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Global Monitoring of Public Interest in Preventive Measures against COVID-19 via Analysis of Google Trends: An Infodemiology and Infoveillance Study

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Abstract

Introduction: The coronavirus disease 2019 (COVID-19) pandemic has influenced people's concerns regarding infectious diseases and their preventive measures. However, the magnitude of the impact and the difference between countries are unclear. This study aimed to assess the magnitude of the impact of COVID-19 on public interest and people's behaviors globally in preventing infectious diseases while comparing international trends and sustainability.
Methods: The study employed an infodemiological and infoveillance approach to delineate public interest regarding COVID-19 preventive measures through web-based data and analysis using Google Trends. A relative search volume was assigned to a keyword, standardizing it from 0 to 100, with 100 representing the highest share of the term searches. The search terms "coronavirus," "wash hands," "social distancing," "hand sanitizer," and "mask" were investigated across 196 different countries and regions from July 2018 to October 2021 and obtained weekly reports of relative search volume. Persistence of interest was assessed by comparing the first 20 weeks with the last 20 weeks of the study period.
Results: Although the relative search volume of "coronavirus" increased and was sustained at a significantly higher value ($p<0.05$) globally than before the pandemic declaration, the trends and sustainability on the interest of preventable measures against COVID-19 varied between countries and regions.
Conclusions: The global differences should be taken into consideration for implementing effective interventions against COVID-19. The increased interest in preventive behaviors against COVID-19 may be related to overall infectious disease prevention.

Article Summary

Strengths and limitations of this study

This is the first study to use Google Trends to objectively show the trends in people's interest in COVID-19 and its preventive measures in countries and regions worldwide.

This study revieal ed the trends and sustainability on the interest of preventable measures against COVID-19 varied between countries and regions around the world.

The global differences should be taken into consideration for implementing effective interventions against COVID-19. The increased interest in preventive behaviors against COVID-19 may be related to overall infectious disease prevention.

This study had some limitations. First, the differences in internet availability may have affected the results. Second, the percentage of Google users may have affected the global-level evaluation of public interest using Google Trends.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) was first reported in Wuhan, China, in November 2019 and was declared a public health emergency of international concern on January 31, 2020. In March 11, 2011, it was declared a pandemic by the World Health Organization (WHO).[1] As of December 6, 2021, there have been 265,194,191 confirmed cases of COVID-19, including 5,254,116 deaths.[2] Considering its widespread relevance, the COVID-19 pandemic may impact people's interest in infectious diseases and their lifestyles.[3] Therefore, the interest in preventive measures against infectious diseases may be growing worldwide at a whole new level. However, the magnitude of the impact on people's preventive behavior is difficult to measure objectively, and the differences in behaviors among countries are unclear. Moreover, with the prolonged pandemic, it is uncertain whether the growing interest in preventive actions against infectious diseases can be sustained.

When faced with rapidly progressing infectious disease outbreaks, such as COVID-19, the assessment of population awareness on infection prevention behaviors needs to be accomplished promptly if the findings are informative in the context of the public health response. However, such an assessment is not an easy task. For instance, population-representative household surveys generally require several months of preparation and data collection; therefore, they do not always provide timely results. Such an effort could be aided using available web search query data, which provide insight into public interests related to such behaviors.

The use of internet search data to draw conclusions on the determinants and delivery of health information is known as infodemiology.[4, 5] Since the first reported use of search engine data to track the 2008 influenza epidemic,[6] several research publications related to behavioral change and public interest in health have utilized the same.[7–11] Google Trends is a web-based tool that analyzes a portion of daily Google searches, generating data on geographical and temporal patterns according to specified keywords. Previous studies showed an accurate prediction and forecasting of current public interests, which allowed for the analysis of various fields.[12–14]

This year, some researchers have investigated the impact of COVID-19 using Google Trends. Effenberger et al.[15] showed a relationship between the highest interest and the peak of newly confirmed cases. Also, Walker et al.[16] reported a correlation between symptom search terms and confirmed case growth. In addition, Sousa-Pinto et al. [17] reported the relationship between media coverage and COVID-19 keywords, whereas Heerfordt et al. [18] evaluated whether COVID-19 was associated with smoking cessation behaviors. Kutlu [19] reported the trends and impacts of dermatologic diseases on public perceptions during the COVID-19 pandemic, and Onchonga [20] reported on the use of the interest in self-medication during the COVID-19 pandemic.

However, the impact of the global COVID-19 pandemic on the long-term interest in preventive measures against infectious diseases has not been studied, and whether such interest can be sustained or is only temporary. Moreover, global differences in public interest regarding COVID-19 and preventive measures have not been objectively monitored.

The purpose of this study was to assess the magnitude of COVID-19's impact on public interest regarding preventive behaviors, by focusing on the pace at which public interest increased due to the COVID-19 pandemic, suitability of the interest, and types of preventive measures preferred by different countries.

MATERIALS AND METHODS

Google Trends was used to quantify and measure changes in internet searches regarding the COVID-19 pandemic worldwide and in each country.

Google trends function

Google Trends uses a fraction of searches for a specific term (also known as "keyword" or "search term") and then analyzes the number of Google searches according to a geographical location and defined timeframe. After the examined keyword(s) or topic(s), the region and the period are entered. The region can be a country, a region, or a combined data set of all regions (global). The popularity of a search term in a given week relative to other weeks in the mentioned time period within a geographic region is shown as relative search volume (RSV). The most popular week has an RSV of 100 and all other weeks are reported relative to the most popular week on a scale from 0 to 99. For example, an RSV of 50 would indicate that search term was 50% as popular as it was in the most popular week. A score of 0 indicates that there are not enough searches to show for this term in the week. When a sufficient number of searches cannot be confirmed for a search keyword or topic in a specified country, the system displays that the data cannot be retrieved.

For international comparisons among countries that use different languages, topic searches are useful. Topics are a group of terms that share the same concept in any language, and they are displayed below search terms. For example, when we search the topic "London," the search includes results for topics such as: "Capital of the UK" and "Londres," which is "London" in Spanish. This study used topic searches following keywords in 196 countries.

The data are retrieved directly from the Google Trends Explore page in .csv format. If the survey period is long, the values are displayed as weekly values.

Target country, search term selection, and study term

For 196 countries and regions around the world, Google Trend's "Topics" was used to show the RSVs of "coronavirus" and typical preventive behaviors, including "wash hand" and "social distancing," and the supplies needed for prevention, such as "hand sanitizer" and "mask." These topic terms were mentioned on the CDC site [21] as recommendations for prevention and were listed as related topics in Google Trend's coronavirus.

The specified survey period was set using the following procedures: First, the end of October 2021 was set as the study's end period, and the most recent RSV was obtained on November 1, 2021. Second, the study's starting point was set from the same interval period between the WHO pandemic declaration and the study's end period. It was 85 weeks before and 85 weeks after the

week of March 11, 2020. [1] Therefore, the date range was from the week of July 22, 2018, to that of October 24, 2021. Assessing the timing of raising interest of each topic term

For each country's topic term, the week in which RSV exceeded 50 (RSV50) after the beginning of 2020 was defined as the timing of the rise in RSV in each country. In Google Trends, RSV50 means 50% of search activity of the peak (RSV100) was performed in particular countries and regions using the defined term. Assessing the sustainability of people's interest

In this study, the sustainability of interest was assessed by comparing the last 20 weeks (from the week of June 13, 2021 to that of October 24, 2021) of the survey period with the first 20 weeks (from the week of July 22, 2018 to that of December 2, 2018) for each topic term. This was because all topics used in this study are terms that had been used prior to the COVID-19 pandemic; thus, if the RSV in the latter period, which was more than 1 year after the WHO pandemic declaration, was higher than the RSV in the period before the outbreak, the sustainability on public interest was presented regardless of its magnitude.

Statistical analysis

The Mann–Whitney U test was used to compare the RSV during the first 20 weeks at the beginning of the study (from the week of July 22, 2018 to that of December 2, 2018) with the RSV during the last 20 weeks at the end of the study (from the week of June 13, 2021 to that of October 24, 2021) for each topic term. All statistical analyses were performed using SPSS version 25 (IBM, Armonk, NY, USA). All figures were created using Microsoft Excel (Microsoft Inc., Seattle, WA, USA). $P < 0.05$ was considered statistically significant.

Ethical considerations

The study did not require ethics approval because the RSVs obtained from Google Trends were publicly available, fully anonymized, and aggregated data.

Patient and public involvement

No patients and no public were involved in setting the research question or the outcome measures, nor were they involved in developing plans for design or implementation of the study. No patients and no public were asked to advise on interpretation or writing up of results. There are no plans to disseminate the results of the research to study participants or the relevant patient community.

