

Did Iranians change their eating behavior following COVID-19 outbreak?

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Background: Significant lifestyle changes have been reported after COVID-19 outbreak. The present study aimed at investigating changes in dietary habits in response to the COVID-19 outbreak in an Iranian population sample. **Materials and Methods:** In this cross-sectional study, the dietary habits of Iranian adults were assessed before and during the COVID-19 outbreak. Consumption of different food groups such as meats, dairy, fruits, vegetables, seeds, and nuts was assessed using a digital questionnaire which was shared on social media platforms. For the statistical analysis, the Wilcoxon signed-rank test was used. **Results:** In this online survey, 1553 questionnaires were completed. The results showed that the reported consumption of protein-rich foods increased ($P < 0.05$), but fish and dairy consumption showed a significant reduction ($P = 0.006$ and < 0.001 , respectively). There was a significant reduction in reported fast-food consumption ($P < 0.001$), fruits and vegetables ($P < 0.001$), natural fruit juices ($P < 0.001$), and water ($P < 0.001$) were consumed more frequently. Individuals also consumed more vitamin and mineral supplements ($P < 0.001$) including those containing Vitamin D. **Conclusion:** During the COVID-19 pandemic, participants reported a significant change in their dietary habits and intake of supplements. Higher intakes of meats, protein-rich foods, fruits, vegetables, and nutritional supplements and lower intakes of fish, dairy, and fast foods were reported.

Key words: COVID-19, dietary supplements, eating behavior, pandemic, severe acute respiratory syndrome-coronavirus-2

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INTRODUCTION

In 2019, a new coronavirus causing a flu-like syndrome emerged in the Chinese province of Hubei, and an outbreak occurred in Wuhan in December 2019.^[1,2] Due to the nature of the pulmonary symptoms, the virus was renamed severe acute respiratory syndrome associated with coronavirus-2 (SARS-COV-2) and is the cause of COVID-19 (1). A public health emergency was declared by the World Health Organization (WHO) on January 30, 2020.^[3] The number of infected and deceased individuals affected by this disease has rapidly increased globally. In Iran, the first confirmed case was identified on February 19,

2020, in Qom, and from that time, cases of COVID-19 have increased.

Given the fact that COVID-19 has no widely available prevention or drug treatment yet, it may be important to adopt healthy eating habits and provide vitamins and minerals to enhance the immune response.^[3,4] In a systematic review by Zhang and Liu,^[2] Vitamin A, Vitamin C, Vitamin E, Vitamin D, B Vitamins, omega-3 fatty acids, zinc, selenium, and iron were mentioned as potentially effective nutrients on the immune system.^[5] The immune response is attenuated by nutritional deficiencies, but no nutritional intervention studies have shown any benefits. Furthermore, in viral disease, nutritional status has not

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been shown to be a contributory factor in the emergence of the disease.^[2] However, the WHO has noted that a healthy diet can help prevention and treatment of the COVID-19, and nutritional recommendations have been provided during the pandemic.^[6]

Currently, there is limited research on dietary patterns and their impact on the incidence or mortality of COVID-19, but it has been proposed that the entry of SARS-COV-2 is facilitated by transmembrane angiotensin-converting enzyme (ACE2) and dietary patterns are associated with ACE levels. Thus, certain foods may be associated with a reduction in infection and mortality.^[7]

Large-scale studies analyzing the eating habits of people during this pandemic are important to support and encourage healthy eating patterns in the population. It may be possible to implement healthy eating patterns during a pandemic, and this may be important for future population health impact.^[6] Therefore, the present study was designed to investigate changes in eating behavior following COVID-19 pandemic in Iranian adults.

METHODS

Study design

A cross-sectional study was conducted from March 27, 2020, to April 29, 2020, to investigate changes in eating behaviors of Iranian adults following COVID-19 outbreak. This survey was performed during the period of COVID-19 epidemic among Iranians from all over the country using an online platform that could be accessed on any device connected to the Internet. The survey included an initial page describing the study objectives and details of the ethics of the survey. Participants could unsubscribe from the survey at any stage before submitting the survey. Incomplete answers were not saved. Online research of this type is recommended as a method for rapid access to individuals and ensures their safety in pandemic situations.^[8] The research protocol of the study was approved by the Research Ethics Committee of Shiraz University of Medical sciences (IR. SUMS. REC.1399.271).

