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Regional differences in online interest in COVID-19 infection and COVID-19 vaccine in pregnancy: A Google Trends analysis

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Abstract:

BACKGROUND: With the advent of the COVID-19 pandemic, pregnant women may turn to online information searches regarding COVID-19 and COVID-19 vaccination.

OBJECTIVE: We aimed to determine global online interest in COVID-19 infection and COVID-19 vaccination in pregnancy.

MATERIALS AND METHODS: We utilized Google Trends data to determine the global search volume index (SVI) for the search terms "COVID-19 in pregnancy" and "COVID vaccine pregnancy" from January 1, 2020, to February 12, 2022, and ranked the top 15 search queries via their individual SVIs to assess the worldwide distribution of interest. Using Pearson correlation, we correlated several economic and pandemic-related country-specific data with the SVIs for the two search terms, while we utilized a one-way analysis of variance to country income groups with the SVIs using ANOVA. Significant correlations were denoted with $P < 0.05$.

RESULTS: SVI for "COVID-19" in pregnancy showed a minimal and nonsignificant downward trend in 2022. SVI for this search term was positively correlated with the SVI for "COVID vaccine pregnancy" ($P < 0.05$). On the other hand, SVI for "COVID vaccine in pregnancy" showed an exponential decline from November 2020 to 2022. SVI for this search term was also negatively correlated with deaths per 100,000 cases ($P < 0.05$). Although this was nonsignificant, high-income countries showed higher online interest with the two search terms than low- to low-middle-income countries. There were no significant correlations among specific economic and pandemic-related country-specific data and SVI for both search terms.

CONCLUSION: We observed a constant online interest in COVID-19 in pregnancy during the time period of the study, which may reflect the watchful engagement of people in the absence of face-to-face physician consultations. Peak online interest in COVID-19 vaccine in pregnancy declined steadily, which may reflect either vaccine hesitancy or an increase in public knowledge of COVID-19 vaccines. High-income countries have apparently higher online interest in COVID-19 vaccines, which may be due to access to early mass administration to the general public. These data can be used as a reference regarding future policy-making in the setting of potentially massive public health emergency in the future.

Keywords:

Google Trends, infodemiology, pandemic, SARS-CoV-2, vaccine acceptance, vaccine hesitance

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Introduction

COVID-19 infection remains a significant health concern a year after it was first declared a global pandemic in 2020. To date (February 22, 2022), there have been 423,437,674 affected individuals and 5,878,328 reported deaths worldwide.[1] Vulnerable populations more likely to develop severe and critical infections include the elderly and those with

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comorbid conditions, especially diabetes.[2] Pregnant women theoretically have increased risk due to the physiologic changes associated with the condition.[3,4] Initial data at the start of the pandemic have shown relatively lower severity and lesser complications associated with pregnancy.[5] While most mothers were discharged without any significant complications, severe maternal morbidity and perinatal deaths due to COVID-19 have been reported.[5-7] Similar to other coronavirus infections, there have been no published cases of clinically documented vertical transmission;[8] however, there have been published reports of neonatal SARS-CoV-2 infection,[5,9] albeit without discounting the probability for it to have been acquired postnatally.

The use of vaccines in COVID-19 proved to be an effective strategy to counter the pandemic and reduce the severity of the disease.[10] However, concerns about its safety have been raised when it was initially recommended to be given to at-risk pregnant women, including pregnant health-care providers; eventually, recommendations and guidelines from several international obstetric societies have been published that initiated widespread vaccination among pregnant women.[11-17] Preliminary studies have shown promising results on vaccination safety in this group.[18] The presence of antibodies against SARS-CoV-2 among neonates born from vaccinated mothers provides additional evidence on the benefits of vaccination.[19-21] Despite these recommendations and initial data on the safety and benefits of vaccination, the SARS-CoV-2 vaccine acceptance rate worldwide among pregnant and breastfeeding women remains low (about 50%–60%).[22] Vaccine hesitancy has been identified as a more important reason for nontakers than limited access to vaccines.[22,23] There are barriers to acceptance, such as safety concerns, lack of knowledge, and lack of confidence in their health-care provider.[24] Interestingly, vaccine safety was not considered a significant contributing factor among pregnant women evaluated specifically for COVID-19 vaccine acceptability.[25]

