the concept of social distancing had been promoted correctly.

The relationship between sudden surges in global RSV and key events suggests that the effect of global public awareness is secondary to promotion by authorities and public figures. The evolution of the internet and social media may offer new avenues for public health communication, particularly in times of crisis.

**Limitations**

There were a few limitations in this study. To begin with, GT data constitute an indirect representation of public awareness; these data do not indicate whether preventive measures were correctly implemented

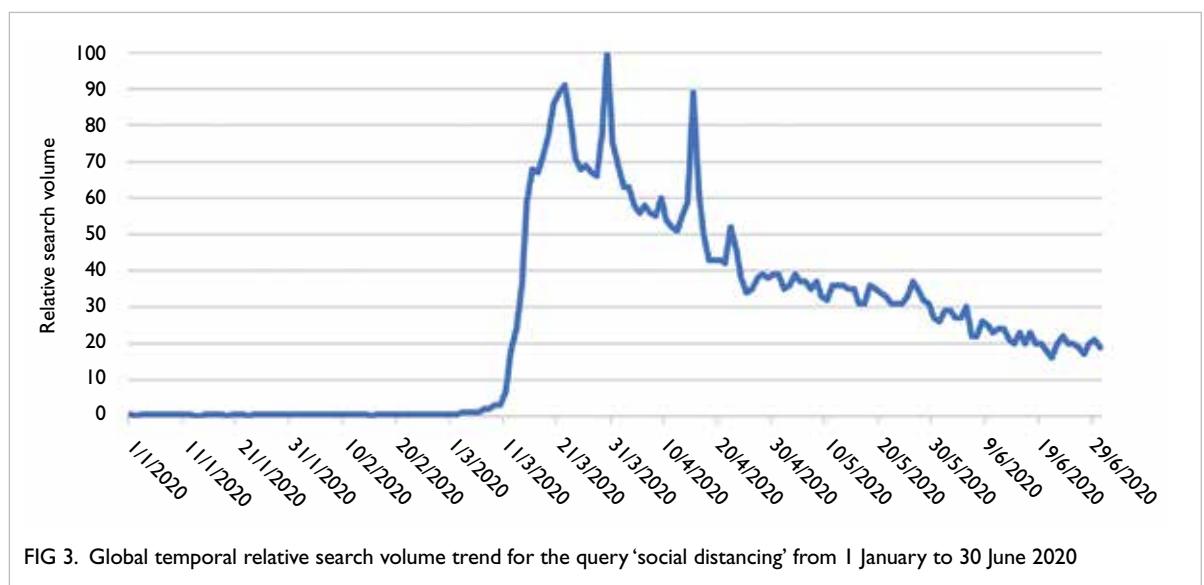
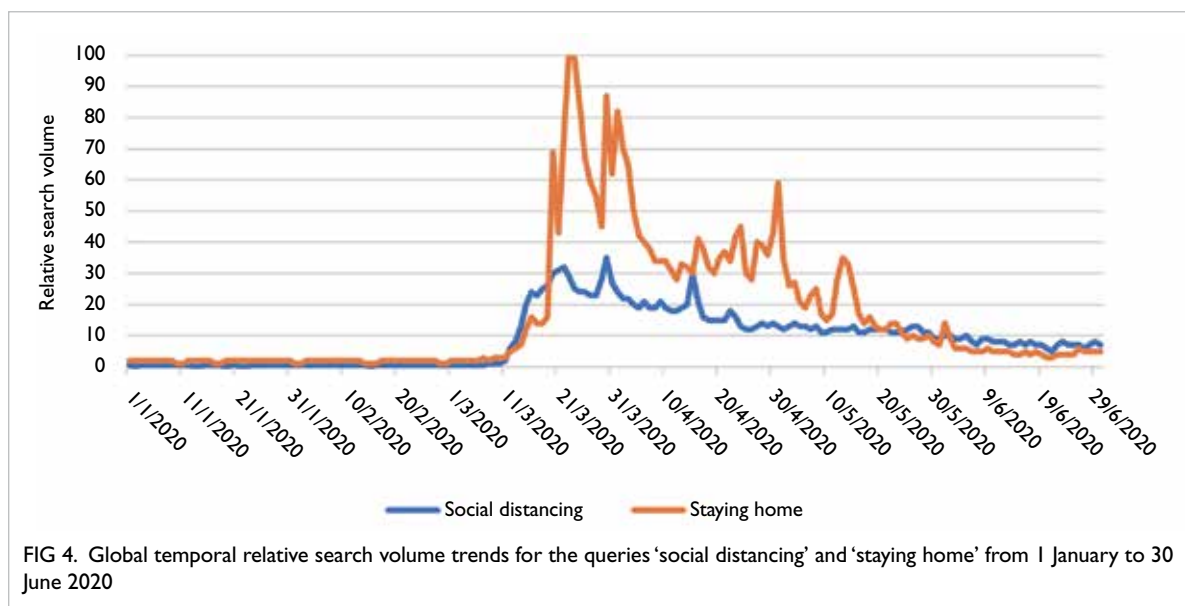


