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Consumption of dietary supplements and their determinants among adults in six Arabic countries: a cross-sectional survey

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Abstract

Background Since the onset of the coronavirus (COVID-19) pandemic crisis, the supplement market has consistently grown. Therefore, we conducted this survey during the fourth wave of the COVID-19 pandemic to study the frequency and context of dietary supplement (DS) consumption (vitamins and mineral intake) and explore the consumer's pharmaceutical buying behaviour; and (3) to study its determinants as regards the demographics, Fatigue Severity Scale (FSS), and healthy eating pyramids.

Methods We conducted a cross-sectional web-based survey on 1333 Arabic adults aged 18 years or more residing in six Arabic-speaking countries in May 2022, using a validated self-administrated questionnaire**.** The survey-involved questions about sociodemographic characteristics, physical activity, FSS, healthy eating pyramid, DS consumption, and consumers' pharmaceutical purchasing behaviour.

Results Most participants were aged 20 to less than 35 years, and 64.6% used dietary supplements. There was a statistically significant difference between supplement users and nonusers as regards consumers' pharmaceutical buying behaviour in terms of advertising quality, safety rules, pharmaceutical forms, and packet quality. Arabic adults consumed the following dietary supplements: 63.5% vitamin C, 60.1% vitamin D, 47.1% iron, and 44.4% zinc. Authorised products (76.0%), natural contents (75.0%), and safety rules (68%), were the most common factors influencing Arabic consumers' pharmaceutical purchasing behavior. Multi-logistic regression analysis showed that being female, having a history of COVID-19, having a positive attitude about the benefits, and being recommended for supplement use were predictors of dietary supplement use.

Conclusion The dietary consumption of supplements is prevalent, mainly including vitamin C, vitamin D, iron, zinc, vitamin B, and magnesium. In addition, Arabic adults are poorly adherent to healthy eating pyramids**.** Given the ongoing COVID-19 pandemic, Arabic health authorities should prioritize this issue to minimize the potential for misusing dietary supplements.

Keywords Consumer's pharmaceutical purchasing behavior, Healthy eating pyramid, Dietary Supplements, Fatigue Severity Scale, Determinants, Arabic adults, Adverse effects

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Introduction

The World Health Organization (WHO) has reported more than 608 million confirmed cases of COVID-19 and more than 6 million deaths as of May 2022 [1]. Even in those at low or high risk of developing a severe acute illness, COVID-19 infection can cause multi-organ damage [2, 3]. As there are limited treatments available for COVID-19, individuals increasingly rely on vitamins and supplements to enhance their immune systems and prevent disease progression [4].

The Dietary Supplement Health and Education Act, approved by Congress in 1994 and passed into law, defines a dietary supplement as any product (other than tobacco), i.e., a pill, capsule, tablet, or liquid, that is designed to be taken by mouth and is marked on the front label panel as a dietary supplement. It also contains one or more dietary elements (e.g., vitamins, minerals, herbs or other botanicals, amino acids, and other substances) or their constituents [5].

During the COVID-19 pandemic, consumer perceptions and opinions about nutraceuticals, as well as factors such as healthy eating behaviour, actual clinical benefit and safety, media coverage, and the behaviour of healthcare providers, can all influence the consumption of dietary supplements. However, these supplements' negative effects remain inadequately documented or tracked [6–8].

In many countries, promoting and advertising dietary supplements is legal. The Food and Drug Administration (FDA) does not require approval for the registration of nutraceutical companies, putting consumers at risk for false, exaggerated health claims that lack sufficient evidence of their efficacy; moreover, the law does not effectively defend and protect consumer rights [9, 10]. The (USA) FDA and Federal Trade Commission (FTC) have issued warnings to many companies selling products that fraudulently claim to prevent or treat COVID-19 [11]. Despite these warnings, the global market for supplements has expanded consistently over the past ten years. However, after the pandemic, sales of dietary supplements unexpectedly surged, for example, by 5% in the USA, 63% in the United Kingdom (UK) for vitamins, and between 40 and 60% in France in March 2020 compared to the same month last year. Customers' enthusiasm greatly increased sales of nutraceuticals in China, the USA, Canada, and France [12–16]. Unfortunately, little information is available on the current state of dietary supplement consumption in the Middle Eastern and Arabic regions.

We anticipate that the market for nutraceuticals and supplements will not sustain exceptional growth rates and will revert to its pre-pandemic levels. As the industry continues to expand, regulatory agencies must ensure customer safety by monitoring products for accuracy, deception, and harmful effects through evidence-based research. Therefore, we conducted this multinational study among adult Arabic populations from six different countries during the fourth wave of the COVID-19 pandemic in May 2022 for the following reasons: (1) to study the frequency, types, and context of dietary supplement consumption among Arabic populations; (2) to explore the consumer's pharmaceutical purchasing behaviour; and (3) to study the determinants of dietary supplement consumption as regards the demographics, excess fatigability scale, and healthy eating pyramids associated with the usage of dietary supplements.

Methods

Study design and participants

We conducted a cross-sectional web-based survey of 1333 Arabic participants during the fourth wave of the COVID-19 pandemic in May 2022. The selection criteria were as follows: adult's aged 18 years or more residing in one of six Arabic-speaking countries (Egypt, Saudi Arabia, Syria, Libya, Iraq, and Algeria). We excluded individuals who were illiterate, did not use the internet, did not own smartphones or computers, had complicated mental, chronic, or psychiatric comorbidities, or did not complete the questionnaire.

Sample size and sampling techniques

We use the following method to determine the sample size: $n = Z^2\ P\ (1-P)/d^2$, where n is the sample size, Z is the level of confidence equal to 1.96 for a confidence level of 95%, P is the expected prevalence equal to 0.0466, and d is precision equal to 0.05 (equivalent to effect size) [17].

The sample size was calculated to be 1400 participants, with a 95% confidence level; it was found that 46.6% of public participants from a multicenter study during the second wave of COVID-19 took dietary supplements [18].

We adopted a multistage sampling technique to select the six-targeted Arabic-speaking countries in the Middle East (Egypt, Saudi Arabia, Syria, Libya, Iraq, and Algeria). We determined the required number of samples from each area, ensuring they met all the selection criteria. We began by selecting three governorates at random from each of the six; we then selected one urban and one rural area from each of the three governorates; and finally, we used the official websites and social media platforms (Facebook, Twitter, official emails, and WhatsApp groups) in each of these areas.

The data collection tool

Questionnaire development and structure

Evidence from other studies was incorporated into the survey's creation and adoption [5, 18–23]. It was initially written in English and then translated into Arabic. A bilingual group of two medical experts and one externally certified medical translator translated the questionnaire's English version into Arabic.

Questionnaire validation

To confirm its comprehension and cultural acceptability, a pilot test was conducted with 60 volunteers from the general community in the six studied countries (15 volunteers completed the Arabic version from each nation). The participants were asked to rate the questionnaire's structure, clarity, and length, as well as to provide a general opinion. Following that, certain questions were revised in light of their input. To check for reliability and reproducibility, the questionnaire was tested again on the same people one week later. The final data analysis did not include the data collected during the pilot test. We calculated a Cronbach's alpha of 0.78 for the questionnaire.