Since the onset of the pandemic, there has been a significant reduction of medical and obstetric consults among non-COVID-19 patients, a factor that may be seen as an impediment to the vaccination drive. Driven by the limited access to a health-care provider, the public used the Internet as an alternative source of information for their health concerns. This has been corroborated by data showing an increased online search on health-related topics during the pandemic.[26-28]

Objective

This study aimed to analyze the public interest on COVID-19 infection and vaccination in relation to pregnancy during the varying periods of the pandemic using Google Trends, a publicly accessible resource that allows for trend estimation of aggregated Google searches, as well as health-related search activity.[29,30] We also aimed to correlate the regional differences on search trends with varying sociodemographic parameters to determine which factors affect interest in COVID-19 in pregnancy.

Materials and Methods

Worldwide online search interest for COVID-19 in pregnancy and COVID-19 vaccination in pregnancy was measured using the Google Trends™ database. Google Trends™ was accessed by visiting http://trends.google.com.[29] Search terms included the topic "COVID-19 in pregnancy" and the search term "COVID vaccine pregnancy." We limited the results to 2 years, from January 1, 2020, to February 12, 2022. Search volume index (SVI) and related queries were obtained from Google Trends™. Search interest relative to the highest point in a determined region and time is presented as units of SVI. An SVI of 100 corresponds to the point where the highest interest for the search term occurred; an SVI of 0 means there is insufficient data for the search term.[31,32]

Data on three measures of economic structure – GDP per capita, country income group, and Gini index – were obtained from the World Bank database.[33] These three statistics are traditional measures of economic growth and inequality.[34] The percentage of Internet users and physician-to-population ratio were also obtained from the same database. Data on total vaccinations per 100 people, persons fully vaccinated per 100 people, cumulative COVID-19 cases per 100,000 people, and COVID-19 deaths per 100,000 people were obtained from the World Health Organization (WHO) COVID-19 Dashboard.[1] Data on WHO regional classifications were obtained from the WHO Database.[35] All data utilized in this study are publicly available, and no personal identifiers have been accessed in the data acquisition.

The correlation between SVI and WHO region group and country income group was determined using one-way analysis of variance, with *post hoc* correction for multiple comparisons. An ANOVA f value with $P < 0.05$ was considered statistically significant. Correlation between SVI and obtained country characteristics was determined using Spearman's rank-order correlation, with a correlation coefficient having $P < 0.05$ considered significant. The statistical analysis was done using the Statistical Package for the Social Sciences version 27 (IBM) (Armonk, NY: IBM Corp).

Results

The SVI for the topic "COVID-19 in pregnancy" across 2020-2022 is shown in Figure 1a and b. The mean global

interest in COVID-19 in pregnancy as measured by SVI across all years is 21.61 ± 12.463, with a minimal and nonsignificant downward trend going into 2022. The mean SVI between 2020, 2021, and 2022 does not differ significantly among each other ($P > 0.05$). Peak SVI was observed at the week of March 15, 2020, approximately around the date as to which COVID-19 was declared as a pandemic (March 13, 2020). Related queries included "COVID vaccine pregnancy," "pregnancy covid symptoms," and "pregnancy covid risk" [Table 1]. The search topic "COVID-19 in pregnancy" was popular in Ireland (SVI = 100), the United Kingdom (SVI = 75), Canada (SVI = 47), and Italy (SVI = 47), among others [Figure 2a].

