Int J Nutr Sci 2025;10(1):48-61

International Journal of Nutrition Sciences

Journal Home Page: ijns.sums.ac.ir

Original Article

The Correlation of Plant-Based Diet with COVID-19 Severity and Symptoms among Individuals Recovered from the Disease

Fatemeh Almasi[1#], Mohammad Nemati[2#], Narges Izadi[1], Mohammad Mehdi Haghighat_Lari[1], Fateme Barforoush[3], Armin Ebrahimzadeh[4], Alireza Milajerdi[1*]

1. Research Center for Biochemistry and Nutrition in Metabolic Diseases, Institute for Basic Science, Kashan University of Medical Sciences, Kashan, Iran
2. Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran
3. Department of Nutrition, Faculty of Public Health, Kerman University of Medical Sciences, Kerman, Iran
4. Nutrition Research Center, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran

[#]The authors contributed equally to this work.

ARTICLE INFO

Keywords:
Plant
Diet
Symptoms
COVID-19
Iran

**Corresponding author:*
Alireza Milajerdi, PhD;
Research Center for Biochemistry and Nutrition in Metabolic Diseases, Institute for Basic Science, Kashan University of Medical Sciences, Kashan, Iran.
Tel: +98-21-88955975
Email: amkhv@yahoo.com

Received: June 30, 2024
Revised: August 25, 2024
Accepted: August 30, 2024

ABSTRACT

Background: COVID-19 is an infectious disease that has spread all over the world and has endangered health care system. Several studies have shown an association between Plant-based diets and the health benefits. This study aimed to investigate the association between Plant-based Diet Index (PDI) and severity and symptoms of COVID-19.

Methods: In a cross-sectional study, 684 patients recovered from COVID-19 were included. Dietary intakes of subjects were assessed using a validated 168-item food frequency questionnaire and PDI, healthful PDI (hPDI) and unhealthful PDI (uPDI). The outcomes such as severity of disease, symptoms and levels of inflammatory biomarkers were assessed through telephone interviews with the participants.

Results: After adjusting for several confounders, participants at the highest quartile of PDI showed lower risks for hypoxia, duration of disease and hospitalization and a lower level of ESR. PDI score was negatively associated with risk of COVID-19 symptoms including fever, chill, weakness, myalgia, chest pain, headache, dizziness, sore throat, diarrhea, nausea, vomiting and anorexia. A greater hPDI score was associated with reduced risk of sever COVID-19, hypoxia, need to respiratory support, lower duration of disease, recovery, lower level of CRP and ESR. A higher uPDI score was associated with greater risk of severe COVID-19, need to respiratory support, duration of disease, higher level of CRP and ESR.

Conclusion: We found that higher PDI was associated with lower risk of COVID-19 outcomes. Also, higher hPDI and lower uPDI scores were associated with reduced risk of sever COVID-19.

Please cite this article as: Almasi F, Nemati M, Izadi N, Haghighat_Lari MM, Barforoush F, Ebrahimzadeh A, Milajerdi AR. The Correlation of Plant-Based Diet with COVID-19 Severity and Symptoms among Individuals Recovered from the Disease. Int J Nutr Sci. 2025;10(1):48-61. doi: 10.30476/ijns.2024.104955.1377.

Introduction

COVID-19 is a highly contagious infection-based disease that is considered as one of the most important threats to human's health in recent years (1). A virus belong to the family of coronaviruses which is named as Severe Acute Respiratory Syndrome Coronavirus-2 is the main cause of COVID-19 (2). COVID-19 epidemic had a great burden to the countries' health system and also on the economy of countries (3). The virus leads to an overreaction of the immune system and significant increase in levels of inflammation in the body (3). Today, production of several vaccines has been developed to prevent this disease, but none of them could provide complete immunity against this virus (4). In addition, more concerns about new strains are exist (4). Adherence to healthy dietary patterns might strength the body's immune system and be related to the overall health (5, 6). Although many studies have been done for the effects of various nutrients (such as vitamin C, vitamin A, zinc, omega 3, etc.) in strengthening body immune system, rare studies focused on the association between whole diet and COVID-19 (7-10).