The structure of the questionnaire

After giving their permission to take part in the study (informed consent), the participants filled out and sent in the questionnaire. The questionnaire was composed of the following sections:

(I) Sociodemographic and health-related factors: age, sex, residence, nationality, educational level, occupation, marital status, weight, height, and comorbidities.

(II) Physical fitness status was assessed using the following:

*Fatigue Severity Scale (FSS). The level of fatigue was assessed using the FSS questionnaire, which had a 0.88 internal consistency and a 0.84 test–retest reliability**.** In the FSS questionnaire, nine statements assess the severity of fatigue symptoms. It was assessed using a Likert scale. A low value (such as 1) indicates strong disagreement, while a high value (such as 7) indicates strong agreement. A total score of less than 36 indicates that you may not feel fatigued. A total score of 36 or higher indicates that additional medical testing may be necessary [19].

*The level of physical activity was measured based on the average step count (using smart watches or smart phones' free applications, such as pedometers or accelerometers) or the subjective report over the last week: The level of physical activity was classified as sedentary if it was less than 5000 steps per day, low if it was between 5000 and 7000 steps per day, average if it was between 7000 and 1000 steps per day, and high if it was greater than 10000 steps [20].

(III) The Healthy Eating Pyramid includes vegetables, fruits, whole grains, healthy oils, and healthy proteins, like nuts, beans, fish, and chicken, in addition to addressing other healthy lifestyle aspects, like exercise and multivitamin supplements. The questionnaire illustrated the size of portions or amounts of each food element (e.g., protein) and the required amount of water, based on Harvard University's Healthy Eating Pyramid. It was available to download and use without authorization [21, 22].

(IV) The context of vitamin, mineral, and other commonly used products, including testosterone and growth hormones: the frequency of use, the forms and types used by participants, the source of information, and the causes and adverse effects of vitamin and mineral intake [23].

(V) Consumer's pharmaceutical purchasing behaviour (e.g., cost, serving size, list of dietary ingredients, amount per serving size (by weight), percent of the daily value (%DV), if established). If the dietary ingredient is botanical, it uses the plant's scientific name, or the common or usual name [5].

The data collection method

Using a multistage sample technique, we chose three governorates at random from each of the six Arabic-speaking countries; we then chose one urban area and one rural area from each of the three governorates; and finally, we used the official websites for each governorate's constituent regions to gather community-based samples.

The questionnaire was filled out and submitted by participants after they agreed to participate in the study (informed consent). The targeted nations in randomly chosen regions and locations were given the questionnaire, which asked about the most popular and official social media platforms in each of these areas (Facebook, Twitter, and WhatsApp groups). To improve the response rate, follow-up and reminder emails were adopted until the required sample was completed.

Following their consent to take part in the study, participants completed and submitted all questions that were obligatory, and they were allowed to fill out the survey once. Follow-up and reminder emails and messages were delivered to the administrators and the targeted demographics until the required sample was completed in order to increase the response rate.

Statistical analysis

The Software Package of Statistical Analysis (SPSS) program version 27 was used to analyze the data. Quantitative information, such as BMI, was presented as mean ± SD and frequencies and percentages for categorical

variables. After analyzing the normally distributed quantitative data using the Kolmogorov-Smirnov test, then the mean, standard deviation (SD), and Student's t-tests were performed to examine the quantitative data. A Chi-squared test (χ^2) was used to determine if categorical variables were associated with qualitative data, such as age groups and sex, which were provided as frequency and percentages. To evaluate the independent relationships between each potential factor and the outcome of interest, we built an adjusted logistic regression model using a stepwise approach. We first included all the variables that the univariable analyses found to be significant ($P<0.05$) in the stepwise regression technique. We calculated the adjusted odds ratios (OR) and 95% confidence interval (CI) from the above-fitted final model and presented them.

Results

The demographic and clinical characteristics of the studied participants

Most of the participants (881, 66.1%) were aged between 20 and less than 35 years. Most of them were female (72.8%) and had a university level of education (77.8%). Nearly half of the participants worked in medical professions (51.3%), and more than one-fourth of the participants were from Egypt (26.1%) and Algeria (18.8%). Most participants were nonsmokers and had no history of chronic diseases (88.9% and 86.6%, respectively). There was a statistically significant relationship between dietary supplement use and sociodemographic criteria, in which supplement use was significantly higher among females, single or married, living in urban regions, and those from Saudi Arabia, Libya, and Egypt compared to their counterparts ($P<0.05$). Participants reported a confirmed history of SARS-CoV-2 infection in about 35.8% of cases, while 22.7% showed suspicions (**Table** 1).

The frequency of DS consumption: nearly two-thirds of study participants used dietary supplements in the last 2 months preceding the study (64.6%). Dietary supplement use was significantly higher (71.7%) among those with a confirmed SARS-CoV-2 infection (**Table** 1).

The healthy eating pyramids and total fatigue severity scale

We found that nearly one-third of the participants took the daily-recommended requirements from protein (32%), vegetables (31.4%), and sun exposure (37%), respectively, and only 17.2% took the daily-recommended requirements from fruits and 23.6% from water. Interestingly, dietary supplement use was significantly higher among those who took daily requirements of protein and water as recommended or less than recommended compared to those who never took the recommended requirements ($P<0.05$), but there was no difference in supplement use regarding other dietary preventive measures.

About half of the participants rarely or never practice physical activity at all (49.8%), with no differences between dietary supplement users and nonusers. About three-quarters of participants recommended the use of supplements, which was significantly more recommended by supplement users compared to nonusers (73.4% vs. 26.6%) (**Table** 2).

The total fatigue severity score was 30.03 ± 13.82. It was significantly higher among supplement users compared to nonusers (30.93 ± 13.88 vs. 28.39 ± 13.57). In addition, the scores of individual domains of fatigue severity were all significantly higher among dietary supplement users compared to nonusers ($P<0.05$), except for the second and sixth domains. More than two-thirds of supplement users had suspected fatigue compared to nonusers (69.9% vs. 30.1%) (**Table** 3).

The context of dietary or other supplement consumption

Figure 1 shows the main sources of information for participants regarding dietary supplements. Physicians and pharmacists (79.9%), specialized coaches (78.3%), scientific books and journals (74.4%), and the internet/specialized pages (74.4%) were the most common sources, while family and friends (66%) were the least common. Non-supplement users, on the other hand, had family and/or friends, TV and/or radio, and social media as the most common information sources, respectively. **Figure** 2 shows the main causes of using DS, in descending order: to promote general health (87.1%), improve immunity (66.7%), improve hair and nails (50.2%), and improve the shape of the body (41.5%).

Table 4 shows that tablets were the most commonly used form of dietary supplements amongusers (90.6%), with 52.5% using them under medical supervision, while 42.7% used them without any supervision. The most used vitamins during COVID-19 pandemic were vitamins C and D [2 (2.40 ± 1.42) and 2 (2.10 ± 1.75), respectively]. Zinc and iron were the most used minerals [1 (2.01 ± 1.39) and 1 (2.05 ± 1.37), respectively] as well.