Table 1: Top associated search terms used by people searching for COVID-19 in pregnancy and COVID vaccine in pregnancy

COVID-19 in pregnancy		COVID vaccine in pregnancy	
Related queries	**SVI**	**Related queries**	**SVI**
COVID	100	Vaccine and pregnancy covid	100
Pregnancy	72	Pregnancy and COVID	99
COVID pregnancy	69	Vaccine and pregnancy	98
COVID 19 pregnancy	32	COVID in pregnancy	59
COVID 19	32	COVID vaccine in pregnancy	55
COVID and pregnancy	25	COVID 19 vaccine pregnancy	36
Pregnant COVID	19	COVID 19 vaccine	36
Embarazo COVID	16	COVID vaccine pregnant	34
COVID-19 and pregnancy	16	Pregnancy after COVID vaccine	25
COVID grossesse	12	COVID vaccine during pregnancy	24
COVID in pregnancy	11	Vaccine during pregnancy	23
COVID gravidanza	9	COVID vaccine affect pregnancy	21
COVID-19	7	Pfizer COVID vaccine pregnancy	19
Pregnancy COVID-19	7	COVID vaccine on pregnancy	19
COVID et grossesse	6	Pfizer vaccine pregnancy	18

SVI: Search volume index

On the other hand, the SVI for the search term "COVID vaccine pregnancy" is shown in Figure 1c and d. There was an observed sudden rise in global interest after the week of November 29, 2020, coinciding with the first mass coronavirus vaccination with Pfizer-BioNTech in the United Kingdom and the near-final recommendations for emergency use authorization of the Pfizer-BioNTech coronavirus vaccines in the United States.[36,37] An exponential decline was observed after that. There is a significant difference in the mean SVIs before (mean = 1.14 ± 1.691) and after (mean = 58.06 ± 28.502) the week of November 29, 2020 ($P = 0.000$). The mean SVI for 2021 was also significantly different from mean SVI for 2020 ($P = 0.000$) and 2022 ($P = 0.000$). Related queries included "Pfizer vaccine" as well as "pregnancy after COVID vaccine" and "COVID vaccine during pregnancy" [Table 1]. The search term COVID vaccine in pregnancy was popular in Ireland (SVI = 100), the United Kingdom (SVI = 73), Canada (SVI = 68), and Qatar (SVI = 56) [Figure 2b].

We observed a positive correlation between the SVIs for "COVID vaccine pregnancy" and "COVID-19 in pregnancy" [$P = 0.012$, Table 2]. We also noted a negative correlation between the SVI for "COVID vaccine pregnancy" and COVID-19-related deaths per 100,000 people ($P = 0.026$). No significant correlations were observed between SVIs for both search terms and GDP per capita, Gini index, percentage of Internet users, physician-to-population ratio, total vaccinations per 100 people, fully vaccinated persons per 100 people,