Plant-based Diet Index (PDI) is an epidemiological tool that used to evaluate adherence of a person to a diet rich in plant foods (11). Limited studies have been done on the association between PDI and COVID-19. Findings of a case-control study showed that individuals in the highest tertile of PDI had lower risk of severe COVID-19 compared to those at the lowest tertile (12). Another study showed that consumption of more vegetables and coffee, while consuming less processed meat, was associated with a reduced risk of contracting COVID-19 (13). In contrast, higher consumption of fruits and sugar sweetened beverage (SSB) was related to higher rate of infection and death caused by COVID-19 (14). It seems that a more comprehensive investigation is needed to determine the association of PDI and COVID-19 severity and symptoms in order to resolve controversies and to expand current knowledge. So we conducted the current study to investigate the relationship between PDI and COVID-19 severity and symptoms among individuals recently recovered from COVID-19.

Materials and Methods

This cross-sectional study was conducted on adults recovered from COVID-19 from June 2021 to May 2022. Participants were selected among COVID-19 patients that maximally lasted for three months from their hospitalization in the referral hospital of Shahid Beheshti and referral health centers in Kashan, Iran. Based on inclusion criteria, 684 participants aged 18-70 years were enrolled using convenient sampling method. An informed written consent was taken from all participants. The protocol of study was approved by the Ethics Committee of Kashan University of Medical Sciences (registration no. IR.KAUMS.MEDNT.REC.1403.062). Subjects with BMI between 18.5 and 40 who recovered from COVID-19, confirmed by diagnostic test of positive polymerase chain reaction test, and maximum of three months passed from a positive COVID-19 test were included. We did not enroll patients with chronic diseases such as diabetes or cardiovascular diseases, HIV infection, being under chemotherapy, undergoing organ transplantation, being pregnant or breastfed, having smoking habits, taking drugs with strong effect on respiratory system, body mass index (BMI)>40 kg/m^2 and those who followed a specific dietary pattern.

Among 3191 COVID-19 patients, 1218 person were diagnosed to be eligible to participate in this study and finally 684 COVID-19 patients were enrolled. Data about patients were collected from their medical record and by telephone interview with patients using standard questionnaires such as food frequency questionnaire (FFQ, demographic questionnaire, short form of the International Physical Activity Questionnaire (IPAQ) and Satisfaction with Life Scale. A 168-item FFQ that its validity and reliability were approved previously was used to assess usual dietary intake of individuals during one year before they were infected with COVID-19 (15). Using usual Iranian portion sizes of foods, daily intake of each food in grams was calculated (16). Utilizing Nutritionist IV software, based on US Department of Agriculture food composition database, daily energy and nutrient intakes of participants were measured (17). Plant-based dietary pattern score was evaluated based on three indices of PDI, healthful PDI (hPDI) and unhealthful PDI (uPDI) as described by Satija et al (11).

In this method, 18 food groups including animals, healthy plants and unhealthy plants were employed. Animal foods consisted of animal fat, eggs, dairy products, meat, fishes/seafoods and miscellaneous animal-based foods. Healthy plant foods were whole grains, vegetables, fruits, legumes, nuts, vegetable oils and tea/coffee. Moreover, unhealthy plant foods were considered as refined grains, potatoes, fruit juices, sugar-sweetened beverages and sweets/desserts. Each of those 18 food groups were divided to deciles based on their daily grams. In order to calculate PDI, scores of 10 and 1 were given to the participants in the highest and lowest deciles of plant foods, while participants in the highest and lowest deciles of animal foods were given scores of 1 and 10, respectively. To determine hPDI, scores of 10 and 1 were considered for participants with the highest and lowest consumption of healthy plant foods, respectively. In addition, a score of 1 was defined for the highest and 10 for the lowest deciles of unhealthy plant and animal foods. To assess uPDI, a score of 10 and 1 was given to the highest and the lowest consumption of unhealthy plant foods, while a score of 1 and 10 was evaluated for the participants at the highest and lowest consumption of animal and healthy plant foods, respectively. Finally, those scores were added up and a total score ranged between 18 and 180 was obtained for each index. Higher scores indicated higher adherence to that food pattern.

