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Applied nutritional investigation

Determination of interest in vitamin use during COVID-19 pandemic using Google Trends data: Infodemiology study

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ARTICLE INFO

Article History:

Received 4 November 2020

Received in revised form 23 December 2020

Accepted 29 December 2020

Keywords:

COVID-19

Google Trends

Vitamins

Immunity

ABSTRACT

Objective: The aim of this study was to determine the interest in vitamin use during the COVID-19 pandemic using Google Trends data.

Method: Searches were made between January 1, 2016 and August 30, 2020. First, the word “vitamin” was searched. Additionally, the search words “vitamin,” “COVID-19,” “immunity,” and Vitamin D,” “Vitamin C,” “Vitamin E,” and “Vitamin A” were searched comparatively. Search was made in Turkish (in Turkey) and English (in world). Additionally, the word “vitamin” was translated into some countries’ languages and was searched. Relative search volumes (RSVs) obtained in searches are presented with graphics. RSVs, downloaded as .csv were transferred to SPSS. Descriptive data was given as numbers and percentages. Kruskal-Wallis analysis was used to determine the difference of RSVs according to years and seasons. Additionally, queries arising related to search words were presented.

Results: Findings from the present study determined that the trend toward vitamins reached 100 RSVs in March 2020, when COVID-19 was declared a pandemic. Vitamins D and C were the most frequently searched vitamin types in Turkey and worldwide. It was determined that searches consisting of a combination of COVID-19 and vitamins were made.

Conclusion: Vitamins attract public interest globally. Seasonal variation and COVID-19 shaped the popularity of vitamins both worldwide and in Turkey. The search frequency was highest in the autumn and spring, but the largest search related to all search terms was determined to be in March 2020. Interest in vitamins has increased since the beginning of the COVID-19 pandemic.

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Introduction

The COVID-19 outbreak, first reported on January 13, 2020 in Wuhan, China, has become a serious public health problem that has spread to many continents and countries in a short time [1]. The lack of immunity against this newly emerging virus increases the damaging effect of the disease. COVID-19 affects the immune system by producing a systemic inflammatory response, or cytokine release syndrome [2].

COVID-19 causes symptoms of infection such as fever, cough, shortness of breath, and respiratory distress within an average of 2 to 14 d after infecting humans [3]. In more severe cases, COVID-19 can cause pneumonia, severe acute respiratory syndrome, kidney

failure, and death [4]. Although COVID-19 affects everyone from newborns to persons 65 years and older, it has been shown that the most serious consequences occur in individuals with chronic diseases, older individuals, and those with weak immune systems [5]. There is no known treatment for COVID-19 and vaccines have begun to be brought to market in January 2021. Because there is no known treatment and because the rollout of vaccines is slow, individual measures are very important to prevent the disease. Mask wearing, social distancing, and good hand hygiene are the primary measures for preventing disease [5]. However, the most important prophylactic approach against COVID-19, which causes serious damage to the immune system and fatal consequences in people with weakened immune systems, is strengthening of the immune system. There are many vitamins and trace elements necessary for the normal functioning of the immune system [6,7]. It has been shown that supplementation of these vitamins has a positive effect on strengthening immunity [8]. Supplementation with vitamins A and D after influenza vaccination increased the humerus immunity of pediatric patients [9]. Although vitamins C and E strengthen the immune

S.Ç. and D.Y.G. were responsible for the study design and manuscript preparation. S.Ç. was responsible for the interpretation of data. The authors have no conflicts of interest to declare.

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system owing to their high anti-inflammatory and antioxidant effects [1,10], it has been reported that vitamin D has an effect that can disrupt viral cellular infection by interacting with angiotensin converting enzymes (ACEs) [10]. It is thought that vitamins D and C play an important role in determining the results of COVID-19 in many studies conducted to determine the efficacy of vitamins in the prognosis of COVID-19 [11–16].

Individuals looking for ways to potentially protect themselves from the rapidly spreading COVID-19 epidemic, or to mitigate its effects after it being diagnosed with it, often turn to vitamins. The beneficial effects of vitamins on the immune system are emphasized in the media, and interested individuals search for information about the effects of vitamins, sources of vitamins, and products they can use. Today, the Internet has become one of the first options when searching for information. The majority of society uses the Internet to quickly access the information they seek. They want to learn as much as they can and often do not spend time with knowledge that requires expertise [17]. The use of Internet data has become an integral part of health informatics over the past decade and can be useful when analyzing and predicting human behavior [18]. The search for data derived from the Internet for epidemiologic purposes is called *infodemiology* (knowledge epidemiology). Infodemiology processes data from search engines, forums, and websites [19].