Figures 3 and 4 show that among the 287, 21.5% of participants who reported a history of adverse effects (AEs) from the consumption of DS, the most common causes were the type of product used (50, 17.4%), using DS without a prescription (45, 15.7%), other causes (41, 14.3%), and health conditions (35, 12.3%). The most frequently reported AEs associated with the use of DS, in descending order, were stomachache (209, 72.9%), constipation (172, 58.9%), nausea and vomiting (102, 35.5%), tachycardia (75, 26.1%), and diarrhea (67, 23.3%).

Table 1 Socio-demographic and clinical characteristics of the study participants

	Total *N.* = 1333(%) F (%)	Dietary supplements use		*P* value
		Yes *N.* = 861 F (%)	No *N.* = 472 F (%)	
Age group (years):				
- < 20 years	163 (12.2)	97 (59.5)	66 (40.5)	
- 20—< 35	881 (66.1)	567 (64.4)	314 (35.6)	
- 35—< 50	178 (13.4)	128 (71.9)	50 (28.1)	0.140
- 50—< 65	97 (7.3)	59 (60.8)	38 (39.2)	
- ≥ 65	14 (1.1	10 (71.4)	4 (28.6)	
Sex				
- Males	362 (27.2)	164 (45.3)	198 (54.7)	**< 0.001***
- Females	971 (72.8)	697 (71.8)	274 (28.2)	
Educational Level:				
- Primary/Intermediate	40 (3.0)	22 (55.0)	18 (45.0)	0.230
- Secondary	74 (5.6)	43 (58.1)	31 (41.9)	
- University	1037 (77.8)	671 (64.7)	366 (35.3)	
- postgraduate	182 (13.7)	125 (68.7)	57 (31.3)	
Occupation:				
- Student / not working	389 (29.2)	242 (62.2)	147 (37.8)	0.439
- Medical worker	684 (51.3)	445 (65.1)	239 (34.9)	
- Other work	260 (19.5)	174 (66.9)	86 (33.1)	
Marital status				
- Single	899 (67.4)	557 (62.0)	342 (38.0)	**0.013***
- Married	396 (29.7)	276 (69.7)	120 (30.3)	
- Divorced /Widow	38 (2.9)	28 (73.7)	10 (26.3)	
Residence:				
- Urban	1000 (75.0)	661 (66.1)	339 (33.9)	**0.046***
- Rural	333 (25.0)	200 (60.1)	133 (39.9)	
Nationality				
- Egypt	348 (26.1)	206 (59.2)	142 (40.8)	**0.002***
- Algeria	251 (18.8)	164 (65.3)	87 (34.7)	
- Saudi Arabia	235 (17.6)	169 (71.9)	66 (28.1)	
- Libya	222 (16.7)	128 (57.7)	94 (42.3)	
- Iraq	137 (10.3)	97 (70.8)	40 (29.2)	
- Syria	124 (9.3)	86 (69.4)	38 (30.6)	
- Others[a]	16 (1.2)	11 (68.8)	5 (31.2)	
Smoker status:				
- Non-smoker	1185 (88.9)	774 (65.3)	411 (34.7)	0.320
- Cigarette	74 (5.6)	41 (55.4)	33 (44.6)	
- Shisha	50 (3.8)	30 (60.0)	20 (40.0)	
- Both	24 (1.8)	16 (66.7)	8 (33.3)	
Chronic disease history:				
- No	1155 (86.6)	740 (64.1)	415 (35.9)	0.713
- Physical disease	143 (10.7)	97 (67.8)	46 (32.2)	
- Psychological disease	23 (1.7)	15 (65.2)	8 (34.8)	
- Both	12 (0.9)	9 (75.0)	3 (25.0)	
SARS-CoV 2 infection				
- No	553 (41.5)	342 (61.8)	211 (38.2)	**< 0.001***
- Yes	477 (35.8)	342 (71.7)	135 (28.3)	
- Suspected	302 (22.7)	176 (58.3)	126 (41.7)	

* $p < 0.05$ there was a statistically significant difference

[a] Others (Turkey– Palestine–France – Germany – Canada– Sudan– Jordan)

Table 2 The Healthy Eating Pyramid, the practice of preventive measures and their relationship to dietary supplements use

Parameters	Total *N* = 1333(%) F (%)	Dietary supplements		*P* value of χ2
		Yes (*N.* = 861) F (%)	No (*N.* = 472) F (%)	
Protein (3 servings / daily)				
- Yes	427 (32.0)	276 (64.6)	151 (35.4)	**0.006***
- Less than recommended	667 (50.0)	453 (67.9)	214 (32.1)	
- More than recommended	48 (3.6)	27 (56.3)	21 (43.8)	
- Never	191 (14.3)	105 (55.0)	86 (45.0)	
Fruits (3–5 servings daily)				
- Yes	229 (17.2)	150 (65.5)	79 (34.5)	0.938
- Less than recommended	894 (67.1)	579 (64.8)	315 (35.2)	
- More than recommended	31 (2.3)	19 (61.3)	12 (38.7)	
- Never	179 (13.4)	113 (63.1)	66 (36.9)	
Vegetables (3–5 servings daily)	**N = 1332**	**N = 860**		
- Yes	418 (31.4)	266 (63.6)	152 (36.4)	0.286
- Less than recommended	723 (54.3)	479 (66.3)	244 (33.7)	
- More than recommended	74 (5.6)	48 (64.9)	26 (35.1)	
- Never	117 (8.8)	67 (57.3)	50 (42.7)	
Water intake (3 Liters daily)				
- Yes	314 (23.6)	195 (62.1)	119 (37.9)	**0.003***
- Less than recommended	819 (61.4)	555 (67.8)	264 (32.2)	
- More than recommended	85 (6.4)	42 (49.4)	43 (50.6)	
- Never	115 (8.6)	69 (60.0)	46 (40.0)	
Physical activity practice				
- High	109 (8.2)	67 (61.5)	42 (38.5)	0.884
- Moderate	357 (26.8)	233 (65.3)	124 (34.7)	
- Low /sedentary	204 (15.3)	130 (63.7)	74 (36.3)	
- Rarely / None	663 (49.8)	431 (65.0)	232 (35.0)	
Sun exposure (1.5 hour weekly)				
- Yes	493 (37.0)	311 (63.1)	182 (36.9)	0.067
- Less than recommended	384 (28.8)	258 (67.2)	126 (32.8)	
- More than recommended	259 (19.4)	154 (59.5)	105 (40.5)	
- Never	197 (14.8)	138 (70.1)	59 (29.9)	
Flu vaccination				
- Yes	331 (24.8)	200 (60.4)	131 (39.6)	0.189
- No but intend to take	236 (17.7)	154 (65.3)	82 (34.7)	
- No and not intend to take	765 (57.4)	506 (66.1)	259 (33.9)	
COVID-19 vaccination				
- Yes	861 (64.6)	571 (66.3)	290 (33.7)	0.195
- No but intend to take	145 (10.9)	89 (61.4)	56 (38.6)	
- No and not intend to take	326 (24.5)	200 (61.3)	126 (38.7)	
DS recommendation				
- Yes	1006 (75.5)	738 (73.4)	268 (26.6)	**< 0.001***
- No	327 (24.5)	123 (37.6)	204 (62.4)	