The severity and symptoms of COVID-19, hospitalization, need to respiratory support, hypoxia, duration of disease, recovery after hospitalization, serum levels of CRP and ESR and life satisfaction were evaluated as outcomes of interest. Severity of COVID-19 was evaluated using COVID-19 Treatment Guidelines (CTG) (18). Patients were divided into five groups based on severity including (i) Asymptomatic or pre-symptomatic patients with positive COVID-19 test in absence of any disease symptoms; (ii) Patients with mild form of disease who had at least one of COVID-19 symptoms (e.g. fever, chills, cough, sore throat, myalgia, headache, weakness, loss of taste and smell, nausea, vomiting and diarrhea) without abnormal chest imaging and severe respiratory symptoms such as dyspnea; (iii) Patients with moderate form of disease who had lower respiratory complications (based on clinical examinations or imaging) and Saturation of Peripheral Oxygen (SpO_2)≥94%; (iv) Patients with severe form of disease who had Respiratory Rate (RR)> 30 breath/minute or arterial partial oxygen pressure to fraction of inspired oxygen ($PaO2/FiO_2$)<300 or SpO_2<94% or more than 50% lung infection; and finally (v) Patients with critical form of disease who experienced respiratory failure, septic shock, and multiple organ dysfunction. In this study, participants of severe and critical form of disease were considered as sever COVID-19 patients.

Symptoms of COVID-19 including fever, chills, dyspnea, chest pain, cough, sneezing, myalgia, weakness, headache, sore throat, runny nose, anorexia, nausea and vomiting and diarrhea were assessed using a standard questionnaire. Need to respiratory support defined as a use of any respiratory assistance (such as nasal cannula, oxygen mask, ventilator and etc.). Hypoxia defined based on SpO2 level of patients, so that SpO2<94% was considered as hypoxia. Life satisfaction score was assessed using validated SWLS (19). Total score of life satisfaction (ranged from 5 to 35) was calculated by summing up score of 5 questions asked from the participants. A higher score indicated better life satisfaction.

General characteristics of participants including age, gender, marital status, height, weight, educational level, occupation, socio-economic status, history of COVID-19 vaccine injection, previous diseases, medications, and dietary supplements during COVID-19 infection were assessed using a standard questionnaire. Level of Physical Activity (PA) was evaluated employing the validated short form of the International Physical Activity Questionnaire (IPAQ) (20). The PA score of participants was presented in MET min/week for each participant. Socio-economic status of participants was evaluated based on the number of family members, home owning and their education status. If number of family member's ≤ 4, owning a home and having university educational level, 1 point was given for each item. In contrast, each of these items was given a score of 0 if the number of family members >4, lacked owning a house and lacked the university educational level. Finally all points were summed up and scores of 2, 1, and 0 indicated a high, moderate and low socio-economic status, respectively.

Statistical analyses were conducted using IBM SPSS Statistics software (Version 26, Chicago, IL, USA). Participants were divided into tertiles based on PDI, hPDI and uPDI scores. Kolmogorov Smirnov test was used to evaluate normality of data. Chi-square test was utilized to compare qualitative variables (such as sex, history of COVID-19 vaccine injection, educational level, etc.) across tertiles of PDI, hPDI and uPDI. One-way analysis of variance was applied to compare quantitative variables (such as age, PA, BMI, etc.) between tertiles of PDI, hPDI and uPDI. Energy and nutrients intake and levels of inflammatory biomarkers across tertiles of PDI, hPDI and uPDI score were compared by analysis of covariance (ANCOVA), while adjusting for age, sex and energy intake. Binary logistic regression analysis in different models was employed to assess the association between PDI, hPDI and uPDI score and COVID-19 outcomes (such as severity, symptoms, hospitalization, duration, etc.); while odds ratios with 95% confidence interval (CI) were reported. Ad P value<0.05 was considered significant.

Results

General characteristics of participants across tertiles of PDI, hPDI and uPDI were presented in Table 1. Significant differences were found among various categories of PDI regarding age, gender, BMI, being overweight and obese, marital status, COVID-19 vaccination and use of antiviral drugs

Table 1: General characteristics of participants according to quartiles of PDI, hPDI and uPDI.