Google is the most widely used website in Internet crests. Therefore, Google Trends [20], which provides analysis of Google search data, has been used in many studies to analyze the public's search behavior [21]. Google Trends can show information trends, networking on the Internet, and changes that can have a negative or positive effect on public health.

Google search data has been used in many studies to predict the COVID-19 outbreak and its effects [21]. In this study, it is aimed to predict the tendency of society to use vitamins through Google Trends.

Research questions

1. Has interest in vitamins differed over the years?
2. Does interest in vitamins differ according to the seasons?
3. Did the COVID-19 pandemic increase interest in vitamins?

Material and methods

The study data were obtained from the Google Trends website provided by Google. Google Trends provides a time-series index of the volume of queries users entered into Google in a given geographic area. Google Trends indicate normalized results (0–100), which are compared with the maximum value for particular

queries during search intervals. Data can be reached separately according to years, days, and geographic areas. Furthermore, it is able to present comparisons between different terms with graphs. It is capable of comparing of five keywords at a time [20,22].

Because Google Trends updated data acquisition methods after 2015, searches were conducted in 2016 and beyond [20]. First, the search word "vitamin" was used. Second, the search words "vitamin", "COVID-19," and "immunity" were searched comparatively. Finally, "Vitamin D," "Vitamin C," "Vitamin E," and "Vitamin A," which are reported to be effective for strengthening the immune system, were searched comparatively [23]. Searches in Turkish (for Turkey) and in English (for the world) are made as. Additionally, in some countries where COVID-19 is common, the search for "vitamin" was translated into their own language.

Analysis

Relative search volumes (RSV) values obtained in searches are presented in the figures. The graphic axis ran from August 1 to July 31. Analyses were made by transferring RSV values downloaded as .csv to an SPSS statistics program. Descriptive data are given as number and percentages. In determining the difference of RSV value according to years and seasons, Kruskal–Wallis analysis was used. Bonferroni correction was used to determine which group caused the difference. Additionally, rising queries related to search words are presented with an expression table.

Results

Figure 1A shows the RSVs for "vitamin" in Turkey. The average RSV for "vitamins" for 5 y from January 2016 to September 2020 was 54.6 ± 11.6 (min 26–max 100; Table 1). Analysis of the distribution of searches within the year shows that it started to increase in September, decrease after May, and reached its peak at the end of October. Considering the seasonal characteristics of exploration in Turkey, the RSVs of the word "vitamins" are the lowest in summer (45.2 ± 9.8) and the difference was statistically significant ($P < 0.001$).

The RSVs of the word "vitamin" varied by years, and the highest RSVs were in 2020 ($P < 0.001$; Table 1). Within the past 5 y, the searches reached 100 RSVs only in March 2020.

There has been an increasing trend in searches related to the word "vitamins" such as "some brands associated with the vitamin", "vitamin D" and "vitamin C," "black elder," "sources of vitamins," and "usage of vitamins" in Turkey (Table 2).

In Figure 1B, the words "vitamin," "immunity," and "COVID-19" were searched comparatively. The figure shows that the RSV values of the three search words also peaked in March 2020. Additionally, there has been an increasing trend in searches related to the word "immunity" such as "Strengthening the immune system in children," "Drugs that disrupt the immune system," "What to eat to strengthen the immune system," "The best drug to

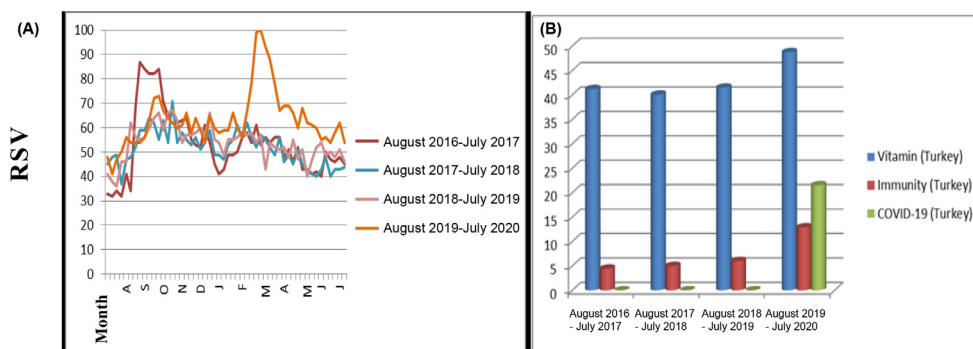


Fig. 1. (A) Relative search volumes obtained using search word "vitamin" in Turkey. (B) Mean of relative search volumes obtained using search words "vitamin," "Immunity (bağışıklık)," and "COVID-19" in Turkey. RSV, relative search volume.