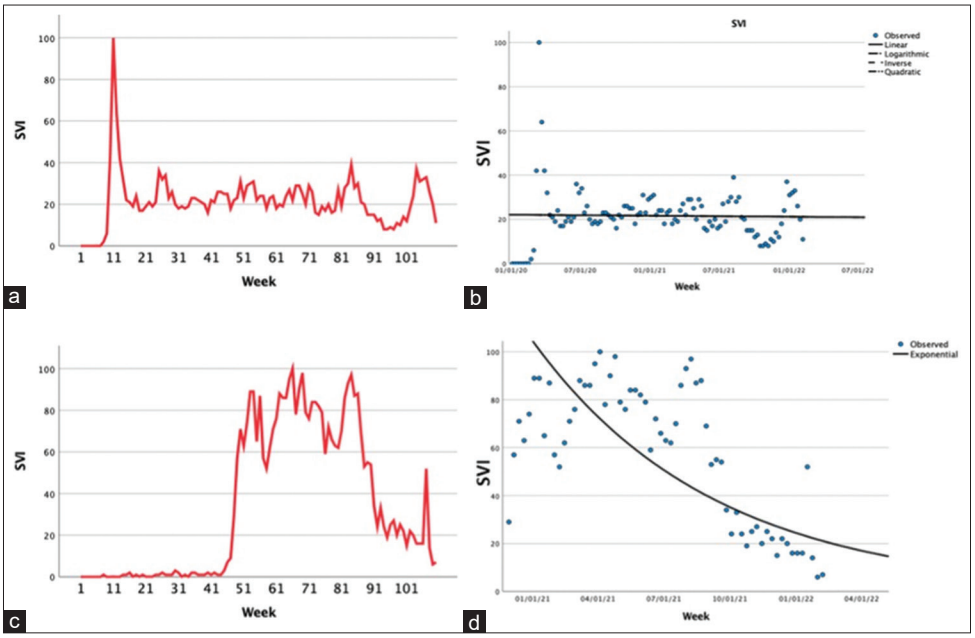

Figure 1: SVI trends for the topic "COVID-19 in pregnancy" (a and b) and "COVID vaccine pregnancy" (c and d) during the COVID-19 pandemic. SVI: Search volume index

Table 2: Correlations between search volume index for COVID-19 in pregnancy and COVID vaccine in pregnancy search terms and country-specific socioeconomic and epidemiologic characteristics

Country-specific indicators	Search terms (correlation coefficient, *P*)	
	COVID-19 in pregnancy	COVID vaccine pregnancy
GDP per capita	0.148, 0.290	0.146, 0.345
Gini index	0.274, 0.054	0.119, 0.465
Internet users	0.057, 0.687	0.080, 0.605
Physician-to-population ratio	0.231, 0.097	−0.214, 0.163
Total persons vaccinated per 100 persons	0.202, 0.147	−0.034, 0.828
Persons fully vaccinated per 100 persons	0.235, 0.094	−0.093, 0.559
Cumulative COVID-19 cases per 100,000 people	0.190, 0.173	−0.129, 0.403
Deaths due to COVID-19 per 100,000 people	0.156, 0.263	−0.336, 0.026

GDP: Gross domestic product

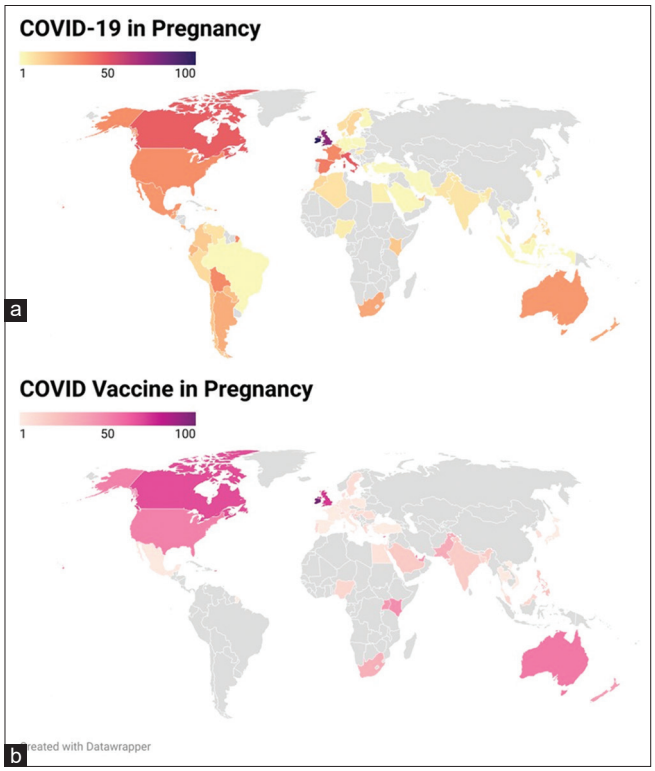

Figure 2: Search frequencies for COVID-19 in pregnancy (a) and COVID-19 vaccine (b) in pregnancy by country during the COVID-19 pandemic. The color intensity represents the percentage of searches for the leading search term in a particular region. Search term popularity is relative to the total number of Google searches performed at a specific time, in a specific location

cumulative COVID-19 cases per 100,000 people, and COVID-19 deaths per 100,000 people.