Variable	PDI				hPDI				uPDI			
	Tertile 1	Tertile 2	Tertile 3	*P* value	Tertile 1	Tertile 2	Tertile 3	*P* value	Tertile 1	Tertile 2	Tertile 3	*P* value
Sample size (n)	**225**	**221**	**230**		**220**	**232**	**224**		**222**	**230**	**224**	
Age (y) *	37.90±14.64	43.19±13.73	43.10±12.39	<0.001	37.44±13.20	40.89±13.71	45.82±13.28	<0.001	42.81±12.94	41.53±13.44	39.87±14.89	0.079
BMI (kg/m^2) *	25.47±4.25	27.11±4.20	26.81±4.39	<0.001	26.82±4.91	25.46±3.78	27.15±4.09	<0.001	26.55±3.86	26.90±4.29	25.93±4.76	0.052
Physical activity (MET-min/week) *	798±1203	794±1821	1180±3425	0.134	945±1813	822± 1070	1017± 3527	0.671	879.93± 1962.22	917.85± 1646.53	983.27± 3205.17	0.897
Female (%)	72.9%	63.8%	55.7%	<0.001	60.0%	63.8%	68.3%	0.068	52.3%	63.9%	75.9%	<0.001
Overweight or obese (%)	48.9%	69.7%	62.2%	0.004	64.5%	51.3%	65.2%	0.877	61.7%	66.5%	52.2%	0.040
Married (%)	64.3%	73.6%	77.9%	0.009	58%	71.2%	79.9%	<0.001	70.9%	71.3%	71.2%	0.975
History of supplement use (%)	31%	38.4%	31.3%	0.873	34.8%	34.9%	30.8%	0.445	30.9%	32.9%	34.1%	0.646
University educational level (%)	42.7%	40.0%	41.2%	0.776	56.3%	41.8%	31.49%	<0.001	50.9%	40.1%	40.0%	0.249
Socio-economic status (%)	5.3% 19.3% 75.4%	2.4% 23.2% 74.4%	3.8% 23.5% 72.5%	0.838	4.5% 19.6% 75.9%	2.1% 21.9% 76%	5.3% 23.1% 71.6%	0.366	7.3% 7.3% 85.5%	1.8% 25.1% 73.1%	4.9% 22.9% 72.2%	0.180
Income (%)	32.2%	45.6%	50.4%	0.001	39.3%	41.1%	43.8%	0.445	60.0%	43.7%	35.1%	0.001
History of disease (%)	24.6%	35.2%	26.7%	0.578	21.4%	28.1%	33.1%	0.034	29.1%	26.3%	29.8%	0.701
Covid-19 vaccination (%)	55.6%	39.4%	38.7%	<0.001	38.2%	47.0%	48.2%	0.034	15.3%	49.1%	68.8%	<0.001
Anti-viral drugs treatment (%)	50.7%	69.7%	66.1%	0.001	64.5%	64.2%	57.6%	0.130	78.4%	60.9%	47.3%	<0.001
Taking dietary supplements during treatment (%)	90.2%	95%	90.4%	0.955	91.4%	90.9%	93.2%	0.470	92.8%	93.9%	88.8%	0.130

* Values were presented as mean±standard deviation. MET: Metabolic Equivalent Task.

(*p*<0.01). There were Significant differences between various categories of hPDI in relation to age, BMI, marital status, educational level (*p*<0.01), history of disease, and COVID-19 vaccine injection (*p*=0.03). Considering uPDI, significant differences were seen between different tertiles regarding age (*p*=0.07), gender (*p*<0.001), being overweight and obese (*p*=0.04), income status, COVID-19 vaccination and utilization of antiviral drugs (*p*<0.01). Dietary intake of participants across tertiles of PDI, hPDI, and uPDI were demonstrated in Table 2. Significant differences were observed for different categories of PDI in relation to energy, protein, carbohydrate, fat, fiber, cholesterol, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), vitamin D, vitamin A, beta-carotene, vitamin E, vitamin C, vitamin B1, vitamin B2, vitamin B3, vitamin B6, vitamin B9, magnesium (*p*<0.001) and iron (*p*=0.01). Significant differences were visible for various categories of hPDI regarding energy, protein, fat (*p*<0.01), fiber, cholesterol, SFA, MUFA, polyunsaturated fatty acid (PUFA), vitamin D, beta-carotene, vitamin E, vitamin C, vitamin B2, vitamin B3, vitamin B6, vitamin B9, vitamin B12 (*p*<0.01) and zinc (*p*=0.02). In addition, significant differences were noticed for different categories of uPDI in relation to energy, protein, fat, cholesterol, SFA, MUFA, PUFA, vitamin D, vitamin A, beta-carotene, vitamin E, vitamin C, vitamin B1, vitamin B2 (*p*<0.001), vitamin B6, vitamin B9, vitamin B12 and zinc (*p*<0.01).