RESULTS

Global trends (Combined data set of all regions)

The search terms "coronavirus," "wash hand," "social distancing," "hand sanitizer," and "mask" reached RSV 50 by the week of the WHO pandemic declaration (March 11, 2020) in global trends (combined data set of all regions). Subsequently, "coronavirus," "wash hand," and "hand sanitizer" RSVs peaked (RSV100) in the week of the WHO pandemic declaration. This was followed by the RSV of "social distancing" a week later (the week of March 15, 2020), and that of "mask" 3 weeks

later (the week of April 5, 2020) (Figure 1). In Global Trends, the RSVs of "coronavirus", "wash hand", "social distancing", "hand sanitizer", and "mask" were significantly higher ($p<0.05$) in the last 20 weeks of the study period (from the week of June 13, 2021 to the week of October 24, 2021) than in the first 20 weeks before the pandemic declaration (from the week of July 22, 2018 to that of December 2, 2018).

Search word "Coronavirus" trend

"Coronavirus" RSVs were obtained in 196 countries and territories. All of the target countries and regions had enough searches to show RSVs. In late January 2020, only eight countries (4.1%) in and mainly around China reached RSV50 (Bhutan, China, Laos, Macao, Mongolia, Philippines, Thailand, and Vietnam). However, in the week of the pandemic declaration (the week of March 8, 2020), the number of countries that reached RSV50 rose sharply, especially in the Americas and Europe, and by late March, 85% of all the countries and regions, including African countries, reached RSV50. Japan, which was the only G7 country that did not initially have an RSV ≥50, had an RSV ≥50 at this time. In early April, the RSV reached 50 in all targeted regions (Table 1, Figure 2).

Search word "Wash Hand" trend

A total of 192 countries and territories had "wash hand" RSVs, and four countries (Central Africa, Commonwealth of Dominica, Eritrea, and Turks and Caicos Islands) did not have enough searches to show RSVs. Six countries (3.1%) reached RSV50 in late January 2020 and included mostly Asian countries around China: Brunei, Vietnam, South Korea, Taiwan, Cambodia, and Singapore. Moreover, Bhutan, Cyprus, Syria, Antigua, and Barbuda were also above RSV50, but this was a temporary increase as it dropped to zero in the following week of late January 2020.

In the week after the pandemic was declared (the week of March 8, 2020), 107 countries (54.6%), mainly in North America, Europe, and Asia, had RSVs ≧50, and by late March, 160 countries (81.6%), including most countries in South America, had RSVs ≧50. Japan, which was the only G7 country that did not have an RSV ≧50 in the week of March 8, 2020, had an RSV ≧50 at this time. Conversely, even in early April, the RSV did not exceed 50 in 21 countries (10.7%), including nine countries on the African continent (Algeria, Botswana, Burundi, Cameroon, Mozambique, Republic of Congo, Seychelles, Sudan, and Vanuatu) and countries in other areas (Table 1, Figure 2).

Search word "Social Distancing" trend

"Social distancing" RSVs were obtained in 174 countries and territories. There were 21 regions and countries that did not have enough searches to show RSVs.

Only 18 countries (9.2%) had an RSV ≧50, even in the week when the pandemic was declared (the week March 8, 2020). In late March, 102 countries (52.0%), mainly in the Americas, Europe, and Asia, had an RSV ≧50. In early April, 125 countries (65.3%) had an RSV ≧50, but 49 countries (25.0%) in various regions, including two G7 countries (France, Italy) in Europe (n=7), Asia and Oceania (n=10), America (n=16), and Africa (n=16) did not have an RSV ≧50 (Table 1, Figure 2). The highest number countries did not reach an RSV of 50 and above with respect to the search

term “social distancing” (n=49) by early April when compared with other study terms, such as “coronavirus” (n=0), “wash hand” (n=21), “hand sanitizer” (n=7), and “mask.” n=41).

Search word “Hand Sanitizer” trend

In 193 countries and territories, “hand sanitizer” RSVs were available, and in the three countries (Central Africa, Eritrea, and Liechtenstein), there were not enough searches to show RSVs.

In late January 2020, eight countries (4.1%), mainly those around China (Cambodia, China, Macao, Maldives, Singapore, South Korea, Taiwan, and Vietnam), had RSVs ≧50, and in the week of the pandemic declaration, the number of countries with an RSV ≧50 increased to 121 (61.7%). Subsequently, the number of countries with an RSV ≧50 gradually increased to 187 (95.4%) in early April (Table 1, Figure 2). The countries with RSVs <50 by early April (Burundi, Commonwealth of Dominica, Liberia, New Caledonia, Suriname, Tajikistan, Turkmenistan) had reached an RSV of 50 at various later times.

Search word “Mask” trend

Valid “mask” RSVs were obtained for 195 countries and regions, and only one country (Eritrea) did not have enough searches to display an RSV. In late January 2020, 27 countries (13.8%) had an RSV ≧50. They consisted mainly of countries around China (Cambodia, China, Japan, Lao PDR, Macao, Malaysia, Mongolia, Myanmar, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam) and some countries in other areas. In late March, there were 130 countries with an RSV ≧50, in contrast, the United States and some European countries still did not have an RSV ≧50. Then, in early April, 154 countries (78.6%) had an RSV ≧50. Forty-one countries including many major European countries (Belgium, Finland, France, Germany, Ireland, Switzerland, and the United Kingdom), African countries, countries on the South American continent, Australia, and New Zealand did not reach RSV ≧50 by early April and had reached an RSV of 50 at various later times (Table 1, Figure 2).

Comparison of RSV in ≥65 weeks after the declaration of the pandemic and before the COVID-19 pandemic

In 191 countries, the RSV of “coronavirus” was significantly higher ($p<0.05$) in the last 20 weeks of this study term than in its first 20 weeks before the pandemic declaration. There were five countries (Central Africa, Djibouti, Eritrea, Liberia, and Samoa) that had no significant difference.

In 24 countries (12.2%), the RSV of “wash hand” was significantly higher ($p<0.05$) in the last 20 weeks of this study term than in its first 20 weeks before the pandemic declaration. The majority of these countries were from Asia and Oceania (Australia, Bangladesh, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam), followed by those the Americas (Brazil, Chile, Colombia, Ecuador, Nicaragua, USA, and Venezuela), Europe (Netherlands and United Kingdom), and Africa (Kenya and South Africa).

The RSV for “social distancing” was significantly higher ($p<0.05$) in 41 countries (20.9%) in the last 20 weeks than in the first 20 weeks of this study before the pandemic declaration. It was widely distributed among 14 Asian and Oceania countries (Australia, Bangladesh, Fiji, India, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore, South Korea, Taiwan,

Thailand, and Vietnam), three Middle Eastern countries (Pakistan, Saudi Arabia, and the UAE) with the above and upper middle income, seven European countries (France, Germany, Ireland, Italy, Spain, Turkey, and the United Kingdom, 14 American countries (Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, USA, and Venezuela), and three African countries (South Africa, South Sudan, and Zimbabwe).

In 74 countries (37.8%), "hand sanitizer" was a significantly higher RSV ($p<0.05$) in the last 20 weeks of this study term than in the first 20 weeks before the pandemic declaration. The distribution of countries with statistical significance was widely distributed among 20 Asian and Oceania countries (Australia, Bangladesh, Brunei, Cambodia, China, India, Indonesia, Japan, Kazakhstan, Malaysia, Myanmar, Nepal, New Zealand, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam), eight Middle Eastern countries (Iran, Kuwait, Lebanon, Oman, Pakistan, Qatar, Saudi Arabia, and the UAE), 17 European countries (Belgium, Demark, Finland, France, Georgia, Germany, Ireland, Italy, Netherland, Norway, Poland, Portugal, Russia, Spain, Turkey, Ukraine, and the United Kingdom), 17 American countries (Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Mexico, Paraguay, Peru, Puerto Rico, Trinidad and Tobago, USA, Uruguay, and Venezuela), and 12 African countries (Algeria, Botswana, Ethiopia, Kenya, Libya, Mauritius, Morocco, Nigeria, South Africa, Tunisia, Uganda, and Zimbabwe).

In 98 countries (50.0%), the RSV of "mask" was significantly higher ($p<0.05$) in the last 20 weeks of this study term than in its first 20 weeks before the pandemic declaration. This was a higher percentage than for any other prevention-related word. Those with significant differences in RSV included 34 European (Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Demark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Isle of Man, Ireland, Jersey, Kosovo, Latvia, Lithuania, Luxembourg, Malta, Moldova, Netherlands, Poland, Portugal, Romania, Russia, Slovenia, Spain, Switzerland, Turley, Ukraine, and the United Kingdom), 16 American (Argentina, Bahamas, Barbados, Brazil, Canada, Cuba, Dominican Republic, Guam, Jamaica, Mexico, Panama, Sint Maarten, Saint Helena, Trinidad and Tobago, USA, and Venezuela), 19 Asian and Oceania (Australia, Bangladesh, Bhutan, Brunei, Cambodia, Fiji, India, Indonesia, Japan, Kazakhstan, Macao, Malaysia, Nepal, New Zealand, Philippines, Singapore, Sri Lanka, Taiwan, and Uzbekistan), 12 Middle Eastern (Afghanistan, Bahrain, Iran, Iraq, Israel, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, the UAE, and Yemen), and 17 African countries (Democratic Republic of the Congo, Egypt, Ethiopia, Ghana, Kenya, Mauritius, Morocco, Nigeria, Reunion, Rwanda, Senegal, Somalia, South Africa, Sudan, Uganda, Zambia, and Zimbabwe) (Figure 3).