We did not observe any statistically significant difference in the mean online interest for COVID-19 in pregnancy based on the WHO region and World Bank income groups ($P > 0.999$) [Figure 3]. However, it was apparent that most countries with a high online interest in COVID-19 infection and vaccines in pregnancy were from European and high-income countries. Low online interest in COVID-19 infection and vaccine in pregnancy mainly were from countries belonging to Africa and Southeast Asia and those classified as lower middle income.

Discussion

Our results demonstrate a tonic online interest in COVID-19 in pregnancy and a decreasing online interest in COVID-19 vaccine in pregnancy since 2020. Not surprisingly, we found that the SVI for COVID-19 in pregnancy is positively correlated with the SVI for "covid vaccine pregnancy" ($P < 0.05$), and the latter is negatively correlated with deaths per 100,000 people ($P < 0.05$); higher interest in the disease drives a higher interest for prophylactic vaccination, which seems to translate to a decreased incidence of death. Regional differences can be observed, with high-income countries showing higher interest in these search topics than low- to low-middle-income countries.

The state of pregnancy itself may confer additional risk of infection with COVID-19. However, most summative studies suggest that the presentation of the disease among pregnant patients tends to be on the milder spectrum.[38-40] Specific comorbidities, such as obesity, hypertension, or other factors such as mode of delivery and racial predilection, have up to two-fold risk of acquiring symptoms compared to asymptomatic pregnant women.[40] COVID-19 infection predisposes to higher cesarean delivery and preterm delivery.[38,39,41] Data on mortality seems conflicting; although some studies note a low mortality rate among COVID-19 pregnant patients,[42-46] a large multinational cohort (INTERCOVID cohort) across 18 countries reports an almost 22-fold risk of maternal mortality.[47] Some studies have shown that pregnant women opt for a decrease in physical prenatal care consults, primarily due to fear of contracting the infection and developing related complications.[48-50]

Thus, accessing online information may become a preferable choice for health education in pregnant women.[51-53] In an online survey that includes pregnant women asking about access to obstetric health care, most women were found to engage with online media platforms such as Facebook and other forums.[53] Pregnant women also do health-related searches in

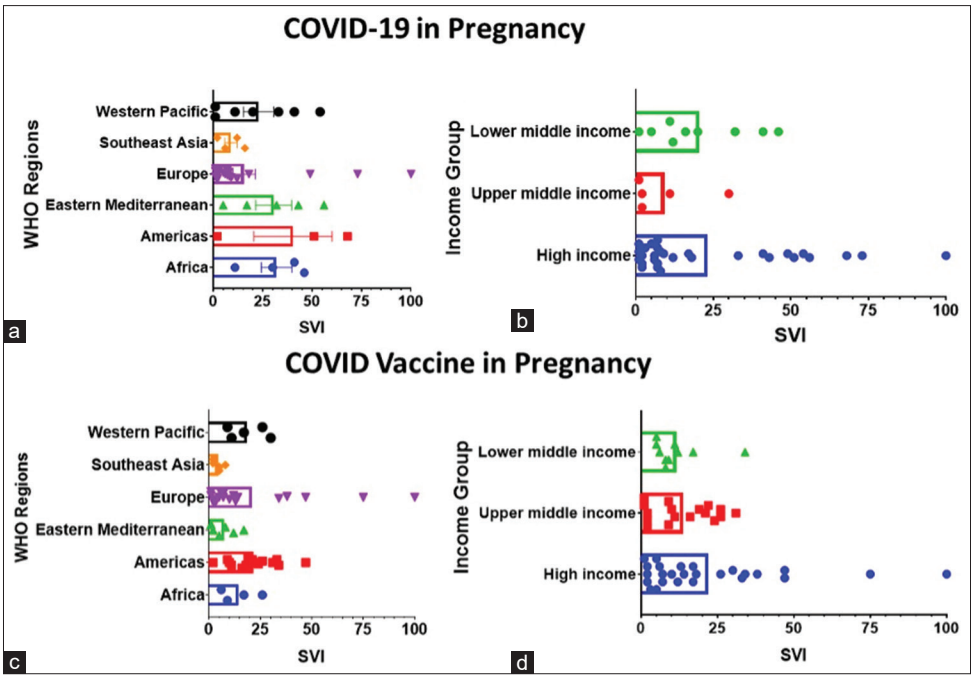

Figure 3: The distribution of online interest for COVID-19 in pregnancy (a and b) and COVID vaccine in pregnancy (c and d) per country based on WHO regions and World Bank income groups. SVI: Search volume index, WHO: World Health Organization