Dietary Supplement (DS)

χ^2, chi-square test

* $p < 0.05$ there was a statistically significant difference

Table 3 Association between fatigue severity scale and the preventive measure practiced by participants according to dietary supplements use

Parameters	Total *N* = 1333	Dietary supplements use		*P* of t test
		Yes *N.* = 861	No *N.* = 472	
Fatigue severity scale mean ± SD				
- My motivation is lower when I am fatigued	4.20 ± 2.23	4.29 ± 2.19	4.03 ± 2.29	**0.041***
- Exercise brings on my fatigue	3.38 ± 2.01	3.44 ± 2.09	3.27 ± 2.12	0.177
- I am easily fatigued	3.75 ± 2.25	3.93 ± 2.26	3.42 ± 2.18	**0.001***
- Fatigue interferes with my physical functioning	3.84 ± 2.15	3.99 ± 2.16	3.58 ± 2.09	**0.001***
- My fatigue prevents sustained physical functioning	3.70 ± 2.14	3.82 ± 2.14	3.48 ± 2.11	**0.004***
- Fatigue interferes with carrying out certain duties and responsibilities	3.71 ± 2.16	3.80 ± 2.18	3.56 ± 2.11	0.051
- Fatigue is among my three most disabling symptoms	3.85 ± 2.24	3.96 ± 2.27	3.64 ± 2.17	**0.011***
- Fatigue interferes with my work, family, or social life	3.59 ± 2.21	3.96 ± 2.22	3.41 ± 2.17	**0.026***
Total fatigue severity score (mean ± SD)	30.03 ± 13.82	30.93 ± 13.88	28.39 ± 13.57	**0.001***
Fatigue status	**F (%)**	**F (%)**	**F (%)**	***P*** of χ^2
- No fatigue (score < 36)	845 (63.4)	520 (61.5)	325 (38.4)	**0.002***
- Suspect fatigue (score ≥ 36)	488 (36.6)	341 (69.9)	147 (30.1)	

χ^2, chi-square test

t test, student t test

* $p < 0.05$ there was a statistically significant difference

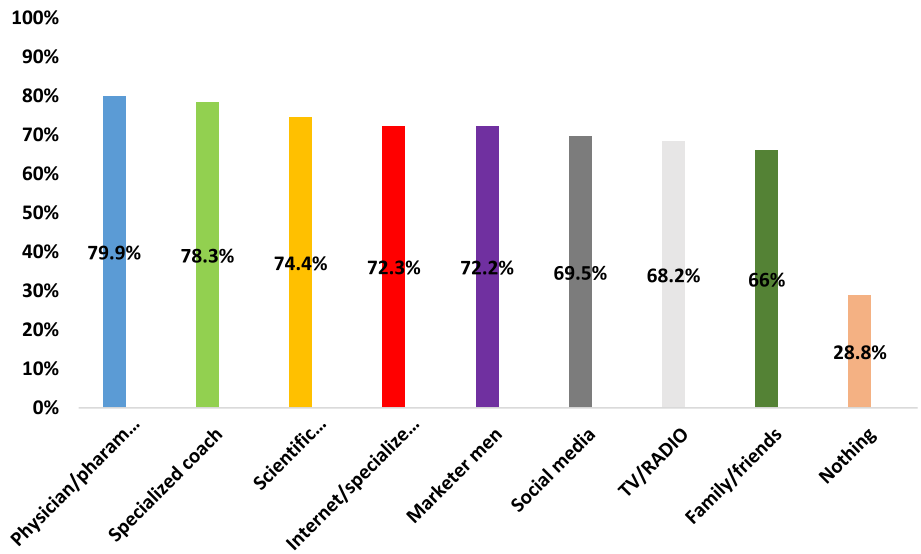

Fig. 1 The sources of information about dietary supplements among adult participants

Authorized and approved product 1024 (76.8%), safety rules 906 (67.9%), and natural products 864 (64.8%). There were statistically significant differences between DS users and nonusers, where advertising quality, safety rules, pharmaceutical forms, packet quality, and approved products significantly influenced supplement choice among users ($P < 0.05$). However, there were no statistically significant differences between groups regarding cost, manufacturing country, packet size, natural contents, or the presence of discount offers (**Table** 5).

In terms of participants' self-reported evaluation of the beneficialness of DS consumption, 47.7% of Arabic adults reported that it is beneficial, while 33.1% of them said that DS is harmful. We found a statistically significant

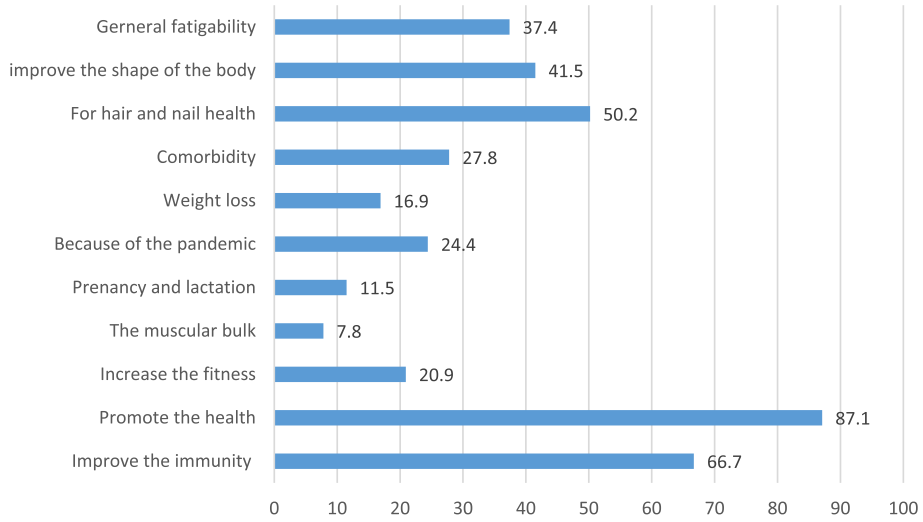

Fig. 2 The main causes of using dietary supplements among the DS users

association between participants self-reported evaluation of the beneficialness of DS consumption and the consumption of DS, as the majority of DS users reported that the DS consumption was very beneficial (81.1%) and beneficial (74.5%), while the majority of DS nonusers thought it was harmful (84.6%) and very harmful (80.0%), respectively (**Table** 5).

Multi-logistic regression analysis revealed that the main predictors linked to supplement use were being female (OR: 2.57; 95% CI 1.93–3.42), having a positive self-reported evaluation of the beneficialness of DS consumption, and recommending the use of DS (OR: 2.33; 95% CI 1.75–3.11 and OR: 2.49; 95% CI 1.79–3.44, respectively).However, one of the risks of DS use was associated with its nonuse (OR: 0.35; 95% CI 0.15–0.855–0.85), as shown in **Table** 6.

Discussion

During the COVID-19 pandemic, the demand for nutritional supplements has increased dramatically. That is why individuals require additional preventive measures by taking nutritional supplements and pharmaceutical alternatives, including vitamins and minerals; these supplements were hoped to provide protection from COVID-19 by boosting the immune system, and they can help reduce disease severity for those who become infected with SARS-CoV-2 [23].