DISCUSSION

The COVID-19 pandemic has had a significant impact on global public awareness and behavior, including an increased interest in the prevention of infectious diseases. However, the magnitude of the impact and the differences among countries are unclear. To our knowledge, this is the first study to use Google Trends to objectively show the trends in people's interest in COVID-19 and its preventive measures in countries and regions worldwide. As globalization progresses, it is necessary to consider countermeasures against globally transmitted infectious diseases, such as

COVID-19, from a global perspective. Therefore, understanding the trends in people's interest in preventive measures is important to consider global countermeasures. We noted some interesting observations in the present situation of the global interest in COVID-19 and preventable measures.

First, the global interest in coronaviruses among people with COVID-19 has increased to an unprecedented level after WHO declared a pandemic in March 2020;[1] interest in "coronavirus" has been maintained to a certain extent even now, more than a year and a half after the outbreak. We also noted an increase of interest in preventable measures globally. However, the timings of the increase differed by country and region. Even though most countries also "reacted" to prevention measures at the timing of the WHO pandemic declaration, some countries increased interest in preventable measures much earlier than others. Geographical and political factors may have influenced the timing of the increase. For example, the countries around China, such as (e.g., Vietnam), increased their public interest much before the WHO's pandemic declaration, when Chinese travelers were banned from the country at a very early phase. [22] Contrastingly, in Japan, the interest in "coronavirus" and preventable measures peaked much later than in other high-income countries after the WHO pandemic declaration; it was when a state of emergency was first declared by the Japanese government on April 7, 2020.

We focused on not only the "increase" in awareness but also how to sustain the interest in measures for preventing infectious diseases. We found that, in most countries and regions, people's interest in COVID-19 and preventive measures increased, but the persistence of interest in these preventable measures was not necessarily maintained; there was also a difference in the sustainability level of interest by country and region. Furthermore, with these differences in each country's characteristics, there are also differences in sustainability between the search words "wash hand," "social distancing," "hand sanitizer", and "mask".

The sustainability of people's interest in masks was confirmed in a wide range of countries and regions than other search terms. At the beginning of the outbreak, interest in masks spread mainly in Asian countries relatively quickly, where a mask culture was already present. A report showed the regional difference of wearing masks by region at an early stage of the COVID-19 pandemic. [23] This might be attributed to the geographic differences and the cultural differences that could have enhanced self-protecting habits. [24] However, notably, the sustainability of the other word "impact" of "masks" was confirmed in many countries that are not necessarily familiar with the practice of wearing of masks during winter, such as many Western countries. [25] This implies that familiarity with masks may spread in countries without a mask-wearing culture. Although the effectiveness of facemask use in community settings for COVID-19 prevention has been controversial, [26–28] the COVID-19 pandemic introduced a "new culture" to these countries and regions.

Contrastingly, countries that were able to sustain interest in the search term "wash hand" were relatively limited. Notably, the impact of COVID-19 was confirmed in relatively few European countries with low sustainable interest for the term "wash hand", where the cumulative number of confirmed cases was high. [2] The impact was concentrated in Southeast and East Asian countries, where the number of confirmed cases and death rates were relatively low. [2] This suggests that for the countries that did not sustain the interest of "wash hand," including many European countries, interventions to maintain public interest may be necessary in cases of repeated outbreaks.

As governments consider effective ways to control infections, they need to consider the fact that they may not be able to sustain the population's interest in preventive actions against infection.

Countries in East and Southeast Asia maintained an interest in "wash hand" and in other preventable measures such as "social distancing" and "hand sanitizer". Thus, in these regions, the COVID-19 pandemic had a great impact on the public mind's interest and awareness of prevention measures against infectious diseases. Since prevention methods are common to many infectious diseases, the increased awareness of people regarding the prevention measures due to the COVID-19 pandemic can be expected to be reflected in future COVID-19 trends and in the decrease in other infectious diseases. Some previous studies in East Asia reported that the number of seasonal influenza cases in the 2019–2020 season was lower after COVID-19 transmission than in previous years and suggested the positive effects of prevention measures against COVID-19 on seasonal influenza. [29–31] The National Institute of Infectious Diseases in Japan also reported that in 2020 and 2021, mycoplasma pneumonia, respiratory syncytial virus infection, and Group A streptococcal pharyngitis decreased, whereas infectious gastroenteritis significantly decreased and reached its lowest level in a decade. [32] These infections can be effectively prevented by washing hands, social distancing, using hand sanitizers, and wearing masks as discussed in this study. In combination with these trends and the results from this study, it is suggested that the increasing interest in preventive actions in East Asian countries may be associated with the decrease in other infectious diseases.

The other main finding of the difference between the regions is the slower pace of development of interest in countries on the African continent as well as the limited areas where the persistence of interest had been observed, especially in terms that were related to behavior change, such as "wash hand" and "social distancing". When we interpret data about African countries, it is necessary to consider the level of internet availability because African countries have relatively low internet availability. [33] However, considering that the trend of increased and sustained interest in "coronavirus" was confirmed even in African countries at the same level as other regions, the general interest in preventive measures in the African continent can be evaluated as being relatively lower. Thus, the data can be used as a reference for understanding the present situation in Africa. Some studies also mentioned the issues in attitude toward knowledge and healthy practices, including COVID-19 preventive practices in African countries. [34–36] The low-level interest in preventive measures in African countries needs to be considered in future strategies for expanding preventive measures against infectious disease at the global level. As the pandemic is still unfolding, there is a strong need to continually implement measures such as health promotions to better understand the pandemic and related health behaviors in the African population and the countries with low impact on public interest for preventable measures.

This study had some limitations. First, the differences in internet availability may have affected the results. Second, the percentage of Google users may have affected the global-level evaluation of public interest using Google Trends. For example, a typical case is that Google's share as a web search engine in China is very low because they may have used other search engines and hence, did not use Google. [37] Therefore, Google Trends is not a suitable tool for understanding trends in countries such as China; the results of these countries should be interpreted with this prior knowledge in mind.

CONCLUSION

The COVID-19 pandemic may have impacted the global public interest of prevention measures against infectious diseases. However, there are differences in interest related to preventable measures and sustainability of that interest between countries and regions. The increased interest in preventive behaviors against COVID-19 may be related to overall infectious disease prevention. These global differences should be considered when implementing effective interventions against infectious diseases at the global level.

Competing Interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

Tomoo Ito was involved in the study design, data analysis, interpretation, and creation of tables and figures, and wrote the final report.

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All work on this paper was done by Tomoo Ito alone, and there were no other collaborators on this paper.

Data Availability Statement

The data that support the findings of this study are available from the author upon reasonable request.

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Tables

Table 1. Number of countries with an RSV ≧50

	Week of January 26, 2020	Week of February 23, 2020	Week of March 8, 2020	Week of March 22, 2020	Week of April 5, 2020
RSV "coronavirus"					
Number of countries with RSV > 50, N (%)	8 (4.1%)	18 (9.2%)	118 (60.2%)	189 (86.4%)	196 (100%)
Number of countries without valid data, N (%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
RSV"wash hands"					
Number of countries with RSV ≧ 50, N (%)	10 (5.1%)	37 (19.9%)	107 (54,7%)	160 (81.6%)	171 (87.1%)
Number of countries without valid data, N (%)	4 (2.0%)	4 (2.0%)	4 (2.0%)	4 (2.0%)	4 (2.0%)
RSV"social distancing"					
Number of countries with RSV ≧ 50, N (%)	0 (0.0%)	0 (0.0%)	19 (9.2%)	102 (52.8%)	125 (62.6%)
Number of countries without valid data, N (%)	22 (11.2%)	22 (11.2%)	22 (11.2%)	22 (11.2%)	22 (11.2%)
RSV "hand sanitizer"					
Number of countries with RSV ≧ 50, N (%)	8 (4.1%)	24 (12.2%)	121 (61.4%)	186 (94.4%)	187 (94.9%)
Number of countries	3 (1.5%)	3 (1.5%)	3 (1.5%)	3 (1.5%)	4 (1.5%)