Participants

Individuals who had access to digital devices and the Internet and were also able to answer our questionnaire were included if they were (1) Iranian adults residing in Iran and (2) aged ≥ 18 years. Pregnant or lactating women and also those who have been hospitalized for 7 days during the past month were excluded from the study. These criteria were verified from the answers given to the survey questions.

Questionnaire

A digital questionnaire containing two major sections was used. In the first section, demographic and anthropometric

information was sought. Data on age, gender, and residing area were recorded and also, self-reported weight and height were gathered. Body mass index (BMI) was calculated using reported data ($[\text{weight (kg)}]/[\text{height (m)}]^2$). In the following section, a modified food frequency questionnaire (FFQ) was used to assess eating behavior. Reproducibility and validity of the FFQ were assessed previously.^[9] Due to the fact that the study was conducted during the difficult period of pandemic-related lockdown, we slightly simplified the questionnaire to prevent the negative effects of the length of the questionnaire on the response rate.^[10] Two answers were asked for each question, one about the timeframe before the outbreak and the other about the period during the COVID-19 pandemic. Intakes of each food item were recorded on the scale of servings per day, week, or month. Furthermore, information on the frequency of consumption of nutritional supplements was recorded.

The digital questionnaire was constructed on the "Porsline" platform (www.porsline.ir) and was distributed via the Internet. The link for the e-form was forwarded throughout social media platforms, and the recipients responded if they were willing to do so. To avoid repeated responses, the domain limited the access using IP addresses.

Statistical analysis

Statistical analysis was done using SPSS version 21 (SPSS Inc. Chicago, IL, USA). Data were checked for normality using Kolmogorov-Smirnov test. Skewed data were analyzed using Wilcoxon signed-rank test. Results were reported as mean \pm standard deviation. Median and interquartile range were also reported for skewed data. $P < 0.05$ was considered significant.

RESULTS

During a period that the link to the digital questionnaire was active, 4434 individuals visited the link. These individuals read the aims of questionnaire but did not necessarily start the questionnaire; 1553 completed questionnaires were submitted. The response rate was 49%. Completing the questionnaire took approximately 12 min on average, and the majority of responders used cellphones (97%).

The demographic and anthropometric characteristics of the participants are shown in Table 1. The mean age of responders was 36.24 ± 10.77 years and 71.2% of them were female. The participants' mean BMI was 25.89 ± 4.78 kg/m². The distribution of participants, on the basis of stated residence, showed that most participants were from southern and central regions of Iran (39.4% and 38.4%, respectively).

Consumption of protein-rich foods before and during the COVID-19 outbreak is shown in Table 2. During the COVID-19 pandemic, the intake of milk, yogurt, and cheese

decreased significantly ($P < 0.05$). However, the consumption of red meat and poultry increased ($P < 0.001$). The intake of

fish and canned fish fell significantly compared to the time before the COVID-19 outbreak ($P = 0.008$). The intake of nuts, grains and beans, and seeds increased significantly, as did dietary egg consumption ($P < 0.001$). The consumption of both types of fast food (homemade and take out) declined significantly ($P < 0.001$).

Table 1: Demographic and anthropometric characteristics of the participants

Variable	n=1553, n (%)
Age groups (years)	
18-30	480 (31.9)
31-50	853 (56.7)
51-65	158 (10.5)
>65	13 (0.9)
Sex	
Female	1096 (71.2)
Male	444 (28.8)
BMI category	
<18.5	51 (3.4)
18.5-24.9	625 (42.2)
25-29.9	570 (38.5)
30-34.9	174 (11.7)
35-39.9	44 (3)
>40	17 (1.1)
Residence	
North	79 (5.2)
South	601 (39.4)
East	94 (6.2)
West	166 (10.9)
Center	587 (38.4)

BMI=Body mass index

The intake of vegetables and fruits is shown in Table 3. In comparison to the period before COVID-19 outbreak, high Vitamin C fruits and vegetables, yellow and green fruits and vegetables, and onion or garlic consumption showed a significant increase ($P < 0.001$). The intake of whole bread also increased ($P < 0.001$).

The amount of water ($P < 0.001$) and the intake of natural fruit juices increased ($P < 0.001$), and the consumption of commercial fruit juice and carbonated drinks fell significantly ($P < 0.001$) [Table 4].

Multivitamins, Vitamin C, Calcium + Vitamin D, Vitamin D, and zinc supplement consumption increased notably during the COVID-19 outbreak ($P < 0.001$) [Table 5].