Dietary supplement consumption frequency

This multinational survey found that, during the fourth wave of the COVID-19 pandemic, 64.6% of adults from more than six nations consumed nutritional supplements. The frequency of DS consumption varied between different places and times; according to a Chinese survey, 31.2% of participants consumed DS to cope with the pandemic [24]. In a Lebanese study (2016), approximately 35% reported using at least 1 herbal product or dietary supplement [25]. In Saudi Arabia in 2017, it was 68.33% [26], while in Saudi Arabia in 2020, 22.1% suggested the use of DS to protect themselves from infection during the pandemic [27]; however, others showed no significant difference in consumption before and during the pandemic [28].

In terms of sex, using a multi-logistic regression analysis, we found that females took more dietary supplements in the previous two months [OR 2.57, 95% C.I. (1.93–3.42)] than men did (P = 0.01). Consistent with our findings, other studies conducted in Korea, the United Arab Emirates, and the US have found a higher frequency among women. Wirnitizer et al. [29] have shown a correlation between the high prevalence of mineral and vitamin consumption among females and the high prevalence of CHO and protein intake among males. A cohort-based study in Greece found that the prevalence of DS was 31.4% and 36.6% for females and 21.2% for men, respectively, with no significant difference; however, the COVID-19 pandemic observed a suggestive increase in the prevalence of consumption among men [30].

In terms of age group, in this study, middle-aged adults were more likely to use DS than other age groups, and this likelihood declined with age. In agreement with a study conducted in Switzerland [31] that revealed that the consumption of vitamins and DS decreases with age in women while increasing in men, the Netherlands reported inconsistent findings, indicating an increase in DS consumption with age, particularly among women between the ages of 51 and 70 [32].

In terms of the level of education, the proportion of postgraduate DS consumption and participants in

Table 4 The context of the used DS and other products among the Arabic adult DS users

Variables	**Dietary Supplements users *N.* = 861 (%) F (%)**					
Forms of dietary supplements[a]						
Tablets	780 (90.6)					
Powders	95 (11.0)					
Injections	102 (11.9)					
Supplements subscription						
Medical subscription	452 (52.5)					
Sport coach subscription	42 (4.8)					
Self-prescribers	367 (42.7)					
Types and dose of the used products in the last 2 months	**As prescribed F (%)**	**Less than prescribed F (%)**	**More than prescribed F (%)**	**Without prescription F (%)**	**Not use at all F (%)**	
Protein (*N.* = 733)	41 (5.6)	48 (6.5)	2 (0.3)	46 (6.3)	596 (81.3)	
Glutamine (*N.* = 713)	16 (2.2)	23 (3.2)	1 (0.1)	15 (2.1)	658 (92.3)	
BCCA (*N.* = 710)	20 (2.8)	20 (2.8)	2 (0.3)	22 (3.1)	646 (91.0)	
Weight gain Powder (*N.* = 715)	12 (1.7)	8 (1.1)	1 (0.1)	25 (3.5)	669 (93.6)	
Creatine(*N.* = 709)	19 (2.7)	11 (1.6)	1 (0.1)	20 (2.8)	658 (92.8)	
Caffeine (*N.* = 714)	26 (3.6)	50 (7.0)	34 (4.8)	106 (14.8)	498 (69.7)	
Testosterone (*N.* = 705)	3 (0.4)	4 (0.6)	1 (0.1)	4 (0.6)	693 (98.3)	
Growth hormone (*N.* = 704)	6 (0.9)	4 (0.6)	1 (0.1)	5 (0.7)	688 (97.7)	
HMB (*N.* = 702)	6 (0.9)	5 (0.7)	1 (0.1)	9 (1.3)	681 (97.0)	
Omega-3 fatty acids (*N.* = 758)	122 (16.1)	88 (11.6)	10 (1.3)	178 (23.5)	360 (47.5)	
Omega-9 fatty acids (*N.* = 708)	33 (4.7)	32 (4.5)	3 (0.4)	45 (6.4)	595 (84.0)	
Vitamins and minerals dose used as nutritional supplements (in the last 2 months)	**Not used at all** F (%)**F (%)**	**Rarely F (%)**	**1–2 times weekly F (%)**	2-< 5 **weekly F (%)**	**≥ 5times weekly F (%)**	**Median** (mean ± SD)
Vitamin A (*N.* = 711)	543 (76.4)	86 (12.1)	40 (5.6)	22 (3.1)	20 (2.8)	1 (1.44 ± 0.94)
Vitamin B (*N.* = 730)	416 (57.0)	125 (17.1)	80 (11.0)	50 (6.8)	59 (8.1)	1 (1.92 ± 1.29)
Vitamin C (*N.* = 798)	291 (36.5)	204 (25.6)	110 (13.8)	82 (10.3)	111 (13.9)	2 (2.40 ± 1.42)
Vitamin D (*N.* = 759)	303 (39.9)	217 (28.6)	152 (20.0)	37 (4.9)	50 (6.6)	2 (2.10 ± 1.75)
Multivitamins (*N.* = 736)	424 (57.6)	115 (15.6)	75 (10.2)	55 (7.5)	67 (9.1)	1 (1.95 ± 1.34)
Calcium (*N* = 748)	443 (59.2)	138 (18.4)	73 (9.8)	35 (4.7)	59 (7.9)	1 (1.84 ± 1.25)
Zinc (*N.* = 784)	436 (55.6)	134 (17.1)	72 (9.2)	53 (6.8)	89 (11.4)	1 (2.01 ± 1.39)
Iron (*N.* = 747)	395 (52.9)	130 (17.4)	84 (11.2)	64 (8.6)	74 (9.9)	1 (2.05 ± 1.37)
Magnesium (*N.* = 768)	513 (66.8)	90 (11.7)	58 (7.6)	36 (4.7)	71 (9.2)	1 (1.78 ± 1.31)
Selenium (*N.* = 725)	612 (84.4)	52 (7.2)	31 (4.3)	17 (2.3)	13 (1.8)	1 (1.30 ± 0.81)

* $P < 0.05$ there was a statistically significant difference

[a] Total more than 100% as multiple choices were allowed

previous research suggested that DS users were more likely to be aware of contemporary dietary recommendations [33], but this was not the case in this study.

In terms of nationality, the prevalence of dietary supplement users was higher among Saudi, Libyan, and Egyptian participants. Studies suggest that the high use of irrational prescriptions is a common practice in Arab countries, especially in Saudi Arabia [34, 35]. This is consistent with our study, as 42.7% of DS users take it without medical supervision.

Other studies indicated that dietary supplement users versus nonusers were more likely to live in urban areas [36] and less likely to be smokers [37], which is in accordance with our results, with the presence of chronic diseases (OR: 2.37, CI: 1.89–2.98).