Table 1
Change of RSVs obtained by using the word "vitamin" according to years and seasons

Year	Turkey					Worldwide				
	Vitamin C	Vitamin D	Vitamin E	Vitamin A	Vitamin	Vitamin C	Vitamin D	Vitamin E	Vitamin A	Vitamin
2016	10.1 ± 3.7 (6–25)	31.9 ± 7.5 (16–56)	7.3 ± 2.3 (4–16)	5.3 ± 3.1 (2–20)	52 ± 15.1 (26–87)	16.7 ± 1.2 (14–19)	21.6 ± 2 (18–26)	7.3 ± 2.3 (4–16)	5.3 ± 3.2 (2–20)	44 ± 2.4 (39–48)
2017	11.5 ± 2.3 (8–18)	35.6 ± 6.8 (19–55)	8.6 ± 1.4 (6–12)	4.9 ± 1.5 (3–12)	51.5 ± 6.9 (37–71)	18.6 ± 1.3 (16–21)	23.8 ± 3 (19–34)	8.6 ± 1.4 (6–12)	4.9 ± 1.5 (3–12)	47.8 ± 2.5 (44–52)
2018	13.3 ± 2.6 (9–19)	47.5 ± 8.5 (28–62)	9.4 ± 1.4 (7–12)	4.9 ± 1.3 (3–8)	52.2 ± 8.1 (36–67)	20.7 ± 1.6 (18–25)	24.8 ± 2.9 (21–30)	9.4 ± 1.4 (7–12)	4.9 ± 1.3 (3–8)	50.2 ± 2.8 (45–56)
2019	17.3 ± 3.2 (11–26)	48.5 ± 9.6 (23–69)	10.9 ± 1.6 (8–15)	5.1 ± 1.3 (2–9)	54.8 ± 7.1 (40–73)	23.9 ± 1.6 (21–28)	25.8 ± 2.9 (21–31)	10.9 ± 1.6 (8–15)	5.1 ± 1.3 (2–9)	53.4 ± 2.9 (48–60)
2020	40.1 ± 22* (19–100)	53.4 ± 12.2* (33–88)	12.6 ± 3.2* (9–25)	5.8 ± 1.1* (4–9)	67.1 ± 12.4* (54–100)	46.2 ± 16.2* (28–100)	33.8 ± 5.5* (27–57)	12.6 ± 3.2* (9–25)	5.8 ± 1.1* (4–9)	70.3 ± 8.8* (59–100)
August										
24	16.8 ± 12.8 (6–100)	42.6 ± 11.8 (16–88)	9.52 ± 2.6 (4–25)	5.13 ± 1.9 (2–20)	54.6 ± 11.6 (26–100)	23.5 ± 11.1 (14–100)	25.3 ± 4.9 (18–57)	9.5 ± 2.6 (4–25)	5.1 ± 1.9 (2–20)	51.8 ± 8.9 (39–100)
Test [†]	157.957 < 0.001	125.737 < 0.001	115.367 < 0.001	16.152 0.003	45.195 < 0.001	207.707 < 0.001	119.204 < 0.001	184.221 < 0.001	125.076 < 0.001	186.419 < 0.001
P-value										
Season										
Winter	15 ± 4.4 (9–25)	48.1 ± 10.1 (30–69)	10.1 ± 2 (6–14)	5.7 ± 1.1 (4–8)	55.5 ± 6.6 (41–76)	22.3 ± 4.8 (16–37)	26.9 ± 3.4 (19–34)	10.1 ± 2 (6–14)	5.7 ± 1.1 (4–8)	51.8 ± 5.8 (41–65)
Spring	21.1 ± 21.4* (7–100)	46.2 ± 13.9 (26–88)	10.1 ± 3.5 (5–25)	4.9 ± 1.3 (3–9)	57.2 ± 12.3 (43–100)	27.6 ± 17.8 (16–100)	27.5 ± 6.5 (20–57)	10.1 ± 3.5 (5–25)	4.9 ± 1.3 (3–9)	55.2 ± 12.7* (43–100)
Summer	14.6 ± 9.6 (6–54)	34.6 ± 9.3* (16–57)	8.1 ± 2.1* (4–13)	3.8 ± 1.8* (2–6)	45.2 ± 9.8* (26–79)	22.5 ± 9.7 (14–47)	22.7 ± 4* (18–33)	8.1 ± 2.1 (4–13)	3.8 ± 0.8* (2–6)	49.8 ± 9 (39–71)
Autumn	15.9 ± 4.2 (7–26)	41.2 ± 7.6 (18–55)	9.9 ± 1.9 (6–16)	6.4 ± 2.9 (3–20)	61.7 ± 10.5 (34–87)	20.9 ± 3.1 (16–28)	23.9 ± 2.6 (19–30)	9.9 ± 1.9 (6–16)	6.4 ± 2.9 (3–20)	49.8 ± 4.1 (43–60)
Test [†]	16.107 0.001	45.586 < 0.001	29.769 < 0.001	83.288 < 0.001	74.760 < 0.001	9.486 0.023	56.152 < 0.001	2.678 0.444	38.422 < 0.001	15.899 0.001
P-value										

RSV, relative search volume.