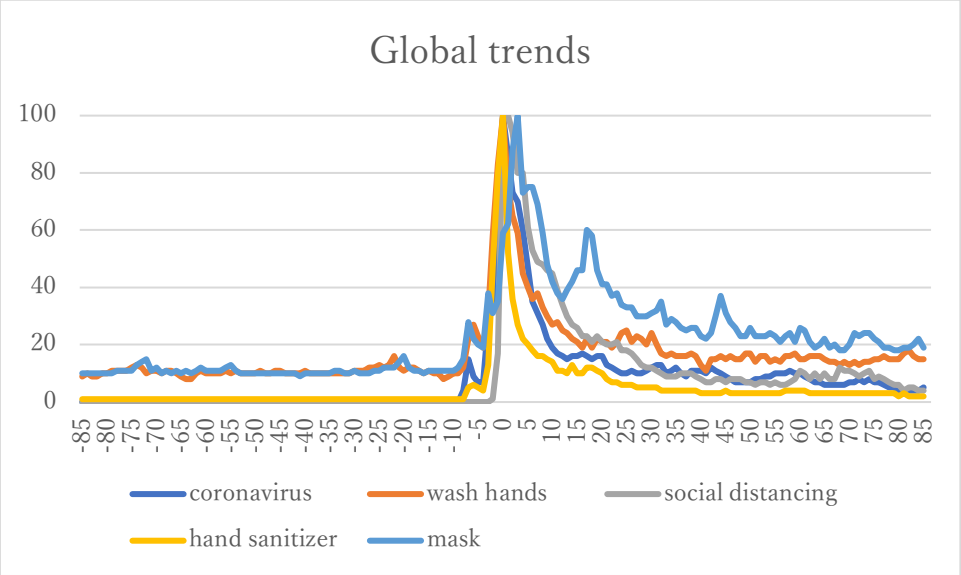
without valid data, N (%)					
RSV "Masks"					
Number of countries with RSV ≧ 50, N (%)	27 (13.8%)	65 (33.2%)	77 (39.3%)	130 (66.3%)	154 (83.4%)
Number of countries without valid data, N (%)	1 (0.5%)	1 (0.5%)	1 (0.5%)	1 (0.5%)	1 (0.5%)

Figure captions

Fig 1. RSV of "coronavirus," "wash hand", "social distancing", "hand sanitizer", and "mask" in the combined data for all countries and regions.
Horizontal axis: depicts the time period. The week of March 11, 2020, when WHO declared a pandemic, is set to 0 and increases hence. The weeks following the week of the pandemic declaration are numbered 1, 2, 3, and so on, until the 85th week (85 depicts the 85th week). The week before the pandemic declaration (0) is numbered -1 for the week one week before, -2 for the week two weeks before, and so on, until the 85th week (-85 means 85 weeks before the declaration of the pandemic).
Vertical axis: RSV value

Fig 2. Distribution trend of countries with "coronavirus" "wash hand" "social distancing" "hand sanitizer" and "mask" RSV ≧50 after the COVID-19 outbreak
Area colored orange: countries with RSV "coronavirus" ≧50
Area colored blue: countries without "coronavirus" ≧50
Are colored gray: countries without valid data

Fig 3. Distribution of countries with statistically significant RSV of "coronavirus", "wash hand", "social distancing", "hand sanitizer", and "mask" in the last 20 weeks compared with that before the COVID-19 pandemic.
Area colored red: countries with statistical significance in the last 19 weeks versus before the COVID-19 pandemic.
Area colored white: countries without statistical significance in the last 19 weeks versus before the COVID-19 pandemic.
Area colored gray: countries without valid data



STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	P1 P2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	P2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	P3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	P3-4
Methods			
Study design	4	Present key elements of study design early in the paper	P4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	P4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	P4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	P4-5
Bias	9	Describe any efforts to address potential sources of bias	P4-5
Study size	10	Explain how the study size was arrived at	P4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	P4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	P4-5
		(*b*) Describe any methods used to examine subgroups and interactions	P4-5
		(*c*) Explain how missing data were addressed	P4-5
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	P4-5
		(*e*) Describe any sensitivity analyses	N/A

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	P4-5
		(b) Give reasons for non-participation at each stage	P4-5
		(c) Consider use of a flow diagram	P4-5
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	P4-5
		(b) Indicate number of participants with missing data for each variable of interest	P4-5
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	P5-8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	P5-8
		(*b*) Report category boundaries when continuous variables were categorized	P5-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	P5-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	P8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P8-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	P8-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Global Monitoring of Public Interest in Preventive Measures against COVID-19 via Analysis of Google Trends: An Infodemiology and Infoveillance Study

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Global Monitoring of Public Interest in Preventive Measures against COVID-19 via Analysis of Google Trends: An Infodemiology and Infoveillance Study

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Abstract

Objectives: The coronavirus disease 2019 (COVID-19) pandemic has influenced people's concerns regarding infectious diseases and their preventive measures. However, the magnitude of the impact and the difference between countries are unclear. This study aimed to assess the magnitude of the impact of COVID-19 on public interest and people's behaviors globally in preventing infectious diseases while comparing international trends and sustainability.

Design: An infodemiology and infoveillance study

Setting: The study employed a web-based data collection to delineate public interest regarding COVID-19 preventive measures using Google Trends.

Primary and secondary outcome measures: A relative search volume was assigned to a keyword, standardizing it from 0 to 100, with 100 representing the highest share of the term searches. The search terms "coronavirus," "wash hand," "social distancing," "hand sanitizer," and "mask" were investigated across 196 different countries and regions from July 2018 to October 2021 and weekly reports of the relative search volume were obtained. Persistence of interest was assessed by comparing the first 20 weeks with the last 20 weeks of the study period.

Results: Although the relative search volume of "coronavirus" increased and was sustained at a significantly higher level ($p<0.05$) than before the pandemic declaration, globally, the trends and sustainability of the interest in preventable measures against COVID-19 varied between countries and regions.

Conclusions: Sustained interest in preventive measures differed globally, with regional differences noted among Asia, Europe, Africa, and the Americas. The global differences should be considered for implementing effective interventions against COVID-19. The increased interest in preventive behaviors against COVID-19 may be related to overall infectious disease prevention.

Strengths and limitations of this study

- This study used Google Trends to objectively show the trends in people's interest in COVID-19 and its preventive measures worldwide.
- The study monitors people's interest in preventive measures over a long period of time to assess the sustainability of the interest in preventable measures.
- The differences in internet availability and the percentage of Google users may have affected the global-level evaluation of public interest using Google Trends.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) was first reported in Wuhan, China, in November 2019 and was declared a public health emergency of international concern on January 31, 2020. On March 11, 2011, it was declared a pandemic by the World Health Organization (WHO).[1] As of December 6, 2021, there have been 265,194,191 confirmed cases of COVID-19, including 5,254,116 deaths.[2] Considering its widespread relevance, the COVID-19 pandemic may impact people's interest in infectious diseases and their lifestyles.[3] Therefore, the interest in preventive measures against infectious diseases may be growing worldwide at a whole new level. However, the magnitude of the impact on people's preventive behavior is difficult to measure objectively, and the differences in behaviors among countries are unclear. Moreover, with the prolonged pandemic, it is uncertain whether the growing interest in preventive actions against infectious diseases can be sustained.

When faced with rapidly progressing infectious disease outbreaks, such as COVID-19, the assessment of population awareness on infection prevention behaviors needs to be accomplished promptly if the findings are informative in the context of the public health response. However, such an assessment is not an easy task. For instance, population-representative household surveys generally require several months of preparation and data collection; therefore, they do not always provide timely results. Such an effort could be aided using available web search query data, which provide insight into public interests related to such behaviors.

The use of internet search data to draw conclusions on the determinants and delivery of health information is known as infodemiology.[4, 5] Since the first reported use of search engine data to

track the 2008 influenza epidemic,[6] several research publications related to behavioral change and public interest in health have utilized the same.[7–11] Google Trends is a web-based tool that analyzes a portion of daily Google searches, generating data on geographical and temporal patterns according to specified keywords. Previous studies have demonstrated accurate prediction and forecasting of current public interests, allowing for analysis in various fields.[12–14]

Since the Pandemic Declaration by the WHO in 2020, some researchers have investigated the impact of COVID-19 using Google Trends. The very first studies reported that Google Trends could forecast the rise of new cases.[15–17] Since then, studies on various COVID-19 topics have been conducted using Google Trends. Effenberger et al.[18] showed a relationship between the highest interest and the peak of newly confirmed cases. Walker et al.[19] reported a correlation between symptom search terms and confirmed case growth. Further, Sousa-Pinto et al.[20] reported a relationship between media coverage and COVID-19 keywords, whereas Heerfordt and Heerfordt[21] evaluated whether COVID-19 was associated with smoking cessation behaviors. Kutlu[22] reported the trends and impacts of dermatologic diseases on public perceptions during the COVID-19 pandemic, Springer et al.[23] reported the people's interest in the medical therapeutic direction, and Onchonga[24] reported on the use of the interest in self-medication during the COVID-19 pandemic.