Adults' perceptions that these supplements are beneficial in treating COVID-19 patients (45.4%) and have a borderline benefit (33.1%). Moreover, 46.6% of the adults considered DS useful for preventing COVID-19. Certain nutrients or dietary supplements are associated with a slight decrease in COVID-19 risk. Many things can affect the immune system and cytokine release. These include trace elements, vitamins (A, B6, B12, C, D, and E), amino acids, long-chain omega-3 fatty acids (docosahexaenoic

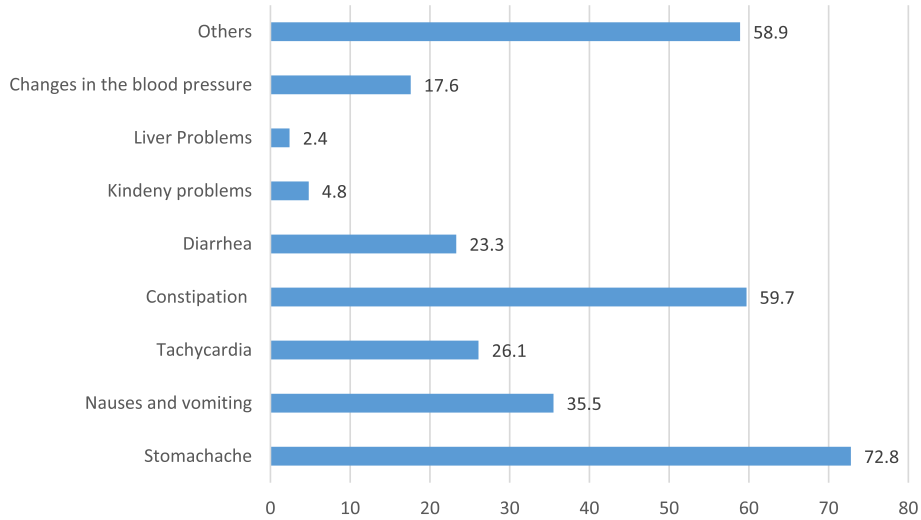

Fig. 3 The main adverse effects among participants who reported history of adverse effects (*N* = 287, 21.5%)

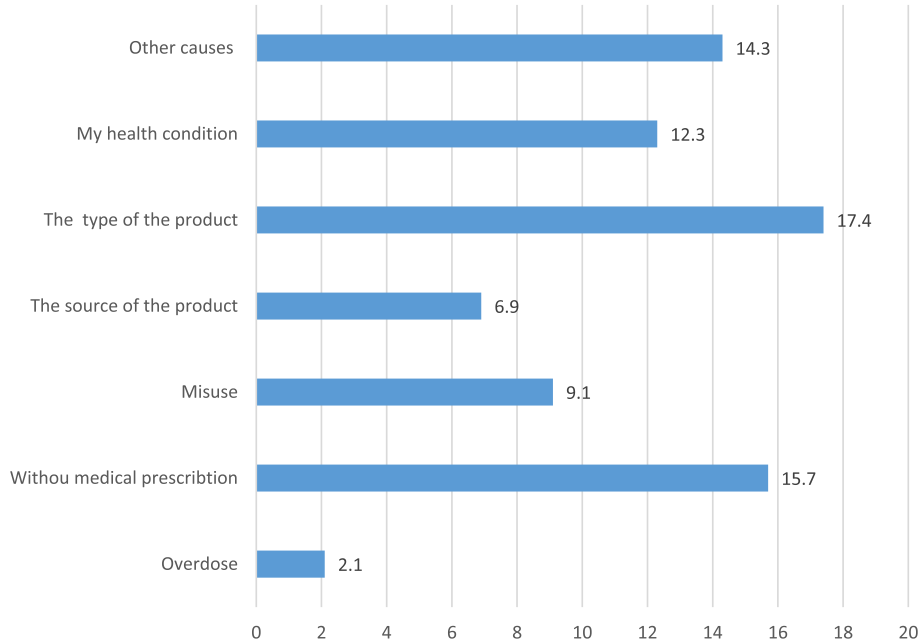

Fig. 4 The main causes of adverse effects among participants who reported history adverse effects (*N* = 287, 21.5%)

and eicosapentaenoic), and bioactive substances that are not nutrients, such as polyphenols. Furthermore, arachidonic or linoleic acid administration partially inhibits its SARS-CoV-1 and coronavirus 229E replication [38]. Furthermore, the Arabic adult consumer's confidence in adopting these items for both preventative and therapeutic immunological enhancement has increased due to the dietary supplements' affordability, accessibility, and acceptability.

The DS consumption during the pandemic revealed high consumption of minerals and multivitamins among women, particularly those aged 35 to 54, during the shutdown in Spain. Other studies have attributed the low consumption of DS among both men and women to a lack of knowledge regarding the benefits of these supplements and the fear that excessive use may result in serious side effects. The current study posits that the low consumption of DS in both genders can be attributed to a

Table 5 Consumer's pharmaceutical purchasing behaviour and its relationship with the use of dietary supplements among Arabic adults

Consumer's pharmaceutical purchasing behaviour	Total *N* = 1333(%) F (%)	Dietary supplements use		*P* value of χ2
		Yes *N.* = 861 F (%)	No *N.* = 472 F (%)	
High cost				
Not affect	626 (47.0)	392 (62.6)	234 (37.4)	0.132
Agree	404 (30.3)	277 (68.6)	127 (31.4)	
Strongly agree	303 (22.7)	192 (63.4)	111 (36.6)	
Acceptable cost				
Not affect	620 (46.5)	386 (62.3)	234 (37.7)	0.247
Agree	512 (38.4)	340 (66.4)	172 (33.6)	
Strongly agree	201 (15.1)	135 (67.2)	66 (32.8)	
Manufacturing country				
Not affect	649 (48.7)	402 (61.9)	247 (38.1)	0.125
Agree	402 (30.2)	273 (67.9)	129 (32.1)	
Strongly agree	282 (21.2)	186 (66.0)	96 (34.0)	
Big size				
Not affect	806 (60.5)	515 (63.9)	291 (36.1)	0.682
Agree	335 (25.1)	223 (66.6)	112 (33.4)	
Strongly agree	192 (14.4)	123 (64.1)	69 (35.9)	
Natural contents				
Not affect	469 (35.2)	287 (61.2)	182 (38.8)	0.080
Agree	424 (31.8)	290 (68.4)	134 (31.6)	
Strongly agree	440 (33.0)	284 (64.5)	156 (35.5)	
Having discount offers				
Not affect	717 (53.8)	461 (64.3)	256 (35.7)	0.224
Agree	379 (28.4)	256 (67.5)	123 (32.5)	
Strongly agree	237 (17.8)	144 (60.8)	93 (39.2)	
Advertising quality				
Not affect	825 (61.9)	543 (65.8)	282 (34.2)	**0.039***
Agree	333 (25.0)	220 (66.1)	113 (33.9)	
Strongly agree	175 (13.1)	98 (56.0)	77 (44.0)	
Safety rules				
Not affect	427 (32.0)	250 (58.5)	177 (41.5)	**0.001***
Agree	437 (32.8)	308 (70.5)	129 (29.5)	
Strongly agree	469 (35.2)	303 (64.6)	166 (35.4)	
Pharmaceutical forms				
Not affect	580 (43.5)	345 (59.5)	235 (40.5)	**0.002***
Agree	420 (31.5)	293 (69.8)	127 (30.2)	
Strongly agree	333 (25.0)	223 (67.0)	110 (33.0)	
Packet quality				
Not affect	528 (39.6)	319 (60.4)	209 (39.6)	**0.009***
Agree	444 (33.3)	310 (69.8)	134 (30.2)	
Strongly agree	361 (27.1)	232 (64.3)	129 (35.7)	
Authorized and approved product				
Not affect	319 (24.0)	160 (50.2)	159 (49.8)	**< 0.001***
Agree	395 (29.6)	282 (71.4)	113 (28.6)	
Strongly agree	629 (46.4)	419 (67.7)	200 (32.3)	