*This group is different from the others.

†Test: Kruskal–Wallis.

Table 2

Related queries with the most hits related to the search word in Turkey and worldwide

Search word	Related queries	
"Vitamin" Turkey	How to use vitamin C Well care vitamin D Natural source of vitamin D What is good for vitamin D deficiency? Normal value of vitamin D How to use vitamin D Vitamin D drops Covid-16 vitamin D Vit d and covid Vitamin D coronavirus Vitamin C and coronavirus Vitamin C sources Coronavirus vitamin C	Vitamin C supplement C vitamin Ocean vit D3 Saol vitamin Wellcare Voonka vitamin Elderberry Vitamin shoppeneare me Vitamine d3 k2 Vitamin C tablet Vitamin E capsule
"Vitamin" worldwide	Strengthening the immune system in children What to eat to strengthen the immune system Herd immunization Immunity covid-19 Corona viris herd immunity	Vitamin syrup Vitamin water content Medicines that impair immunity The best medicine to strengthen immunity Coronavirus Immunity coronavirus Corona immunity
"Bağışıklık" Turkey		
"immunity" worldwide		

strengthen immunity," "Herd immunization," and "Coronavirus" (Table 2).

Figure 2A shows RSVs for the word "vitamin" on a worldwide basis. RSVs of the word "vitamin" are seen an average of 54.6 ± 11.6 (min 26–max 100) from January 2016 to September 2020 (Table 1). The RSV started to increase in January, peaked in mid-February, and started to decrease after May (Fig. 2A). The majority of searches were made in the spring (55.2 ± 12.3) on a worldwide basis and the difference was statistically significant (Table 1). That the RSV value of the word "vitamin" varied statistically by years, with the highest number of searches in 2020 (P < 0.001; Table 1). In the calls made, it was determined that 100 RSVs were reached only in March 2020 in the past 5 y (Fig. 2A). Searches for vitamins such as "COVID-19 vitamin D", "vit D and covid", "vitamin D coronavirus", "vitamin C and coronavirus", "vitamin C sources" around the world showed an increasing trend.

Figure 2B shows the comparative search results of the search words "vitamin," "immunity," and "COVID-19". The RSVs of the three search words also increased rapidly in March 2020 (Fig. 2B). Additionally, searches involving "immune" such as "Immunity COVID-19," "Immunitycoronavirus," "Corona virus herd immunity," and "Corona immunity" showed an increasing trend (Table 2).

Figure 3 shows the RSVs for the words "vitamin C," "vitamin D," "vitamin E," and "vitamin" in Turkey and worldwide. The words "vitamin C" was the word with the highest number of searches during the past five years. While the searches continued similarly for 5 y, the searches for all vitamin types peaked in March 2020 and this increase is statistically different from the RSVs of the previous years (P < 0.001). In March 2020, in Turkey and throughout the world, "vitamin C" word-related searches had 100 RSVs. "Vitamin D"-related searches in Turkey reached 88 RSVs, whereas worldwide it reached 33 RSVs (Table 1). Searches dropped again after March 2020. RSVs for vitamin types show seasonal differences. In Turkey, RSVs of the word "vitamin C" were highest in the spring months; "vitamin D," "vitamin E," and "vitamin" were

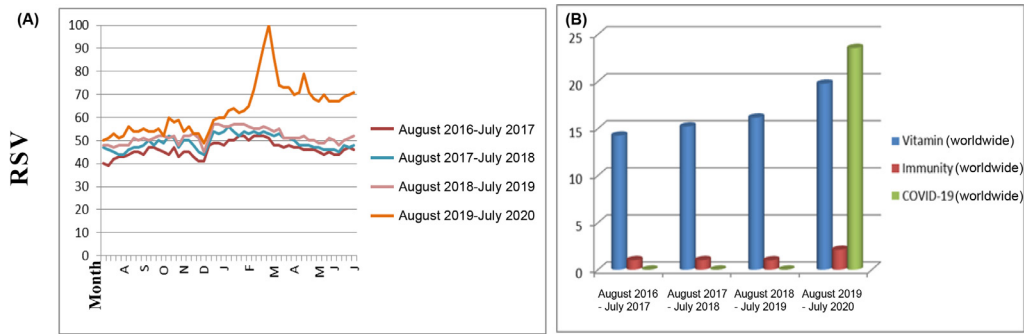


Fig. 2. (A) Relative search volumes obtained using search word "vitamin" worldwide. (B) Mean of relative search volumes obtained using search words "vitamin," "Immunity," and "COVID-19" worldwide. RSV, relative search volume.

lowest during the summer months ($P < 0.001$). Worldwide, the RSVs of the word "vitamin C" was the highest in the spring ($P < 0.05$), and "vitamin D" was the lowest in summer ($P < 0.001$; Table 2).