However, the impact of the global COVID-19 pandemic on the long-term interest in preventive measures against infectious diseases has not been studied, and whether such interest can be sustained or is only temporary. Moreover, global differences in public interest regarding COVID-19 and preventive measures have not been objectively monitored.

This study aimed to assess the magnitude of COVID-19's impact on public interest regarding preventive behaviors by focusing on the pace at which public interest increased due to the COVID-19 pandemic, the suitability of the interest, and types of preventive measures preferred by different countries.

MATERIALS AND METHODS

Google Trends was used to quantify and measure changes in internet searches regarding the COVID-19 pandemic worldwide and in each country.

Google Trends' function and data collection method

Google Trends uses a fraction of searches for a specific term (also known as "keyword" or "search term") and then analyzes the number of Google searches according to a geographical location and defined timeframe. After examining the keyword(s) or topic(s), the region and the period are entered. The region can be a country, a region, or a combined data set of all regions (global). The popularity of a search term in a given week relative to other weeks in the mentioned time period within a geographic region is shown as the relative search volume (RSV). The most popular week has a RSV of 100, while all other weeks are reported relative to the most popular week on a scale from 0 to 99. For example, a RSV of 50 would indicate that the search term was 50% as popular as it was in the most popular week. A score of 0 indicates insufficient searches to show for this term in the week. When a sufficient number of searches cannot be confirmed for a keyword or topic in a specified country, the system display indicates that the data cannot be retrieved.

For international comparisons among countries using different languages, topic searches are useful. Topics are a group of terms that share the same concept in any language, and they are displayed below search terms. For example, when we searched the topic "London," the search provided results for topics such as the "Capital of the UK" and "Londres"(Spanish), which is "London." This study used topic searches using keywords in 196 countries, and the results of the topic searches are reported as the frequency of searches for all included keywords that refer to the same concept, regardless of the language in the specific countries. This method allowed us to understand the situation on a global level, including in countries where English is not the native language.

The data are retrieved directly from the Google Trends Explore page in .csv format. If the survey period is long, the values are displayed as weekly values.

In this study, first, the RSV of one topic in one country was obtained for a defined period on a weekly basis. This work was repeated for all the topics. Second, the same process was repeated for the 196 countries and regions. Finally, differences between countries and regions in the trends and sustainability of the topics were examined. Data for global trends (combined data set of all regions) were obtained by changing the location setting on Google Trends to “Worldwide” for a defined period for each topic.

Target country, search term selection, and study term

For the 196 countries and regions around the world, Google Trend's “Topics” was used to show the RSVs of “coronavirus” and typical preventive behaviors, including “wash hand” and “social distancing,” and the supplies needed for prevention, such as “hand sanitizer” and “mask.” These

topic terms were mentioned on the Centers for Disease Control and Prevention (CDC) site [25] as recommendations for prevention and were listed as related topics in Google Trend's coronavirus.

The specified survey period was set using the following procedures: First, the end of October 2021 was set as the study's end period, and the most recent RSV was obtained on November 1, 2021. Second, the study's starting point was set from the same interval period between the WHO pandemic declaration and the study's end period. It was 85 weeks before and 85 weeks after the week of March 11, 2020. [1] Therefore, the date range was from the week of July 22, 2018, to that of October 24, 2021. Assessing the timing of raising the interest in each topic term

For each country's topic term, the week in which RSV exceeded 50 (RSV50) after the beginning of 2020 was defined as the timing of the rise in RSV in each country. In Google Trends, RSV50 means 50% of the search activity of the peak (RSV100) was performed in particular countries and regions using the defined term.

Assessing the sustainability of people's interest

In this study, the sustainability of interest was assessed by comparing the last 20 weeks (from the week of June 13, 2021, to that of October 24, 2021) of the survey period with the first 20 weeks (from the week of July 22, 2018, to that of December 2, 2018) for each topic term. This was because all topics used in this study are terms that had been used before the COVID-19 pandemic; thus, if the RSV in the latter period, which was more than 1 year after the WHO pandemic declaration, was higher than the RSV in the period before the outbreak, the sustainability on public interest was presented regardless of its magnitude.

Statistical analysis

The Mann–Whitney U test was used to compare the RSV during the first 20 weeks at the beginning of the study (from the week of July 22, 2018, to that of December 2, 2018) with the RSV during the last 20 weeks at the end of the study (from the week of June 13, 2021, to that of October 24, 2021) for each topic term. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 25 (IBM Corp., Armonk, NY, USA). $P < 0.05$ was considered statistically significant.

Ethical considerations

The study did not require ethics approval because the RSVs obtained from Google Trends were publicly available, fully anonymized, and aggregated data.

Patient and public involvement

No patients and/or general public were involved in setting the research question or the outcome measures, nor were they involved in developing plans for the study design or implementation. They were not asked to advise on the interpretation or writing of results. There are no plans to disseminate the research results to study participants or the relevant patient community.

RESULTS

Global trends (combined data set of all regions)

The search terms “coronavirus,” “wash hand,” “social distancing,” “hand sanitizer,” and “mask” reached RSV 50 by the week of the WHO pandemic declaration (March 11, 2020) in global trends (combined data set of all regions). Subsequently, “coronavirus,” “wash hand,” and “hand sanitizer”

RSVs peaked (RSV100) in the week of the WHO pandemic declaration. This was followed by the RSV of "social distancing" a week later (the week of March 15, 2020) and that of "mask" 3 weeks later (the week of April 5, 2020) (Figure 1). In Global Trends, the RSVs of "coronavirus," "wash hand," "social distancing," "hand sanitizer," and "mask" were significantly higher ($p<0.05$) in the last 20 weeks of the study period (from the week of June 13, 2021, to the week of October 24, 2021) than in the first 20 weeks before the pandemic declaration (from the week of July 22, 2018, to that of December 2, 2018).

Search word "coronavirus" trend

"coronavirus" RSVs were obtained in 196 countries and territories. All of the target countries and regions had enough searches to show RSVs. In late January 2020, only eight countries (4.1%) in and mainly around China reached RSV50 (Bhutan, China, Laos, Macao, Mongolia, Philippines, Thailand, and Vietnam). However, in the week of the pandemic declaration (the week of March 8, 2020), the number of countries that reached RSV50 rose sharply, especially in the Americas and Europe, and by late March, 96.4% of all the countries and regions, including African countries, reached RSV50. Japan, which was the only G7 country that did not initially have a RSV ≥50, had a RSV ≥50 at this time. In early April, the RSV reached 50 in all targeted regions (Table 1, Figure 2).

Table 1. **Number of countries with a RSV ≧50**

	Week of January 26, 2020	Week of February 23, 2020	Week of March 8, 2020	Week of March 22, 2020	Week of April 5, 2020
RSV "coronavirus"					
Number of countries with RSV > 50, N (%)	8 (4.1%)	18 (9.2%)	118 (60.2%)	189 (96.4%)	196 (100%)
Number of countries without valid data, N (%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
RSV"wash hand"					
Number of countries with	10 (5.1%)	37 (18.9%)	107 (54.6%)	160 (81.6%)	171 (87.2%)

RSV ≧ 50, N (%)					
Number of countries without valid data, N (%)	4 (2.0%)	4 (2.0%)	4 (2.0%)	4 (2.0%)	4 (2.0%)
RSV“social distancing”					
Number of countries with RSV ≧ 50, N (%)	0 (0.0%)	0 (0.0%)	18 (9.2%)	102 (52.0%)	125 (63.8%)
Number of	22 (11.2%)	22 (11.2%)	22 (11.2%)	22 (11.2%)	22 (11.2%)

countries without valid data, N (%)					
RSV “hand sanitizer”					
Number of countries with RSV ≧ 50, N (%)	8 (4.1%)	24 (12.2%)	121 (61.7%)	186 (94.9%)	187 (95.4%)
Number of countries without valid data, N (%)	3 (1.5%)	3 (1.5%)	3 (1.5%)	3 (1.5%)	3 (1.5%)

RSV "mask"					
Number of countries with RSV ≧ 50, N (%)	27 (13.8%)	65 (33.2%)	77 (39.3%)	130 (66.3%)	154 (78.6%)
Number of countries without valid data, N (%)	1 (0.5%)	1 (0.5%)	1 (0.5%)	1 (0.5%)	1 (0.5%)

Search word "wash hand" trend

In total, 192 countries and territories had "wash hand" RSVs, and four countries (Central Africa, Commonwealth of Dominica, Eritrea, and Turks and Caicos Islands) did not have enough searches to show RSVs. Six countries (3.1%) reached RSV50 in late January 2020 and included mostly

Asian countries around China: Brunei, Cambodia, Singapore, South Korea, Taiwan, and Vietnam. Moreover, Antigua and Barbuda, Bhutan, Cyprus, and Syria were also above RSV50, but this was a temporary increase as it dropped to zero in the following week of late January 2020.