public online search engines, such as Google. To the best of our knowledge, no study has explored yet the depth of health-related searches in Google regarding COVID-19 in pregnancy; our study provides a baseline knowledge on this matter.

Peak SVI for COVID-19 in pregnancy was around the week it was declared a pandemic in March 2020; this was expected since not much knowledge was known regarding the maternal and fetal effects of infection. Most systematic analyses and meta-analyses on pregnancy and COVID-19 have only been established in the latter half of 2020 when the large multinational cohort exploring pregnancy outcomes in COVID-19 infection was only established in 2021.[38-47] Although a minimal downward trend was observed for this topic, there was no significant difference in global online interest from 2020 to 2022, reflecting the near-constant search activity for this topic.

One of the related queries included "COVID vaccine pregnancy." Notably, peak SVI for "COVID vaccine pregnancy" was observed around the week when Pfizer-BioNTech underwent final recommendations in the United States and mass vaccination rollout was started in the United Kingdom. Both of these events are spurs of medical expert panel recommendations. In part, physician recommendation plays a significant role in maternal decision-making, affecting vaccination status; we infer that the two events mentioned above reflect how this element shapes vaccine interest and acceptance. However, we noted an exponential decrease in online interest in the COVID-19 vaccine in pregnant women afterward. Although we cannot definitively state whether this observed decrease in global interest in COVID-19 vaccine in pregnancy affirms vaccine hesitancy or rather due to an increase in public knowledge of pregnant women regarding COVID-19 vaccines, there is still a need to bolster knowledge on COVID-19 vaccination in pregnancy in order to increase acceptance rates among this population.

The result of this infodemiology study also reflects the regional disparities in COVID vaccine administration. The US and many European countries started administering vaccines in December 2020. In contrast, countries in Africa and Southeast Asia began administering vaccines in March 2021.[54] Moreover, most of the obstetrics and gynecology societies in these regions recommended using COVID-19 vaccines in pregnant patients.[11-17] These early efforts in high-income countries to educate pregnant patients on the risks of COVID-19 infection in pregnancy and the safety and efficacy of vaccination may have increased pregnant patients' awareness and online health-seeking behavior.

Google Trends has been utilized in examining attention toward significant health events in the recent decades, such as the Middle East respiratory syndrome epidemic,[55] the Ebola outbreak,[56] and the Swine flu.[57] Most recently, Google Trends has been utilized to assess the potential of Internet infoveillance in determining public interest in the COVID-19 pandemic.[58-62] It is a valuable asset compared to population surveys and adjunct to traditional analyses.[58] This study aimed to complete

three out of four main steps (to measure the general online interest in a particular search topic or search term, to measure the seasonality of search topic or term about actual cases, and to correlate online search activity with current and global data) in evaluating the COVID-19 pandemic issue and vaccination data about pregnancy.[63] Future studies may aim to perform the fourth step to predict trends and forecast health-related events, based on eventual data on maternal COVID-19 mortality, morbidity, and other related factors.