The word "vitamin" was translated into some countries' language where COVID-19 is common and was searched (Fig. 4). Although the searches related to the word "vitamin" were similar for 5 y in all evaluated countries, the RSVs of the word "vitamin" in all countries reached 100 in March 2020. Similarly in all countries it decreased after the peak.

Discussion

In 2020, as the world was fighting against the COVID-19 pandemic, individuals began taking individual measures. It is reported

in the literature that vitamins have an important effect on strengthening the immune system [6,8]. Their ease of access, lack of required prescription, frequent advertisement in the media, and inclusion in many food sources have led many people to use vitamins first when trying to strengthen their immune systems. The present study aimed to determine whether the COVID-19 pandemic has changed people's interest in the use of vitamins.

In the present study, when the trend toward the search word "vitamin" in Turkey was examined, the searches revealed seasonal characteristics. Searches started to increase in September, reached the highest level at the end of October, and started to decrease after May (Fig. 1). In Turkey, the air temperature starts to decrease in September and increases with the summer season after May. Furthermore, there is also an increase in viral respiratory tract infections in the autumn season, which begins in September [24].

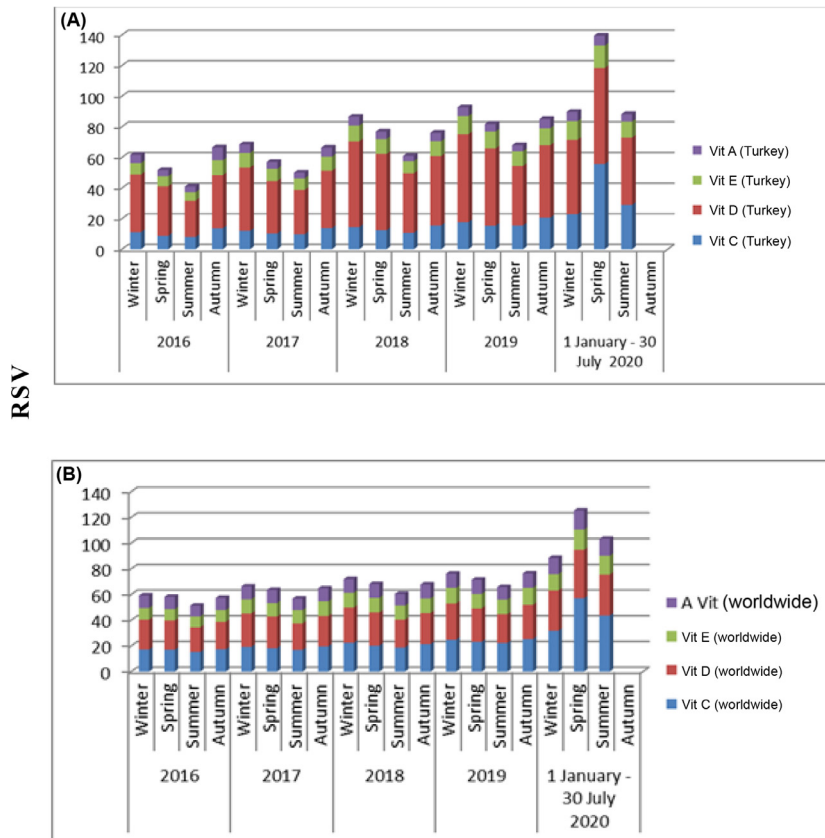


Fig. 3. (A) Mean of relative search volume types of vitamin in Turkey. (B) Mean of relative search volume types of vitamins worldwide. RSV, relative search volume.