In the week after the pandemic was declared (the week of March 8, 2020), 107 countries (54.6%), mainly in North America, Europe, and Asia, had RSVs ≧50, and by late March, 160 countries (81.6%), including most countries in South America, had RSVs ≧50. Japan, which was the only G7 country that did not have a RSV ≧50 in the week of March 8, 2020, had a RSV ≧50 at this time. Conversely, even in early April, the RSV did not exceed 50 in 21 countries (10.7%), including nine countries on the African continent (Algeria, Botswana, Burundi, Cameroon, Mozambique, Republic of Congo, Seychelles, Sudan, and Vanuatu) and countries in other areas (Table 1, Figure 2).

Search word "social distancing" trend

"social distancing" RSVs were obtained in 174 countries and territories. There were 22 regions and countries that did not have enough searches to show RSVs.

Only 18 countries (9.2%) had a RSV ≧50, even when the pandemic was declared (the week of March 8, 2020). In late March, 102 countries (52.0%), mainly in the Americas, Europe, and Asia, had a RSV ≧50. In early April, 125 countries (63.8%) had a RSV ≧50, but 49 countries (25.0%) in various regions, including two G7 countries (France, Italy) in Europe (n=7), Asia and Oceania (n=10), America (n=16), and Africa (n=16) did not have a RSV ≧50 (Table 1, Figure 2). The highest number of countries did not reach a RSV ≥50 with respect to the search term "social distancing" (n=49) by early April compared with that noted for other study terms, such as "coronavirus" (n=0), "wash hand" (n=21), "hand sanitizer" (n=7), and "mask." n=41).

Search word "hand Sanitizer" trend

In 193 countries and territories, "hand sanitizer" RSVs were available, and in the three countries (Central Africa, Eritrea, and Liechtenstein), there were not enough searches to show RSVs.

In late January 2020, eight countries (4.1%), mainly those around China (Cambodia, China, Macao, Maldives, Singapore, South Korea, Taiwan, and Vietnam), had RSVs ≧50, and in the week of the pandemic declaration, the number of countries with a RSV ≧50 increased to 121 (61.7%). Subsequently, the number of countries with a RSV ≧50 gradually increased to 187 (95.4%) in early April (Table 1, Figure 2). The countries with RSVs <50 by early April (Burundi, Commonwealth of Dominica, Liberia, New Caledonia, Suriname, Tajikistan, Turkmenistan) had reached a RSV of 50 at various later times.

Search word "mask" trend

Valid "mask" RSVs were obtained for 195 countries and regions, and only one country (Eritrea) did not have enough searches to display a RSV. In late January 2020, 27 countries (13.8%) had a RSV ≧50. They consisted mainly of countries around China (Cambodia, China, Japan, Lao PDR, Macao, Malaysia, Mongolia, Myanmar, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam) and some countries in other areas. In late March, there were 130 countries with a RSV ≧50; in contrast, the United States and some European countries still did not have a RSV ≧50. Then, in early April, 154 countries (78.6%) had a RSV ≧50. Forty-one countries, including many major European countries (Belgium, Finland, France, Germany, Ireland, Switzerland, and the United Kingdom), African countries, countries on the South American continent, Australia, and New Zealand had not reached RSV ≧50 by early April but had reached RSV of 50 at various later times (Table 1, Figure 2).

Comparison of RSV ≥65 weeks after the declaration of the pandemic and before the COVID-19 pandemic

In 191 countries, the RSV of "coronavirus" was significantly higher ($p<0.05$) in the last 20 weeks of this study term than in its first 20 weeks before the pandemic declaration. There were five countries (Central Africa, Djibouti, Eritrea, Liberia, and Samoa) with no significant difference.

In 24 countries (12.2%), the RSV of "wash hand" was significantly higher ($p<0.05$) in the last 20 weeks of this study term than in its first 20 weeks before the pandemic declaration. The majority of these countries were from Asia and Oceania (Australia, Bangladesh, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam); followed by those of the Americas (Brazil, Chile, Colombia, Ecuador, Nicaragua, USA, and Venezuela); Europe (the Netherlands and the United Kingdom); and Africa (Kenya and South Africa).

The RSV for "social distancing" was significantly higher ($p<0.05$) in 41 countries (20.9%) in the last 20 weeks than in the first 20 weeks of this study before the pandemic declaration. It was widely distributed among 14 Asian and Oceania countries (Australia, Bangladesh, Fiji, India, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore, South Korea, Taiwan, Thailand, and Vietnam); three Middle Eastern countries (Pakistan, Saudi Arabia, and the UAE); seven European countries (France, Germany, Ireland, Italy, Spain, Turkey, and the United Kingdom); 14 American countries (Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Dominican Republic, Ecuador, Mexico, Panama, Paraguay, Peru, USA, and Venezuela); and three African countries (South Africa, South Sudan, and Zimbabwe).

In 74 countries (37.8%), "hand sanitizer" had a significantly higher RSV ($p<0.05$) in the last 20 weeks of this study term than in the first 20 weeks before the pandemic declaration. The countries

with statistical significance were widely distributed among 20 Asian and Oceania countries (Australia, Bangladesh, Brunei, Cambodia, China, India, Indonesia, Japan, Kazakhstan, Malaysia, Myanmar, Nepal, New Zealand, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam); eight Middle Eastern countries (Iran, Kuwait, Lebanon, Oman, Pakistan, Qatar, Saudi Arabia, and the UAE); 17 European countries (Belgium, Demark, Finland, France, Georgia, Germany, Ireland, Italy, Netherland, Norway, Poland, Portugal, Russia, Spain, Turkey, Ukraine, and the United Kingdom); 17 American countries (Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Mexico, Paraguay, Peru, Puerto Rico, Trinidad and Tobago, USA, Uruguay, and Venezuela); and 12 African countries (Algeria, Botswana, Ethiopia, Kenya, Libya, Mauritius, Morocco, Nigeria, South Africa, Tunisia, Uganda, and Zimbabwe).

In 98 countries (50.0%), the RSV of "mask" was significantly higher ($p<0.05$) in the last 20 weeks of this study term than in its first 20 weeks before the pandemic declaration. This was a higher percentage than for any other prevention-related word. Those with significant differences in RSV included 34 European (Albania, Austria, Belarus, Belgium, Bulgaria, Croatia, Demark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Isle of Man, Ireland, Jersey, Kosovo, Latvia, Lithuania, Luxembourg, Malta, Moldova, Netherlands, Poland, Portugal, Romania, Russia, Slovenia, Spain, Switzerland, Turley, Ukraine, and the United Kingdom); 16 American (Argentina, Bahamas, Barbados, Brazil, Canada, Cuba, Dominican Republic, Guam, Jamaica, Mexico, Panama, Sint Maarten, Saint Helena, Trinidad and Tobago, USA, and Venezuela); 19 Asian and Oceania (Australia, Bangladesh, Bhutan, Brunei, Cambodia, Fiji, India, Indonesia, Japan, Kazakhstan, Macao, Malaysia, Nepal, New Zealand, Philippines, Singapore, Sri Lanka, Taiwan, and Uzbekistan); 12 Middle Eastern (Afghanistan, Bahrain, Iran, Iraq, Israel, Kuwait,

Oman, Pakistan, Qatar, Saudi Arabia, the UAE, and Yemen); and 17 African countries (Democratic Republic of the Congo, Egypt, Ethiopia, Ghana, Kenya, Mauritius, Morocco, Nigeria, Reunion, Rwanda, Senegal, Somalia, South Africa, Sudan, Uganda, Zambia, and Zimbabwe) (Figure 3).

DISCUSSION

The COVID-19 pandemic has had a significant impact on global public awareness and behavior, including an increased interest in the prevention of infectious diseases. However, the magnitude of the impact and the differences among countries are unclear. To our knowledge, this is the first study to use Google Trends to objectively show the trends in people's interest in COVID-19 and its preventive measures in countries and regions worldwide. As globalization progresses, it is necessary to consider countermeasures against globally transmitted infectious diseases, such as COVID-19, from a global perspective. Therefore, understanding the trends in people's interest in preventive measures is important to consider global countermeasures. We noted some interesting observations in the present situation of the global interest in COVID-19 and preventable measures.