Table 5 (continued)

Consumer's pharmaceutical purchasing behaviour	Total *N* = 1333(%) F (%)	Dietary supplements use		*P* value of $\chi 2$
		Yes *N.* = 861 F (%)	No *N.* = 472 F (%)	
Personal opinion about the value of DS				
Very beneficial	212 (15.9)	172 (81.1)	40 (18.9)	**< 0.001***
Beneficial	636 (47.7)	474 (74.5)	162 (25.5)	
Borderline value (neutral)	441 (33.1)	208 (47.2)	233 (52.8)	
Harmful	39 (2.9)	6 (15.4)	33 (84.6)	
Very harmful	5 (0.4)	1 (20.0)	4 (80.0)	

Dietary Supplement (DS)

χ^2, chi-square test

* $P < 0.05$ there was a statistically significant difference

lack of knowledge. Rontogianni et al. [30] discovered that employed men were more likely to use DS than unemployed ones, indicating that they are more likely to have a better level of education and economic position.

The healthy eating pyramids

Sicinska et al. [39] used multivariate logistic analysis to find the factors that could predict DS. They found that physical activity had an OR of 1.79 and a 95% CI of 1.45–2.20. Researchers have registered and are currently conducting several clinical studies to evaluate the effectiveness of specific nutrients in COVID-19 patients [40]. We reported that, among Arabic adults, 32.1% consumed the daily-recommended requirements of protein, 31.4% of vegetables, 17.2% of fruits, and 23.6% of water. This is inconsistent with another cross-sectional study of university students in Poland and other cohort studies in France, which showed that DS users consumed a lot of vegetables, seeds, and fruits, which does not agree with this result [33, 39].

The COVID-19 pandemic may be associated with changes in dietary habits towards a healthier diet regarding health restrictions imposed on lockdown. Many foods, fruits, and vegetables that provide nutrients that have anti-inflammatory properties and boost immunity were recommended for managing and reducing the risk of COVID-19. Using a network analysis-based technique, 60 disease-diet interactions were predicted, yielding a considerable precision of 76.7% validated interactions between foods and diets, COVID-19, and 46 other disorders as relevant in either illness progression or risk prevention or mitigation. Therefore, diet-based approaches are challenging [41]. Therefore, adherence to nutritious eating guidelines could be a close-in expression of faraway social factors, such as malnutrition, that influence health and decrease the burden of some infectious diseases in the past [38].

The context of dietary consumption and the total fatigue severity scale

In terms of the prescription of the dietary supplements, we reported that the majority of users (444, 52.5%) were under medical prescription and (361, 42.7%) were self-prescribers, compared to a study conducted in SA in 2017, where higher frequencies were reported as (57, 69.5%) were under medical prescription and only (15, 18.2%) were self-prescribers [26]. Even though different approaches have been made to fight the pandemic and 70% of the world's population will be protected against COVID-19 by the middle of 2022, the need for additional preventative measures and studies, including the use of vitamin and mineral supplements and pharmaceutical substitutes, is required. It is hoped that this supplement will protect against SARS-CoV-2 infection, boost the immune system, and make COVID-19 less severe [22].

During the fourth wave of the COVID-19 pandemic, Arabic adults consumed the following DS types: 63.5% vitamin C, 61.1% vitamin D, 47.1% iron, 44.4% zinc, 43.3% vitamin B, and 33.2% magnesium. Recent research has discovered that adequate doses of vitamins C, D, and E, as well as zinc and omega-3 fatty acids, may have clinical benefits in infectious diseases. Their plasma concentration deficiency is associated with immune system dysfunction, and their well-established immunomodulatory and antioxidant effects predispose them to certain infections. Furthermore, managing COVID-19 requires a crucial role that involves lowering the viral load, reducing the severity of the disease, and reducing the length of hospital stays [26, 41].

The most used vitamins during the COVID-19 pandemic were vitamins C and D [2 (2.40 ± 1.42) and 2 (2.10 ± 1.75), resp.]. We reported that vitamin C was the most commonly used DS at 63.5%, which was higher than the 34.4% of another study [41]. Vitamin C's multiple pharmacological characteristics, including its

Table 6 Multi-logistic regression analysis for predictors of nutritional supplements use

Predictor factors	Dietary supplements use[a]	
	P value	AOR (95% CI)
Intercept	**0.029***	
Sex		**2.57 (1.93–3.42)**
Male[b]	1.00	
Female	**0.001****	
Marital status		
Divorced /widow[b]	1.00	
Single	0.379	0.69 (0.30–1.58)
Married	0.751	0.87 (0.38–2.02)
Residence		
Rural[b]	1.00	1.15 (0.85–1.56)
Urban	0.366	
SARS-CoV-2 infection		
No[b]	1.00	
Yes	0.572	0.91 (0.66–1.26)
Suspected	**0.005***	**1.53 (1.14–2.06)**
Protein intake (3 servings daily)		
Yes,[b]	1.00	
More than recommended	0.634	0.85 (0.43–1.67)
Never	0.207	0.77 (0.52–1.15)
Less than recommended	0.802	0.96 (0.72–1.3)
Water intake (3 Liter daily)		
Yes[b]	1.00	
More than recommended	0.062	0.59 (0.35–1.03)
Never	0.071	0.63 (0.38–1.04)
Less than recommended	0.850	1.0 (0.71–1.33)
Fatigue status		
No[b]		1.31 (0.99–1.72)
Suspect	1.00	
Suspected	0.052	
Personal opinion about dietary supplements value		
Neutral[b]	1.00	
Very beneficial / beneficial	**0.001***	**2.33 (1.75–3.11)**
Very harmful / harmful	**0.021***	**0.35 (0.15–0.85)**
Dietary supplements recommendation		
No[b]	1.00	
Yes	**0.001***	**2.49 (1.79–3.44)**

Test: Multi-logistic regression analysis

AOR Adjusted Odds Ratio, *CI* Confidence interval

* Significant at $p < 0.05$

[a] Nutritional supplements non-use was used as the reference category

[b] Reference category. ( ) refers to the daily-recommended requirements

effectiveness as an antiviral and antioxidant and its ability to enhance immunity, make it a promising immune response for combating COVID-19 infection [42]; similarly, vitamin D's antiviral effect suggests its theoretical benefit as an enhancement in treating COVID-19 infections [43]. Furthermore, studies have linked vitamin D deficiency to various illnesses such as diabetes, high blood pressure, and obesity, all of which heighten the risk of COVID-19 [41].