DISCUSSION

The present study assessed the changes in eating behavior

Table 2: Comparison of protein-rich food consumption before and during COVID-19 outbreak

Food items	Before of COVID-19 outbreak		During of COVID-19 outbreak		P*
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)	
Milk (serving/week)	2.29±2.51	1.75 (0-3.5)	2.11±2.67	1 (0-3)	<0.001
Yogurt (serving/week)	3.05±2.62	2.5 (1-4)	2.83±2.67	2 (1-4)	<0.001
Cheese (serving/week)	4.33±3.58	4 (2-6)	4.15±3.70	3 (2-6)	<0.001
Red meat (serving/week)	5.92±5.68	4 (3-7)	6.03±6.00	4 (2-7)	<0.001
Poultry (serving/week)	6.52±6.31	5 (3-8)	6.75±6.87	5 (3-8)	<0.001
Fish (serving/week)	1.51±2.61	1 (0-2)	1.34±2.34	0.5 (0-2)	0.006
Canned fish (serving/week)	0.82±1.79	0 (0-1)	0.72±1.67	0 (0-1)	0.008
Nuts (number/week)	14.74±19.57	9 (1-20)	16.63±23.30	10 (1-20)	<0.001
Legumes and beans (food spoon/week)	12.67±14.24	8 (4-15)	13.72±15.20	9 (5-20)	<0.001
Soy bean (food spoon/week)	2.56±4.50	1 (0-3)	2.61±4.62	1 (0-3)	0.1
Seeds (food spoon/week)	5.02±7.57	2 (0.5-6)	5.28±8.04	3 (0-6)	0.006
Egg (number/week)	4.16±2.59	4 (2-5)	4.51±3.01	4 (3-6)	<0.001
Homemade fast foods (serving/month)	5.83±6.74	3 (0-9)	5.24±7.90	3 (0-6)	<0.001
Take out fast foods (serving/month)	5.41±8.02	3 (0-9)	0.54±2.49	0 (0-0)	<0.001

*Wilcoxon signed-rank test was used for skewed data. $P < 0.05$ significant. SD=Standard deviation; IQR=Interquartile range

Table 3: Comparison of fruits and vegetables intake before and during COVID-19 outbreak

Food items	Before of COVID-19 outbreak		During of COVID-19 outbreak		P*
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)	
High Vitamin C fruits (number/week)	7.15±5.35	6 (4-9.5)	8.58±6.55	7 (4-10)	<0.001
High Vitamin C vegetables (serving/week)	3.71±3.34	3 (2-5)	4.19±3.76	3 (2-5)	<0.001
Green, yellow fruits and vegetables (serving/week)	3.49±3.10	3 (1-5)	3.97±3.55	3 (1-5)	<0.001
Onion/garlic (serving/week)	4.02±3.96	3 (1-5)	5.43±5.21	4 (2-7)	<0.001
Dried fruits (number/week)	3.05±5.33	0 (0-5)	2.65±4.92	0 (0-4)	<0.001
Whole bread (serving/week)	7.29±9.24	5 (0-10)	7.58±9.56	5 (0-10)	<0.001

*Wilcoxon signed-rank test was used for skewed data. $P < 0.05$ significant. SD=Standard deviation; IQR=Interquartile range

Table 4: Comparison of water and drinks intake before and during COVID-19 outbreak

Food item	Before of COVID-19 outbreak		During of COVID-19 outbreak		P*
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)	
Water (glass/day)	5.01±2.78	5 (3-6)	6.09±3.19	6 (4-8)	<0.001
Alcohol (ounce/month)	0.37±2.06	0 (0-0)	0.39±2.2	0 (0-0)	0.1
Natural fruit juices (glass/week)	0.95±1.48	0 (0-2)	1.33±1.94	0 (0-2)	<0.001
Commercial fruit juices (glass/week)	0.61±1.26	0 (0-1)	0.49±1.15	0 (0-0)	<0.001
Carbonated drinks (glass/week)	1.43±2.07	1 (0-2)	1.26±1.97	0 (0-2)	<0.001

*Wilcoxon signed-rank test was used for skewed data. P<0.05 significant. SD=Standard deviation; IQR=Interquartile range

Table 5: Comparison of vitamin and mineral supplement intakes before and during COVID-19 outbreak