Although there is no conclusive evidence yet regarding any risks associated with COVID-19 vaccination in pregnancy, there is a wide range of COVID-19 vaccine acceptance among pregnant women, from 29.7% to 77.4% based on a recent systematic review.[64] Vaccine hesitancy may be in part due to various factors, such as the risk of COVID-19 infection (during the process of vaccination itself), sociocultural differences among different geographies, lack of knowledge (lower level of education, misinformation, and lack of robust safety studies), and pregnancy status in itself (risk to the fetus or pregnant women themselves).[64,65]

Based on the results of this study, we emphasize the need to maximize the Internet and social media to improve the awareness and knowledge of pregnant patients about COVID-19 infection during pregnancy. Due to the limited face-to-face consultation during the pandemic, there is a need to increase infrastructure to utilize online antenatal care for physicians to relegate correct and timely information regarding COVID-19 vaccination.[52,60] There is also a need to improve Internet access in developing countries. Only 47% of households in developing nations have an Internet connection and just 19% in the least developed countries.[66] The pandemic has expanded the digital divide between rural and urban citizens, and although the lack of reliable Internet does not vastly impact living conditions, this may exacerbate the difficulty in accessing health-care services as most services have tried to shift to digital platforms to minimize face-to-face transmission of the disease.[67] Finally, there is a need to provide online health information regarding COVID-19 infection and vaccination in pregnancy translated into native languages to reach those populations that are non-English speakers.

In this study, age-related Internet penetration has not been evaluated, and this would be an additional important indicator regarding the online practices of pregnant patients during the time period of the study. Furthermore, the influence of mass media cannot be fully evaluated by Google Trends, since most of media consumption relies on mobile social media applications, and this may leave out users who search for information through such applications. Correlation does not also necessarily equate to causation, and results should be taken in the context of other factors that may affect Internet usage. Keyword selection could have missed out on similar relevant keywords, especially in the vernacular language.

By using Google, we encompassed a large population worldwide compared to other search engines that use native language or lesser popularity. However, this also provides an inherent limitation since (i) some countries still do not have access to Google, and (ii) online searches in other search engine platforms and languages were not included. This study only included data from people with Internet access, potentially excluding populations from low-income brackets and regions with curtailed freedom of speech. The latter population is particularly important, as these populations may instead turn to the use of virtual private networks that can break through information blockades and government censorship. By setting up a different country of access other than their own, the number of that country's users that have keyed in a specific online query may artificially increase and affect the replicability of this study.[68]

Conclusion

As more and more people utilize the Internet for instantaneous access to a wealth of health information, we reiterate that online trends on search terms for health topics are now being utilized to measure public health. Google Trends, a publicly accessible resource that allows for trend estimation of aggregated Google searches, also evaluates health-related search activity.[30] In this study, we showed that there is a consistent global online interest in COVID-19 in pregnancy, and this is positively correlated with searches related to COVID-19 vaccines in pregnancy ($P < 0.05$); the latter is also negatively correlated with deaths per 100,000 cases ($P < 0.05$). There are regional differences in online interest with these two topics, with high-income countries showing higher interest than low- to low-middle-income countries.

It is recommended that the aforementioned limitations are taken into consideration in future studies. In addition, future research may also take into account comparisons between actual and well-constructed patient surveys and questionnaires that have been adapted in the vernacular language in order to compare the global Google Trends search data against local data to gauge the relative differences and similarities of these two potential datasets.

Regardless, we highlight that the pandemic has reinforced that Internet access is an emerging social determinant of health[69,70] and that it is becoming a necessity for better access to quality health information.

Our observations can be utilized to create related public information campaigns regarding COVID-19 in pregnancy that effectively coincide with the trends we noted. With the limitations of performing physical surveys among populations involved, data from Google Trends may serve as a surrogate to note online engagement and aid in intervention assessments and campaign awareness.[71,72]

Authorship contributions

Manuel S. VIDAL, Jr., MD and Ourlad Alzeus G. Tantengco, MD - Conceptualization, methodology, formal analysis, visualization.

Manuel S. VIDAL, Jr., MD ; Ourlad Alzeus G. Tantengco, MD and Melissa D. Amosco, MD - Writing - original draft.

Manuel S. VIDAL, Jr., MD - Writing - review and editing.

Melissa D. Amosco - Supervision.

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Conflicts of interest

There are no conflicts of interest.

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