The most used minerals during the COVID-19 pandemic. Zinc and iron were the most commonly used minerals [1 (2.01 ± 1.39) and 1 (2.05 ± 1.37), resp.] because

they are inexpensive and widely available [42]. Clinical practice uses both zinc and iron as medicine, immune boosters, and food supplements [43]. Taking zinc supplements boosts the natural anti-infective abilities of different kinds of white blood cells, like neutrophils, basophils, and eosinophils. This makes the immune system work better and helps treat mild to moderate COVID-19 [44, 45].

Our study demonstrated *that the main sources of information* about dietary supplements were healthcare providers, with almost 80%, and specialized coaches, with 78.3%. In addition, about 28.8% had no sources. Sources of information on dietary supplements appear to vary greatly in a couple of previous studies in Saudi Arabia, which reported lower use of nutritional supplements. They were both very similar in the supplement's adoption, with 37.5% and 39.4% relying on social media or websites [27, 46], while Yani et al. [47] reported that magazines, scientific books, and the internet were the three main sources of information.

Healthcare professionals and specialized coaches were the main information sources. This accounts for the evaluation of dietary supplements by Arabic adults, 47.7% of whom viewed them as beneficial and 33.1% as harmful. This may be due to their role in assisting patients by discussing their health situation with them; this could significantly reduce the number of poor outcomes associated with acquiring medication from unlicensed manufacturers [48, 49]. Zinc, for example, has many positive or negative effects depending on the customer's health condition; it is required for the growth of certain pathogenic fungi that cause fatal mucormycosis. High zinc levels in hepatitis patients can increase the virus load by inhibiting interferon production, causing T cells, B cells, and thymocytes to die, and preventing copper absorption, which can lead to anemia and leukopenia [44].

The FSS, which assesses the effects of fatigue on cognitive and psychosocial aspects, found that 488 (36.6%) of Arabic adults had suspected fatigue. Given that fatigue is a common post-COVID-19 symptom [50], it is likely that 477 (35.8%) of participants had a positive history of SARS-CoV-2 infection. DS was recommended for 1006 (75.5%) of the recruited Arabic adults, as it is well known that minerals and vitamins play important roles in improving chronic physical, mental, and general health conditions. Vitamin C, zinc, iron, and magnesium are all involved in energy metabolism and, when used in the right amounts, can stimulate physiological functions by enhancing the body's self-sufficiency, which has health benefits in terms of physical and mental fatigue [51]. Additionally, the DS could potentially decrease the reliance on commonly used drugs in these situations.

FSS was significantly higher among DS users (341, 39.6%) compared to non-users (147, 31.1%). In the current study, multi-logistic regression analysis showed that having COVID-19 is a good predictor of dietary supplement use (OR: 1.53, 95% CI: 1.14–2.06). This finding contradicts the reported decrease in FSS among supplement users [52–54].

Finally, based on our findings, we recommend:

1. To share the results regarding consumers' pharmaceutical purchasing behavior in terms of advertising quality, safety regulations, pharmaceutical forms, and packet quality with the pharmaceutical campaigns in the Arabic region.
2. Medical prescriptions and health education regarding the standard of consumption of DS to maximize the benefits of their use and minimize the potential risks.
3. Further cohort and laboratory studies should be conducted to better comprehend the effects of DS.
4. Mass media campaigns to increase the public's adherence to the recommended dietary eating pyramid and physical activity level.

Strength

This multicounty study aims to represent a large sample of Arabic adults from six different nationalities in Arabic countries. The study focuses on dietary supplement consumption and the demographic factors that influence it. Moreover, we used three internationally validated tools including Healthy eating pyramids, consumers' pharmaceutical purchasing behavior and FSS determinants in Arabic adults during the fourth wave of the COVID-19 pandemic.

Limitations

The first limitation is that our study has all the biases and confounding factors that observational studies have. The second limitation is that the study used an online self-administered survey, which makes the data less reliable because of recall bias, as well as the fact that more than 80% of the sample were well-educated women (72.3%) who worked in the medical (51.3%), had access to, and knew how to use the internet. The data was also less reliable because it was self-administered and self-reported. We also disqualified participants who did not use the internet or could not read or write.

The third limitation is that a lack of knowledge regarding the negative effects of vitamin and mineral intake may have contributed to the failure to submit pertinent information at this time. It is impossible to distinguish between issues caused by COVID-19-related effects and problems that already existed. Despite the fact that these factors are not ideal, other international research has found support for our findings.

Finally, the sample sizes from different countries vary greatly for two main reasons: 1) The methodology estimated the sample size based on a variety of variables, such as the total population. For instance, Syria's population was approximately 17 million, Saudi Arabia's was approximately 34 million, and Egypt's was over 110 million. 2) The response rate from Syria was extremely low due to the use of an online questionnaire and political upheaval, which hinders people's ability to use the internet effectively and frequently in those countries.

Conclusion

This multinational cross-sectional study, conducted in six Arab countries, found that the dietary consumption of supplements is prevalent. Arabic adults are poorly adherent to the healthy eating pyramids, which indeed call for advice and support for a healthy dietary pattern. Being female and having a prior history of SARS-CoV-2 infection are independent predictors of supplement use.

Authorized and approved products, natural contents, safety rules, packet quality, cost, and manufacturing country were the most common factors influencing Arabic adults' pharmaceutical purchasing behavior.

Abbreviations

AEs	Adverse effects
CI	Confidence interval
DS	Dietary Supplement
FSS	Fatigue Severity Scale.
FDA	Food and Drug Administration
OR	Odds ratios
% DV	Percent of the daily value
SD	Standard Deviation
χ^2	The chi-squared test
FTC	The Federal Trade Commission
SA	Saudi Arabia
UK	The United Kingdom
USA	United States of America

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Authors' contributions

Conceptualization: Samar Amer (SA), Mohammed N. A. Abdel-hameid (MN), Shimaa Y. S. Elsheikh (SHE). Methodology: SA .Validation: SA, MN, SHE. Formal analysis: Mona Ibrahim (MI). Data curation: MN, SHE, Lina Douaouia(LD), Sara Nasser Abuhaimed (SHN), Ehab M. Ishteiwy(EMI), Lina Raad Abdullh (LR), Mohamed Muhanad Balid (MB), Youmna Amer(YA). Writing and preparation of the first draft: SA, Taher Shailabi (TS), Nahla Zaitoun(NAZ), Nermeen Zaitoun (NEZ). Writing, reviewing and editing: SA, YA,Sarya Swed (SS). Visualization: SS, MI. Supervision: SA, SS. Project administration: SA. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request (dr_samar11@yahoo.com).

Declarations

Ethics approval and consent to participate

All participants provided informed written consent after clarification of the goals, data confidentiality, voluntary participation, and withdrawal. The questionnaire contains no sensitive questions, and the data was collected anonymously. The Zagazig University Institutional Review Board approved this study ZU-IRP#9921/28-4-2022. Harvard University owns the Healthy Eating Pyramid. It was acceptable to download and use it without authorization.

Consent for publication

A written informed consent for publication was obtained from all authors

Competing interests

The authors declare that they have no competing interests.

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