Food item	Before of COVID-19 outbreak		During of COVID-19 outbreak		P*
	Mean±SD	Median (IQR)	Mean±SD	Median (IQR)	
Multivitamin (number/month)	4.16±8.15	0 (0-4)	5.70±9.63	1 (0-5)	<0.001
Vitamin C (number/month)	1.43±4.24	0 (0-0)	2.84±6.44	0 (0-2)	<0.001
Calcium + Vitamin D (number/month)	2.49±6.29	0 (0-1)	2.93±6.45	1 (0-2)	<0.001
Calcium (number/week)	0.65±2.69	0 (0-0)	0.72±2.89	0 (0-0)	0.2
Zinc (number/month)	1.66±5.18	0 (0-0)	2.06±5.96	0 (0-0)	0.001
Vitamin D (number/month)	1.75±4.53	1 (0-1)	2.06±4.61	1 (0-2)	<0.001

*Wilcoxon signed-rank test was used for skewed data. P<0.05 is considered significant. SD=Standard deviation; IQR=Interquartile range

during COVID-19 outbreak in Iran. To the best of our knowledge, it is the first study to investigate the pandemic's impact on eating patterns in Iran. Our results revealed that the consumption of protein-rich foods increased except for the dairy products and fish which showed a significant reduction. Fast-food consumption was also reduced significantly. During the outbreak, fruits and vegetables and natural fruit juices and water were consumed more often, and individuals had an increased consumption of vitamin and mineral supplements including Vitamin D supplements.

The consumption of milk, yogurt, and cheese decreased during the pandemic. A study in Italy showed that following COVID-19 pandemic, the consumption of fresh milk decreased, while the consumption of pasteurized milk with a long half-life increased.^[11] In addition, in a population-based study in Italy, during the COVID-19 outbreak,^[3] 45.7% of participants reported consuming one serving/day of milk and yogurt. In our study, we found that the weekly median of milk and yogurt consumption is one and two servings, respectively. It should be mentioned that in the Italian survey,^[3] every 125 g is considered as one serving for milk and yogurt, while our serving consists of 3/4 of a cup for yogurt which is 180 g, and for milk, one cup equals to 250 g. The reduced consumption of dairy products during the outbreak might be due to the lockdown/home confinement at this time.^[5]

It has previously been shown that consumption of yogurt and dairy products can enhance the immune system,^[12,13] but the effects on the immune system may not necessarily translate into a benefit against COVID-19.^[2] Future studies are needed to assess the effects of dairy products on COVID-19 infection.

Our participants reported higher intakes of red meat and poultry and lower intakes of both fresh and canned fish in the outbreak period. Italians also reported increased consumption of red and white meat, while increments in the white meat consumption were more pronounced.^[3] With respect to dietary fish, Italian individuals reduced their consumption of fresh fish but increased the consumption of frozen fish.^[3] Although red meat has been shown to induce inflammation,^[14] meats are rich sources of zinc and this may enhance the immune response.^[15] Therefore, a higher consumption of meats, especially poultry and fish may be of some benefit in the face of the pandemic, and especially fish, due to its anti-inflammatory properties may be a better choice.^[16] Of note, it has been proposed that meat derived from the wild should not be consumed during the SARS-COV-2 outbreak.^[17] Furthermore because of the potential exposure to infection in the marketplace, frozen or canned meats may be a better choice.

Consumption of fast food and ultra-processed foods is associated with inflammatory effects.^[3,8] It has been suggested that there may be a link between the consumption of such foods and impairment in the coordination of innate and adaptive immunity. Such a problem has been shown to increase the risk of developing COVID-19 or increase the risk of complications.^[11,18] Results of the present study revealed a significant reduction in fast-food consumption, both take-out and home-made fast foods. Other studies have also shown a reduction in fast-food intake during the COVID-19 pandemic.^[6,19] This reduction in fast-food consumption may be due to several reasons. First, due to lockdown, there was a reduction in people going out to eat. Second, families have more free time to cook. In Italy, during the COVID-19 outbreak, homemade pizza consumption

increased,^[3] which may be because the main concern for fast food is about preparation procedures. Our results also showed that the reduction in take-out fast food was more pronounced than for home-made fast food.