As shown in Table 3, no significant differences were noted between different tertiles of PDI/hPDI/uPDI regarding respiratory rate, blood pressure, pulse rate and life satisfaction score. However, a significant inverse association was seen between PDI and serum levels of ESR (*p*=0.046) in patients with COVID-19. The analyses illustrated significant inverse relationship between hPDI and serum levels of CRP and ESR (*p*<0.001), and a significant positive relationship between uDPI and serum levels of those biomarkers in patients with COVID-19. Full-adjusted binary logistic regression resulted in a not-significant association between PDI and risk of infection for severe form of COVID-19, hospitalization, need to respiratory support and duration of recovery after hospitalization; while, being at the highest tertile of PDI was significantly associated with the reduced risk of hypoxia (OR: 0.59, 95% CI: 0.51-1.35, *p*=0.042), duration of disease (OR: 0.46, 95% CI: 0.28-0.75, *p*=0.002) and duration of hospitalization (OR: 0.44, 95% CI: 0.25-0.78, *p*=0.004) in patients recovered from COVID-19 (Table 4). With regards to hPDI, no significant association was found for the odds and duration of hospitalization. However, comparing the highest to the lowest tertile of hDPI, a 44% reduced risk of infection to severe form of COVID-19 (OR: 0.56, 95% CI: 0.34-0.91, *p*=0.023), 43% lower risk of hypoxia (OR: 0.57, 95% CI: 0.33-0.98, *p*=0.046) and 57% lower risk of need to respiratory support (OR: 0.43, 95% CI: 0.25-0.72, *p*=0.001) were exhibited. An inverse association was displayed between hPDI and duration of disease (OR: 0.36, 95% CI: 0.22-0.60, *p*=0.001) and duration of recovery after hospitalization (OR: 0.54, 95% CI: 0.34-0.87, *p*=0.011). No significant association was seen between uPDI and risk of hospitalization, hypoxia, duration of hospitalization and duration of recovery after hospitalization. Comparing the highest to the lowest tertile of uDPI, an 1.83-fold increased risk of infection to severe form of COVID-19 (OR: 1.83, 95% CI: 1.02-3.28, *p*=0.041), a greater odds of need to respiratory support (OR: 2.47, 95% CI: 1.40-4.38, *p*=0.002), and an 1.99-fold increased odds of duration of disease (OR: 1.99, 95% CI: 1.08-3.67, *p*=0.030, Table 4) were demonstrated.

The association between PDI/hPDI/uPDI and risk of COVID-19 symptoms was shown in Table 5. Individuals in the highest tertile of PDI when compared to the lowest tertile showed a lower risk for fever (OR: 0.47, 95% CI: 0.29-0.76, *p*=0.003), chill (OR: 0.58, 95% CI: 0.38-0.88, *p*=0.013), weakness (OR: 0.72, 95% CI: 0.57-0.90, *p*=0.006), myalgia (OR: 0.54, 95% CI: 0.35-0.83, *p*=0.005), chest pain (OR: 0.54, 95% CI: 0.34-0.85, *p*=0.009), headache (OR: 0.38, 95% CI: 0.25-0.59, *p*<0.001), dizziness (OR: 0.60, 95% CI: 0.37-0.96, *p*=0.035), sore throat (OR: 0.49, 95% CI: 0.32-0.75, *p*=0.001), nausea and vomiting (OR: 0.55, 95% CI: 0.32-0.93, *p*=0.030), diarrhea (OR: 0.34, 95% CI: 0.13-0.84, *p*=0.019) and anorexia (OR: 0.59, 95% CI: 0.38-0.90, *p*=0.016). Regarding cough, a positive association was illustrated for PDI (OR: 1.53, 95% CI: 1.04-2.26, *p*<0.001); while no significant relationship was found for other symptoms. Regarding hPDI, individuals in the highest tertile of hPDI had a significantly lower risk of headache (OR: 0.59, 95% CI: 0.37-0.94, *p*=0.024), chill (OR: 0.51, 95% CI: 0.33-0.80, *p*=0.003), weakness (OR: 0.55, 95% CI: 0.33-0.92, *p*<0.023), fever (OR: 0.45, 95% CI: 0.27-0.74, *p*=0.002), dizziness (OR: 0.35, 95% CI: 0.21-0.58, *p*<0.001), cough (OR: 0.53, 95% CI: 0.34-0.83, *p*=0.006), dyspnea (OR: 0.52, 95% CI: 0.33-0.83, *p*=0.008), and sore throat (OR: 0.55, 95% CI: 0.35-0.86, *p*=0.009). The association between uPDI and risk of COVID-19 symptoms was demonstrated in Table 5 too. Individuals in the highest tertile of uPDI displayed a higher risk for headache (OR: 1.81, 95% CI: 1.07-3.06, *p=0.023*), cough (OR: 2.25 95% CI: 1.33-3.81, *p*=0.003), weakness (OR: 2.46, 95% CI: 1.39-4.35, *p*=0.002), dizziness (OR: 2.60, 95% CI: 1.45-4.68, *p*=0.001) and sore throat (OR: 2.48, 95% CI: 1.46-4.21, *p*=0.001); while no significant relationship was found for the other symptoms.