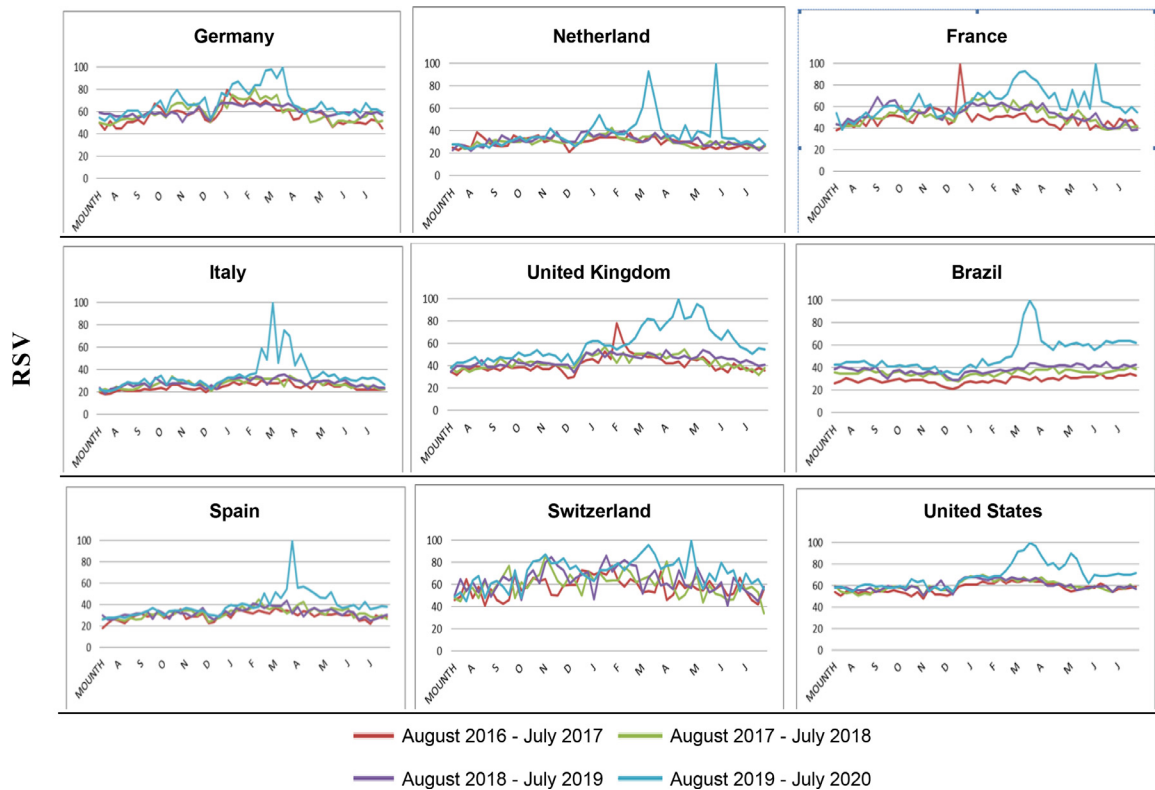


Fig. 4. RSVs of the word "vitamin" in some countries according to month and year. RSV, relative search volume.

In Turkey, the word "vitamin" reached the highest RSV in winter, which may be due to people's tendency to use vitamin supplements owing to the cooling of the weather and the increase in influenza infections. There are seasonal differences around the world. However, in the studies, it was generally determined that they increased in January and February, during which the weather is cold, and decreased after May, as the weather warmed up (Fig. 2).

The first COVID-19 case was reported in China in December 2019. After this date, it spread rapidly and cases were observed in many parts of the world. The World Health Organization declared a pandemic on March 11, 2020. Furthermore, the first COVID-19 case in Turkey was reported on March 11, 2020. In the study, the search on vitamins in Turkey, around the world, and in some countries increased rapidly in March 2020, unlike other years, and all search RSV values for vitamins in 2020 were significantly higher than in previous years (Fig. 1, 2, and 4; Table 1). Furthermore, in the study, searches for vitamin, immunity, and COVID-19 were evaluated comparatively. The RSV values of the three search words increased rapidly in March 2020. Nevertheless, searches such as "COVID-19 vitamin D," "vit D and covid," "vitamin D coronavirus," "vitamin C and coronavirus," "Vitamin C sources," "Strengthening the immune system in children," "Drugs that disrupt immunity," "What to eat to strengthen the immune system," "The best drug to strengthen immunity," "herd immunity," and "Coronavirus" showed an increasing trend. Based on these results, it can be concluded that the increasing trend in March 2020 is an indicator of the public's search for information to protect against COVID-19. In Turkey, the word "Sambucus nigra" is also an increasing trend. It is reported that *Sambucus nigra*, with a rich content of vitamin C [25], has a positive effect on strengthening the immune system [26]. This result indicates that people may have turned toward herbal supplements to strengthen the immune system.

Some vitamins are indicated to be effective in strengthening the immune system [2,23]. During the COVID-19 pandemic, the media frequently has mentioned that these vitamins contribute to both protection from disease and the healing process in case of illness [11–16]. Accordingly, in the study, a comparative search was conducted to determine the tendency toward vitamins that have positive effects on strengthening the immune system. The interest in the types of vitamin both worldwide and in Turkey shows seasonal characteristics. The tendency toward vitamin D was determined to be the highest in the winter in Turkey. This result can be attributed to people's need for supplementary products for vitamin D owing to the lack of sunlight in the winter months. The tendency toward all types of vitamins decreased in summer. The tendency toward vitamin C increased in the spring both in Turkey and worldwide. The tendency toward all types of vitamins increased in 2020 and differed significantly from previous years. In particular, the tendency toward vitamin C reached 100 RSVs. Vitamin C, or ascorbic acid, is a water-soluble food that cannot be synthesized by humans. Vitamin C acts as an antioxidant that can scavenge reactive oxygen species, and thus it protects biomolecules such as proteins, lipids, and nucleotides from oxidative damage and dysfunction. Vitamin C accumulates in leukocytes at concentrations 50 to 100 times higher than in plasma. It is well known that vitamin C provides a preventive benefit in infectious disease. Vitamin C supplementation supports respiratory defense mechanisms, prevents viral infections, and has antihistamine properties that can improve flulike symptoms as well as reducing the duration and severity of infections. This essential protective effect against respiratory tract infections has made vitamin C an attractive target for COVID-19 [27].