Nutritional status plays an important role in protecting against the emergence of new viral pathogens.^[20] A nutrient-rich diet with antioxidant and anti-inflammatory activities, such as the Mediterranean diet, helps reduce the severity of SARS-COV-2 so that it has been suggested that the Mediterranean diet may demonstrate one of the best dietary models for restoring innate and adaptive immunity and may be an adjunctive treatment choice for COVID-19.^[3]

Limited consumption of fresh fruits and vegetables leads to borderline status or deficiency of vitamins and minerals, including Vitamin C, Vitamin E and beta-carotene, and deprivation of their antioxidant and anti-inflammatory properties.^[21] Deficiency of these micronutrients is associated with an impaired immune response, thus making people more susceptible to viral infections.^[3] During the pandemic, due to lockdown, the reduction in agricultural productivity, and rising prices,^[3,22] some studies have reported reduced consumption of fruits and vegetables,^[8,11] while some other studies have reported an increase in the consumption of these food items.^[6,19] This could be due to the recommendations for increasing the consumption of such foods during the pandemic so that the WHO recommends legumes, fruits, and vegetables as the best foods during quarantine.^[6] In Iran, the recommendations were made for increasing the consumption of fruits and vegetables during the COVID-19 pandemic, and also, food supply was not affected. Therefore, in the present study, Iranians turned toward eating more fresh fruits and vegetables, while the consumption of dried fruits decreased significantly. This might have two reasons: first, people consumed fresh fruits and vegetables for their high Vitamin C content, so dried fruits were not as rich in this vitamin and second, the difficulty of dried fruits' hygienic may have led the population to choose fresh fruit instead.

During the pandemic, the reported consumption of garlic and onion also increased in our study. This might be related to the fact that in Iranian traditional medicine, garlic and onion are considered to have strong antibacterial and antiviral properties, as well as immune-boosting effects.^[23] Compounds such as allicin, methyl-allyl trisulfide, and S-allyl cysteine exist in garlic have shown anti-inflammatory properties.^[24] In addition, onion has been reported to boost the immune system,^[25] but future studies are required to assess the effects of them on COVID-19 infection.

During the outbreak, Iranians drank more water and natural fruit juices and limited their consumption of commercial fruit juices and carbonated drinks. These changes indicate

a change to a healthy drinking pattern which can be a good behavior change that have short-term effects in modulating immune responses^[26] and long-term health effects in preventing chronic disease.^[27-29]

We found that Iranians tended to consume more multivitamin, calcium, Vitamin C, zinc, and Vitamin D supplements during the outbreak. The effectiveness of these nutrients has been proposed by published articles.^[2] This behavior change could be due to the experts' statements on mass media about using nutritious foods and nutrients that can help preventing COVID-19. From all nutrients and supplements, effects of Vitamin D on the immune system and antiviral immunity have been widely proposed, and published literature during the COVID-19 outbreak states that Vitamin D supplementation can reduce the risk of COVID-19 infection and death.^[30]

The present study had several limitations. First, research using an anonymous online survey does not make it possible to verify data based on objective measures. However, our web-based survey was undertaken during the pandemic, and it would have been difficult to do this using any other approach. Second, online sampling may lead to the recruitment of a narrow demographic sample, with some groups within the population that are not reachable; therefore, a representative sample cannot be expected. For example, the mean age and BMI of the study respondents, reveals mostly younger and nonobese individuals filled questionnaire. Younger respondents may be overrepresented because of the use of social media and their greater familiarity with digital technologies. Third, data on food intake before the pandemic may be prone to recall bias, and it was inevitable because there were no preplanned research projects before the pandemic. Finally, we did not measure weight and height and used self-reported values because of the virtual identity of our questionnaire and data gathering method. However, in view of the challenges of conducting such studies during quarantine, it would be very difficult to overcome such limitations. However, the present study was the first study that assessed the Iranian eating behavior and supplement intakes during COVID-19 pandemic. Moreover, using the electronic questionnaire, we were able to gather data from several regions within Iran. Further investigations are proposed to assess the effects of these lifestyle changes on nutritional status of the Iranians. Furthermore, it is recommended to assess the long-term effects of this pandemic on eating behavior and health status of the people.

CONCLUSION

During the COVID-19 pandemic, participants reported a significant change in their dietary habits and intake of supplements as assessed using an online survey of dietary habits. Higher intakes of meats, protein-rich foods, fruits,

and vegetables and lower intakes of fish, dairy, and fast foods were reported. Furthermore, individuals consumed more nutritional supplements, especially vitamin D supplements. These changes might be driven by access to specific food items, avoidance behavior during lockdown, and received beliefs about diet and health.

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Conflicts of interest

There are no conflicts of interest.

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