Table 2: Dietary intake of participants across quartile of PDI, hPDI and uPDI.

Variable	PDI				hPDI				uPDI			
	Tertile 1	**Tertile 2**	**Tertile 3**	***P* value**	**Tertile 1**	**Tertile 2**	**Tertile 3**	***P* value**	**Tertile 1**	**Tertile 2**	**Tertile 3**	***P* value**
Energy (kcal/day)	1911.71± 746.51	2309.86± 695.93	2501.47± 650.93	<0.001	2618.72± 712.09	2205.41± 677.71	1911.52± 655.06	<0.001	399.26± 82.11	332.06± 102.86	255.89± 95.62	<0.001
Protein (g/day)	70.39± 30.91	87.08± 31.61	88.82± 28.59	<0.001	95.86± 27.57	83.18± 32.43	67.51± 27.50	0.002	109.80± 22.08	80.23± 25.41	56.61± 20.68	<0.001
Carbohydrate (g/day)	272.00± 109.20	338.16± 100.60	375.63± 95.76	<0.001	379.13± 106.74	326.09± 102.26	282.44± 101.45	0.474	399.26± 82.11	332.06± 102.86	255.89± 95.62	0.292
Fat (g/day)	68.61± 32.75	83.69± 32.64	85.43± 27.86	0.003	97.23± 31.95	76.42± 28.46	64.55± 26.71	<0.001	101.96± 25.03	80.05± 28.61	55.96± 24.06	<0.001
Fiber (g/day)	13.20± 5.95	18.58± 6.47	21.12± 6.51	<0.001	17.74± 6.34	18.52± 7.87	16.67± 6.94	<0.001	23.90± 5.50	17.21± 5.57	11.93± 4.46	<0.001
Cholesterol (mg/day)	274.42± 154.23	344.25± 174.25	320.37± 174.50	<0.001	386.28± 154.83	322.41± 172.12	230.93± 145.80	<0.001	448.40± 156.24	302.22± 146± 50	189.53± 87.93	<0.001
SFA (g/day)	19.91± 10.61	23.98± 10.25	23.17± 9.30	<0.001	29.27± 11.19	20.98± 7.87	16.98± 7.04	<0.001	28.41± 8.98	23.17± 9.96	15.50± 6.98	0.001
MUFA (g/day)	20.07± 11.33	24.04± 10.65	23.32± 9.35	<0.001	28.98± 10.86	21.44± 9.29	17.16± 7.90	<0.001	29.41± 8.75	22.32± 9.69	15.76± 8.61	<0.001
PUFA (g/day)	16.89± 9.02	20.59± 10.13	22.89± 9.39	0.115	22.47± 8.82	19.48± 9.38	18.54± 10.77	0.003	25.66± 8.42	20.23± 9.27	14.59± 8.51	<0.001
Vitamin D (µg/day)	1.39± 1.05	1.62± 0.98	1.48± 0.88	<0.001	1.95± 1.04	1.46± 0.90	1.09± 0.77	<0.001	2.13± 0.76	1.51± 1.00	0.86± 0.69	<0.001
Vitamin A (RAE/day)	841.47± 516.10	1128.19± 537.60	1235.58± 594.27	0.001	1150.67± 471.76	1094.61± 647.95	963.15± 572.44	0.075	1461.00± 467.59	1057.64± 495.19	693.05± 485.90	<0.001
Beta-carotene (µg/day)	434.89± 397.19	682.20± 433.00	831.92± 608.13	<0.001	612.88± 377.02	691.80± 589.41	645.66± 549.91	<0.001	984.23± 444.26	591.23± 472.26	381.58± 439.64	<0.001
Vitamin E (mg/day)	3.81± 2.87	5.04± 2.75	4.84± 2.15	0.001	5.75± 3.09	4.44± 2.37	3.52± 1.92	<0.001	6.41± 2.25	4.41± 2.64	2.89± 1.73	<0.001
Vitamin C (mg/day)	94.70± 44.78	125.57± 48.87	150.79± 57.42	<0.001	116.01± 46.92	133.93± 61.37	121.20± 55.92	<0.001	158.67± 51.12	124.14± 50.61	89.13± 41.56	<0.001
Vitamin B1 (mg/day)	1.54± 0.71	1.98± 0.68	2.11± 0.63	0.037	2.16± 0.70	1.88± 0.68	1.60± 0.66	0.116	2.39± 0.54	1.85± 0.64	1.41± 0.59	<0.001
Vitamin B2 (mg/day)	1.34± 0.61	1.64± 0.60	1.66± 0.54	0.006	1.79± 0.53	1.58± 0.61	1.27± 0.54	0.002	2.05± 0.43	1.56± 0.50	1.03± 0.37	<0.001