Vitamin D reached the second highest RSV value. A fat-soluble vitamin, vitamin D has a vital role in modulating both innate and

adaptive immune responses [28]. The epidemiologic data have associated vitamin D deficiency with increased susceptibility to acute respiratory viral infections [29]. A systematic review indicated that vitamin D plays a significant regulatory role in innate immune responses to respiratory viral infections such as Influenza A and B, parainfluenza 1 and 2, and respiratory syncytial virus [30]. It has been suggested that vitamin D deficiency increases the frequency and severity of COVID-19 infection. Adequate vitamin D levels may help protect respiratory epithelium from pathogenic spread and reduce the risk for infection. There are studies demonstrating that patients with COVID-19 have lower vitamin D levels with average plasma concentrations about half that of controls. Therefore, vitamin D supplementation is recommended to improve immunity against COVID-19 and reduce human deaths [31–35].

Conclusion and recommendations

Undoubtedly, vitamins have many positive effects in strengthening the immune system. However, accurate determination of the need, accurate product selection, and the appropriate amount and correct use of vitamins will ensure maximum benefit and also prevent the occurrence of potential side effects. Therefore, it is important that people are informed correctly and reach the right sources of information. At this point, the role of dietitians, doctors, nurses, and the media—which is highly influential—in guiding people is very important. Additionally, databases such as pubmed.gov and scholar.google.com can be used to examine the peer-reviewed journal literature on vitamins.

Limitations

The present study had some limitations. Google Search Trends provides data related solely to the population that has internet access and uses the Google search engine. These kinds of searches can be a good proxy for the public's interests, concerns, or intentions, but these searches do not necessarily represent user opinions.