First, the global interest in coronaviruses among people with COVID-19 has increased to an unprecedented level after the WHO declared a pandemic in March 2020;[1] interest in "coronavirus" has been maintained to a certain extent even now, more than a year and a half after the outbreak. We also noted an increase in interest in preventable measures globally. However, the timings of the increase differed by country and region. Even though most countries also "reacted" to prevention measures at the time of the WHO pandemic declaration, some countries increased interest in preventable measures much earlier than others. Geographical and political factors may

have influenced the timing of the increase. For example, the countries around China, such as (e.g. Vietnam), increased their public interest much before the WHO's pandemic declaration, when Chinese travellers were banned from the country at a very early phase. [26] Contrastingly, in Japan, the interest in "coronavirus" and preventable measures peaked much later than in other high-income countries after the WHO pandemic declaration. This occurred when the Japanese government first declared a state of emergency on April 7, 2020.

The "increase" in awareness and how to sustain the interest in measures for preventing infectious diseases were focused on. In most countries and regions, I found that people's interest in COVID-19 and preventive measures increased, but the persistence of interest in these preventable measures was not necessarily maintained; there was also a difference in the sustainability level of interest by country and region. Furthermore, with these differences in each country's characteristics, there are also differences in sustainability between the search words "wash hand," "social distancing," "hand sanitizer," and "mask."

The sustainability of people's interest in masks was confirmed in a wide range of countries and regions than other search terms. At the beginning of the outbreak, interest in masks spread mainly in Asian countries relatively quickly, where a mask culture was already present. A report showed the regional difference in wearing masks by region at an early stage of the COVID-19 pandemic. [27] This might be attributed to geographic and cultural differences that could have enhanced self-protecting habits. [28] However, notably, the sustainability of the other word "impact" of "mask" was confirmed in many countries that are not necessarily familiar with the practice of wearing masks during winter, such as many Western countries. [29] This implies that familiarity with masks may spread in countries without a mask-wearing culture. Although the effectiveness of

facemask use in community settings for COVID-19 prevention has been controversial, [30–32] the COVID-19 pandemic introduced a "new culture" to these countries and regions.

Contrastingly, countries that could sustain interest in the search term "wash hand" were relatively limited. Notably, the impact of COVID-19 was confirmed in relatively few European countries with low sustainable interest for the term "wash hand," where the cumulative number of confirmed cases was high. [2] The impact was concentrated in Southeast and East Asian countries, where the number of confirmed cases and death rates were relatively low. [2] This suggests that for the countries that did not sustain the interest of "wash hand," including many European countries, interventions to maintain public interest may be necessary in cases of repeated outbreaks. As governments consider effective ways to control infections, they need to consider that they may not be able to sustain the population's interest in preventive actions against infection.

Countries in East and Southeast Asia maintained an interest in "wash hand" and in other preventive measures such as "social distancing" and "hand sanitizer." Thus, in these regions, the COVID-19 pandemic greatly impacted the public mind's interest and awareness of prevention measures against infectious diseases. Since prevention methods are common to many infectious diseases, the increased awareness of people regarding the prevention measures due to the COVID-19 pandemic can be expected to be reflected in future COVID-19 trends and in the decrease in other infectious diseases. Some previous studies in East Asia reported that the number of seasonal influenza cases in the 2019–2020 season was lower after COVID-19 transmission than in previous years and suggested the positive effects of prevention measures against COVID-19 on seasonal influenza. [33–35] The National Institute of Infectious Diseases in Japan also reported that in 2020 and 2021, mycoplasma pneumonia, respiratory syncytial virus infection, and Group A streptococcal pharyngitis decreased, whereas infectious gastroenteritis significantly decreased and

reached its lowest level in a decade. [36] These infections can be effectively prevented by washing hands, social distancing, using hand sanitizers, and wearing masks, as discussed in this study. In combination with these trends and the results from this study, it is suggested that the increasing interest in preventive actions in East Asian countries may be associated with the decrease in other infectious diseases.

The other main finding of the difference between the regions is the slower pace of development of interest in countries on the African continent as well as the limited areas where the persistence of interest had been observed, especially in terms that were related to behavior change, such as "wash hand" and "social distancing." When interpreting data about African countries, it is necessary to consider their relatively low level of internet availability. [37] However, considering that the trend of increased and sustained interest in "coronavirus" was confirmed even in African countries at the same level as other regions, the general interest in preventive measures in the African continent can be considered relatively lower. Thus, the data can be used as a reference for understanding the present situation in Africa. Some studies also mentioned the issues of attitude toward knowledge and healthy practices, including COVID-19 preventive practices in African countries. [38–40] The low-level interest in preventive measures in African countries needs to be considered in future strategies for expanding preventive measures against infectious diseases at the global level. As the pandemic is still unfolding, there is a strong need to continually implement health promotion measures to better prevent the pandemic and improve related-health behaviors in African populations and countries with low impact of public interest on preventable measures.

The COVID-19 pandemic caused damage and impacted people's lives worldwide. The study results showed that people's interest in preventable measures against infectious diseases increased in most countries. This unprecedented opportunity should be maximized by

policymakers, and appropriate policies should be implemented to maintain the increased interest in preventable measures, which will lead to future infectious disease control.

This study had some limitations. First, differences in the levels of internet availability may have affected the results. Second, the percentage of Google users may have affected the global-level evaluation of public interest using Google Trends. A typical example is the extreme low share of Google as a web search engine in China, given that they may have used other search engines and hence did not use Google.[41] Therefore, Google Trends is not a suitable tool for understanding trends in countries such as China; the results of these countries should be interpreted based on this prior knowledge. Although it is necessary to consider these differences to interpret the results globally, the sustainability of the search term "coronavirus" was uniform in almost all countries because of the consistent volume of internet searches from almost all countries and regions throughout the study period. This suggests that the global spread of the tools used in this study was sufficient to grasp global trends.

CONCLUSION

The COVID-19 pandemic may have impacted the global public interest in prevention measures against infectious diseases. However, there are differences in interest related to preventable measures and sustainability of that interest between countries and regions. The increased interest in preventive behaviors against COVID-19 may be related to overall infectious disease prevention. These global differences should be considered when implementing effective interventions against infectious diseases at the global level.

Competing Interests

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

Tomoo Ito was involved in the study design, data analysis, interpretation, and creation of tables and figures and wrote the final report.

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Ethical Approval

The study did not require ethics approval because the RSVs obtained from Google Trends were publicly available, fully anonymized, and aggregated data.

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All work on this paper was done by Tomoo Ito alone, and there were no other collaborators on this paper.

Data Availability Statement

The data that support the findings of this study are available from the author upon reasonable request.

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Figure captions

Fig 1. RSV of "coronavirus," "wash hand," "social distancing," "hand sanitizer," and "mask" in the combined data for all countries and regions.

Horizontal axis: depicts the time period. The week of March 11, 2020, when the WHO declared a pandemic, is set to 0 and increases thereafter. The weeks following the week of the pandemic declaration are numbered as 1, 2, 3, and so on, until the 85th week (85 depicts the 85th week). The week before the pandemic declaration (0) is numbered -1 for the week before, -2 for two weeks before, and so on, until the 85th week (-85 means 85 weeks before the declaration of the pandemic).

Vertical axis: relative search volume (RSV) value

Figure 1 was created using Microsoft Excel (Microsoft Inc., Seattle, WA, USA).

Fig 2. Distribution trend of countries with "coronavirus," "wash hand," "social distancing," "hand sanitizer," and "mask" with relative search volume (RSV) ≧50 after the coronavirus disease 2019 (COVID-19) pandemic

Area colored red: countries with RSV "coronavirus" ≧50

Are colored gray: countries without valid data

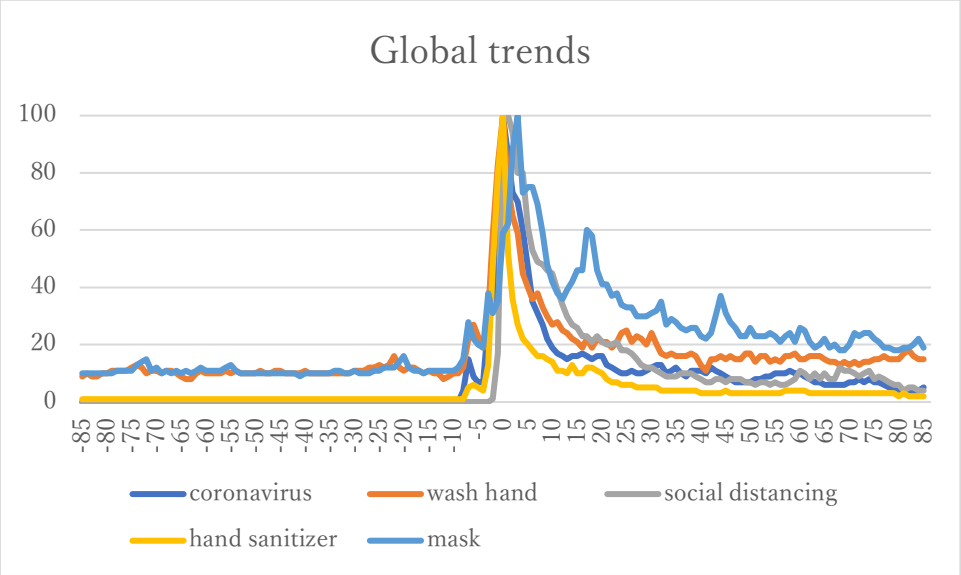
Figure 2 was created using QGIS version 3.24 with background map data obtained from OpenStreetMap contributors (www.openstreetmap.org).