Vitamin B3 (mg/day)	18.43±8.35	22.39±7.61	23.16±7.28	<0.001	25.62±7.77	21.12±7.45	17.35±6.62	<0.001	26.86±6.06	21.18±7.32	16.01±6.67	0.005
Vitamin B6 (mg/day)	1.08±0.42	1.43±0.50	1.65±0.49	<0.001	1.50±0.51	1.44±0.53	1.23±0.50	<0.001	1.77±0.39	1.41±0.48	0.99±0.38	<0.001
Vitamin B9 (mg/day)	228.50±115±32	328.69±128.94	356.96±122.59	<0.001	321.41±106.06	319.85±153.62	273.38±132.07	<0.001	430.04±104.69	294.54±92.86	191.68±78.39	<0.001
Vitamin B12 (mg/day)	3.73±2.22	4.41±2.87	4.24±3.10	0.202	4.98±3.11	4.17±2.36	3.24±2.53	0.002	5.02±2.34	4.38±3.27	2.97±2.14	0.001
Zinc (mg/day)	6.75±3.00	8.41±3.11	8.75±2.85	0.077	9.19±2.73	8.10±3.26	6.64±2.77	0.027	10.61±2.22	7.91±2.58	5.42±2.00	<0.001
Calcium (mg/day)	674.36±316±33	791.07±271.67	838.75±246.11	0.898	856.79±278.93	769.87±286.57	680.20±270.30	0.032	965.27±214.65	788.89±272.69	552.39±205±32	<0.001
Magnesium (mg/day)	191.02±86.64	255.70±95.25	278.01±80.03	<0.001	267.50±77.34	249.11±104.62	208.88±90.58	<0.001	331.12±65.20	234.44±68.66	160.72±59.66	<0.001
Iron (mg/day)	17.93±8.90	22.46±8.98	24.22±9.38	0.089	23.36±9.16	22.50±9.87	18.79±8.70	<0.001	27.85±8.74	21.51±8.71	15.35±6.26	<0.001
Selenium (mg/day)	0.03±0.02	0.04±0.02	0.05±0.02	0.016	0.05±0.02	0.04±0.02	0.03±0.02	0.068	0.06±0.02	0.04±0.02	0.03±0.02	<0.001

Values were presented as mean±standard deviation. *Adjusted P value was reported for adjustment of energy intake. SFA: Ssaturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA: Polyunsaturated fatty acids.

Table 3: Association between PDI, hPDI, uPDI and levels of CRP, ESR, respiratory rate, blood pressure, pulse rate and life satisfaction score.