FIG 3. Global temporal relative search volume trend for the query ‘social distancing’ from 1 January to 30 June 2020



by the general public. Therefore, the analysis may have overestimated or underestimated correlations. Moreover, despite the use of search topics to explore GT data, the selected keywords may not accurately represent the concept of each preventive measure because of variations in language, translation, terminology, and spelling of the same concept. Furthermore, to facilitate comparison, this study exclusively analysed the queries in a single search platform (ie, Google). This limited focus may have led to sampling error based on access to Google, as well as regional search engine preferences. Internet accessibility also varies among regions; therefore, GT data may not accurately represent public awareness in regions with fewer internet users.

An important example is China (not including Hong Kong), which was regarded as a country with 'low search volume' for some queries, despite its 538 million netizens.<sup>56</sup> There are multiple reasons for this bias. First, Google holds <20% of China's online search market; Baidu is the most popular search engine.<sup>57</sup> Future studies involving China should consider the use of Baidu, as in a previous internet query study specifically focused on China.<sup>57</sup> However, a study by Kang et al<sup>56</sup> revealed that Chinese GT data may be used as a valid complementary source of information for influenza surveillance in south China.

Second, this study did not consider potential confounders in the correlation analyses, including the stringency of public health measures, the containment capacities of the countries and regions included, and the degree to which those countries and regions are vulnerable to public health threats.<sup>58-60</sup>

Third, this study primarily focused on public awareness and progression of COVID-19 in the early

stages of the pandemic; thus, factors identified during later stages of the pandemic were not evaluated.

Finally, research concerning preventive measures against COVID-19 is largely limited by the lack of randomised controlled trials. Considering the current scale of the pandemic, it is neither feasible nor ethical to conduct individual randomised controlled trials for each preventive measure in healthcare or non-healthcare settings. Therefore, infodemiology studies remain valuable in policy making for the foreseeable future.

## Conclusion

Google Trends offers large-scale population data regarding public health events. The results of RSV trend analysis revealed an earlier RSV peak in countries/regions with lower average number of daily cases, suggesting that early public awareness can slow the spread of a pandemic. During future pandemics, global and local public health authorities could focus on early public awareness to facilitate effective disease control. Additionally, our findings illustrate the value of early public health communication regarding the use of masks, hand washing, hand sanitiser, and disinfection among the general public during the COVID-19 pandemic.

## Author contributions

Concept or design: JYC Teoh, A Mok.

Acquisition of data: JYC Teoh, A Mok, OUY Mui.

Analysis or interpretation of data: JYC Teoh, A Mok, OUY Mui.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: All authors.



All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

### Conflicts of interest

As editors of the journal, CF Ng, MCS Wong and JYC Teoh were not involved in the peer review process. Other authors have disclosed no conflicts of interest.

### Funding/support

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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