Fig 3. Distribution of countries with statistically significant relative search volume (RSV) of "coronavirus," "wash hand," "social distancing," "hand sanitizer," and "mask" in the last 20 weeks compared with that before the coronavirus disease 2019 (COVID-19) pandemic.

Area colored red: countries with statistical significance in the last 20 weeks versus before the COVID-19 pandemic.

Area colored gray: countries without valid data

Figure 3 was created using QGIS version 3.24 with background map data obtained from OpenStreetMap contributors (www.openstreetmap.org).



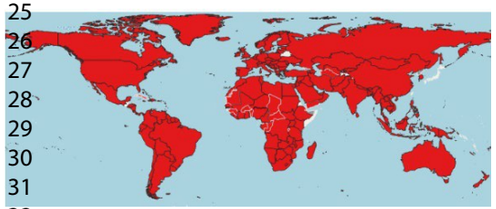
"coronavirus" RSV trends

(A) "coronavirus" RSV for the week of January 26, 2020

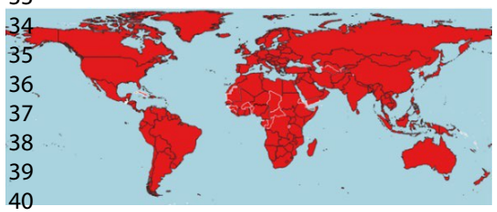
(B) "coronavirus" RSV for the week of February 23, 2020

(C) "coronavirus" RSV for the week of March 8, 2020

(D) "coronavirus" RSV for the week of March 22, 2020



(E) "coronavirus" RSV for the week of April 5, 2020



"wash hand" RSV trends

(A) "Wash hand" RSV for the week of January 26, 2020

(B) "wash hand" RSV for the week of February 23, 2020

(C) "wash hand" RSV for the week of March 8, 2020

(D) "wash hand" RSV for the week of March 22, 2020

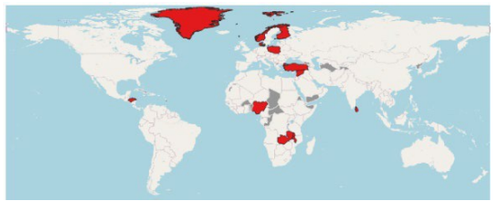
(E) "wash hand" RSV for the week of April 5, 2020

"social distancing" RSV trends

(A) "social distancing" RSV for the week of January 26, 2020

(B) "social distancing" RSV for the week of February 23, 2020

(C) "social distancing" RSV for the week of March 8, 2020



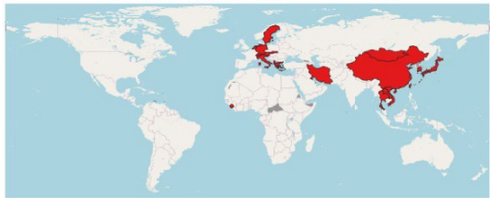
(D) "social distancing" RSV for the week of March 22, 2020

(E) "social distancing" RSV for the week of April 5, 2020

"hand sanitizer" RSV trends

(A) "hand sanitizer" RSV for the week of January 26, 2020

(B) "hand sanitizer" RSV for the week of February 23, 2020



(C) "hand sanitizer" RSV for the week of March 8, 2020

(D) "hand sanitizer" RSV for the week of March 22, 2020

(E) "hand sanitize" RSV for the week of April 5, 2020

"mask" RSV trends

(A) "mask" RSV for the week of January 26,2020

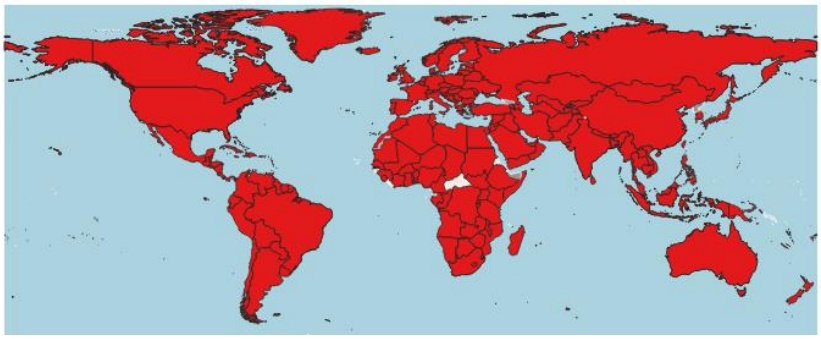
(B) "mask" RSV for the week of February 23,2020

(C) "mask" RSV for the week of March 8,2020

(D) "mask" RSV for the week of March 22,2020

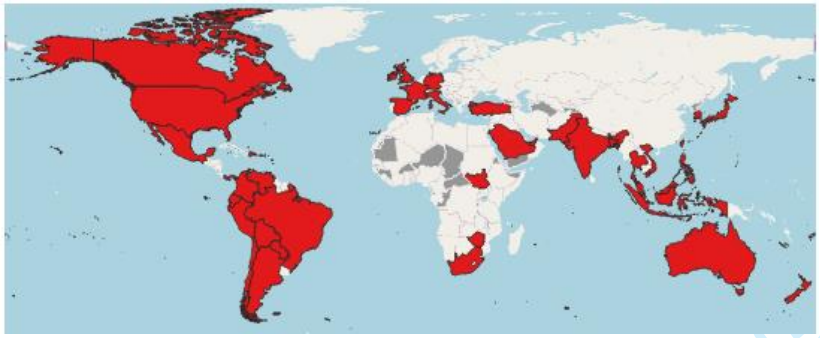
(E) "mask" RSV for the week of April 5,2020

(A) Countries with significant difference of 'coronavirus' RSV in the first 20 weeks and the last 20 weeks



(B) Countries with significant difference of 'wash hand' RSV in the first 20 weeks and the last 20 weeks

(C) Countries with significant difference of 'social distancing' RSV in the first 20 weeks and the last 20 weeks



(D)Countries with significant difference of 'hand sanitizer' RSV in the first 20 weeks and the last 20 weeks

(E) Countries with significant difference of 'mask' RSV in the first 20 weeks and the last 20 weeks

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2	Line 2 and line 29. Design: An infodemiology and infoveillance study
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3	Lines 23-46, Abstract
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5	Introduction (lines 66-102).
Objectives	3	State specific objectives, including any prespecified hypotheses	5.6	Introduction (lines 103-110).
Methods				
Study design	4	Present key elements of study design early in the paper	6	MATERIALS AND METHODS (lines 113-114). Google Trends was used to quantify and measure changes in internet searches regarding the COVID-19 pandemic worldwide and in each country.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-8	MATERIALS AND METHODS (lines 115-167)
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7	Line 145: 196 countries and regions around the world

		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7.8	Lines 144-167.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8	Lines 115-167
Bias	9	Describe any efforts to address potential sources of bias	7	Line 127-135 This method allowed us to understand the situation on a global level, including in countries where English is not the native language.
Study size	10	Explain how the study size was arrived at	7	Line 145: 196 countries and regions around the world
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8	Lines 156-167
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9	Lines 168-174
		(*b*) Describe any methods used to examine subgroups and interactions	N/A	N/A
		(*c*) Explain how missing data were addressed	6	Lines 125-126 When a sufficient number of searches cannot be confirmed for a search keyword or topic in a specified country, the system displays that the data cannot be retrieved.
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls	N/A	N/A

was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy		
(*e*) Describe any sensitivity analyses	N/A	N/A

Continued on next page

Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10,14,15,16	Lines 197, 210, 225, 236, 246
		(b) Give reasons for non-participation at each stage	6	Lines 125-126 When a sufficient number of searches cannot be confirmed for a search keyword or topic in a specified country, the system displays that the data cannot be retrieved.
		(c) Consider use of a flow diagram	N/A	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7	Line 145: 196 countries and regions around the world
		(b) Indicate number of participants with missing data for each variable of interest	10,14,15,16	Lines 197, 210, 225, 236, 246
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	9-19	Lines 185-305
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A	N/A
		(*b*) Report category boundaries when continuous variables were categorized	N/A	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A	N/A
Discussion				
Key results	18	Summarise key results with reference to study objectives	23	Lines 406-412

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	23	Lines 394-404
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	19-23	Lines 317-404
Generalisability	21	Discuss the generalisability (external validity) of the study results	23	Lines 394-404
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24	Lines 421-423

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.