References

- Cheng RZ. Can early and high intravenous dose of vitamin C prevent and treat coronavirus disease 2019 (COVID-19)? *Med Drug Discov* 2020;5:100028.
- Shakoor H, Feehan J, Al Dhaheer AS, Ali HI, Platat C, Ismail LC, et al. Immune-boosting role of vitamins D, C, E, zinc, selenium and omega-3 fatty acids: could they help against COVID-19? *Maturitas* 2021;143:1–9.
- Xu Z, Shi L, Wang Y, Zhang J, Huang L, Zhang C, et al. Pathological findings of COVID-19 associated with acute respiratory distress syndrome. *Lancet Respir Med* 2020;8:420–2.
- Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 2020;395:1054–62.
- World Health Organization COVID-19 and NCDs. Available at: www.who.int/internal-publications-detail/covid-19-and-ncds. Accessed August 25, 2020.
- Wintergerst ES, Maggini S, Hornig DH. Contribution of selected vitamins and trace elements to immune function. *Ann Nutr Metab* 2007;51:301–23.
- Carr AC, Maggini S. Vitamin C and immune function. *Nutrients* 2017;9:1211.
- Zabetakis I, Lordan R, Norton C, Tsoupras A. COVID-19: the inflammation link and the role of nutrition in potential mitigation. *Nutrients* 2020;12:1466.
- Patel N, Penkert RR, Jones BG, Sealy RE, Surman SL, Sun Y, et al. Baseline serum vitamin A and D levels determine benefit of oral vitamin A & D supplements to humoral immune responses following pediatric influenza vaccination. *Viruses* 2019;11:907.
- Iddir M, Brito A, Dingo G, Del Campo SSF, Samouda H, La Frano MR, et al. Strengthening the immune system and reducing inflammation and oxidative stress through diet and nutrition: considerations during the COVID-19 crisis. *Nutrients* 2020;12:1562.
- Grant WB, Lahore H, McDonnell SL, Baggerly CA, French CB, Aliano JL, et al. Evidence that vitamin D supplementation could reduce risk of influenza and COVID-19 infections and deaths. *Nutrients* 2020;12:988.
- Carr AC. A new clinical trial to test high-dose vitamin C in patients with COVID-19. *Critical Care* 2020;24:1–2.
- Rhodes JM, Subramanian S, Laird E, Kenny RA. Editorial: low population mortality from COVID-19 in countries south of latitude 35 degrees North supports vitamin D as a factor determining severity. *Aliment Pharmacol Ther* 2020;51:1434–7.
- Alipio M. Vitamin D supplementation could possibly improve clinical outcomes of patients infected with coronavirus-2019 (COVID-19). SSRN Electronic J 2020. 09.04.2020, pre-print version. Electronic copy available at: <https://ssrn.com/abstract=3571484>. (Date of access: 10.08.2020).
- Hemilä H, Chalker E. Vitamin C as a possible therapy for COVID-19. *Infect Chemother* 2020;52:222–3.
- Shiravi AA, Saadatkish M, Abdollahi Z, Miar P, Khanahmad H, Zeinalian M. Vitamin D can be effective on the prevention of COVID-19 complications: a narrative review on molecular aspects. *Int J Vitam Nutr Res* 2020;1–13.
- Uçak NÖ, Al U. Information seeking behaviours on the internet. *Türk Kütüphaneciliği* 2000;14:317–31.
- Mavragani A, Ochoa G. Google Trends in infodemiology and infoveillance: methodology framework. *JMIR Public Health Surveill* 2019;5:e13439.
- Eysenbach G. Infodemiology and infoveillance. *Am J Prev Med* 2011;40:S154–8.
- Google Trends. Available at: trends.google.com/trends/?geo=US. Accessed January 21, 2021.
- Nuti SV, Wayda B, Ranasinghe I, Wang S, Dreyer RP, Chen SI, et al. The use of google trends in health care research: a systematic review. *PLoS One* 2010;9:e109583.
- Mavragani A, Tsagarakis KP. YES or NO: Predicting the 2015 GReferendum results using Google Trends. *Technological forecasting and social change*. Amsterdam: Elsevier; 2015. p. 1–5.
- Alschuler L, Weil A, Horwitz R, et al. Integrative considerations during the COVID-19 pandemic. *Explore (NY)* 2020;16:354–6.
- Elçin Ö, Tanı TVA. Viral upper respiratory tract infections. Available at: thb.hacettepe.edu.tr/arsiv/2002/sayi_1/baslik4.pdf. Accessed January 21, 2021.
- Młynarczyk K, Walkowiak-Tomczak D, Łysiak GP. Bioactive properties of Sambucus nigra L. as a functional ingredient for food and pharmaceutical industry. *J Funct Foods* 2018;40:377–90.
- Lindsay K. Nutrition for immune health. *Nutrition* 2021. Available at: <https://ssih.uci.edu/tip/nutrition-for-immune-health/>. Accessed January 21.
- Zhon X, Zeng M, Bian H, Zhong C, Xiao F. An evaluation of the protective role of vitamin C in reactive oxygen species-induced hepatotoxicity due to hexavalent chromium in vitro and in vivo. *J Occup Med Toxicol* 2017;12:15.
- Aranow C. Vitamin D and the immune system. *J Invest Med* 2011;59:881–6.
- Monlezun DJ, Bittner EA, Christopher KB, Camargo CA, Quraishi SA. Vitamin D status and acute respiratory infection: cross-sectional results from the United States National Health and Nutrition Examination Survey, 2001–2006. *Nutrients* 2015;7:1933–44.
- Zdrengeha MT, Makrinioti H, Bagacean C, Bush A, Johnston SL, Stanciu LA. Vitamin D modulation of innate immune responses to respiratory viral infections. *Rev Med Virol* 2017;27.
- D'Avolio A, Avataneo V, Manca A, Cusato J, De Nicolo A, Lucchini R, et al. 25-hydroxy vitamin d concentrations are lower in patients with positive PCR for SARS-CoV-2. *Nutrients* 2020;12:1359.
- Annweiler C, Hanotte B, de l'Épervier CG, Sabatier JM, Lafaie L, Célariet T. Vitamin D and survival in COVID-19 patients: a quasi-experimental study. *J Steroid Biochem Mol Biol* 2020;204:105771.
- Castillo ME, Costa LME, Barrios JMV, Díaz JFA, Miranda JL, Bouillon R, et al. Effect of calcifediol treatment and best available therapy versus best available therapy on intensive care unit admission and mortality among patients hospitalized for COVID-19: a pilot randomized clinical study. *J Steroid Biochem Mol Biol* 2020;203:105751.
- Annweiler G, Corvaisier M, Gautier J, Dubé V, Legrand E, Sacco G, et al. Vitamin D supplementation associated to better survival in hospitalized frail elderly COVID-19 patients: the GERIA-COVID Quasi-Experimental Study. *Nutrients* 2020;12:3377.
- Mercola J, Grant WB, Wagner CL. Evidence regarding vitamin D and risk of COVID-19 and its severity. *Nutrients* 2020;12:3361.