Variable	PDI				hPDI				uPDI			
	Tertile 1	Tertile 2	Tertile 3	*P* value	Tertile 1	Tertile 2	Tertile 3	*P* value	Tertile 1	Tertile 2	Tertile 3	*P* value
CRP	33.25±33.23	27.23±34.80	22.10±31.79	0.069	33.41±30.92	20.80±27.74	27.72±40.65	<0.001	15.33±19.92	33.65±35.30	37.01±41.63	0.001
ESR	33.37±26.37	27.18±25.22	24.67±23.81	0.046	35.09±28.32	22.82±20.64	26.70±25.17	<0.001	19.59±21.53	34.96±28.11	32.56±23.39	<0.001
Respiratory Rate	18.10±2.43	18.15±2.26	18.03±3.87	0.535	17.61±2.73	18.04±3.14	18.35±2.71	0.845	17.78±3.02	17.79±2.93	18.39±2.80	0.659
Systolic blood pressure	122.84±19.87	119.16±22.85	127.04±19.95	0.057	120.41±17.47	121.22±23.75	125.13±20.26	0.417	121.00±18.88	124.14±19.11	122.09±23.06	0.436
Diastolic blood pressure	75.77±11.69	75.86±15.91	81.51±11.56	0.136	77.82±11.92	77.97±14.06	77.06±13.80	0.836	78.36±15.50	78.39±12.52	76.73±13.93	0.742
Pulse rate	87.92±17.11	88.46±17.97	87.30±11.62	0.862	91.38±15.04	85.65±17.33	88.32±14.92	0.336	87.10±14.76	88.14±15.74	87.91±16.40	0.915
Life satisfaction score	23.88±6.72	24.79±6.51	24.91±6.34	0.961	25.37±6.32	24.99±6.18	23.23±6.91	0.304	26.92±5.68	23.97±6.52	22.73±6.64	0.486

Values were presented as mean±standard deviation. *Adjusted P value was reported for adjustment of age, sex, energy intake, physical activity and BMI. CRP: C Reactive Protein, ESR: Erythrocyte Sedimentation Rate.

Table 4: Association between PDI, hPDI, uPDI and risk of sever COVID-19 infection, hospitalization, hypoxia, need to respiratory support, lung infection and duration of disease, hospitalization, recovery after hospitalization and respiratory support.

Variable	PDI				hPDI				uPDI			
	Tertile 1	Tertile 2	Tertile 3	*P* trend	Tertile 1	Tertile 2	Tertile 3	*P* trend	Tertile 1	Tertile 2	Tertile 3	*P* trend
Severe COVID-19 infection												
Crude	1	1.07 (0.70-1.64)	0.77 (0.50-1.20)	0.423	1	0.63 (0.43-0.93)	0.74 (0.50-1.09)	0.127	1	1.18 (0.80-1.73)	0.82 (0.55-1.22)	0.338
Adjusted †	1	0.95 (0.60-1.48)	0.73 (0.46-1.16)	0.170	1	0.61 (0.39 -0.96)	0.56 (0.34-0.91)	0.023	1	1.86 (1.16-3.01)	1.83 (1.02-3.28)	0.041
Hospitalization												
Crude	1	2.42 (1.59-3.68)	1.77 (1.19-2.63)	0.004	1	1.28 (0.85-1.92)	1.11 (0.74-1.67)	0.590	1	0.31 (0.19-0.50)	0.24 (0.15-0.39)	<0.001
Adjusted †	1	1.20 (0.53-2.73)	0.53 (0.22-1.29)	0.197	1	2.16 (0.89-5.23)	1.18 (0.47-2.97)	0.864	1	0.92 (0.33-2.52)	1.44 (0.48-4.28)	0.358
Hypoxia												
Crude	1	0.96 (0.62-1.51)	0.71 (0.45-1.12)	0.129	1	0.58 (0.34-0.90)	0.63 (0.41-0.98)	0.043	1	1.62 (1.06-2.46)	1.21 (0.77-1.89)	0.281
Adjusted †	1	0.83 (0.51-1.35)	0.59 (0.51-1.35)	0.042	1	0.59 (0.36-0.96)	0.57 (0.33-0.98)	0.046	1	1.90 (1.15-3.14)	1.62 (0.85-3.07)	0.099
Need to respiratory support												
Crude	1	1.35 (0.93-1.96)	0.89 (0.61-1.30)	0.556	1	1.01 (0.69-1.46)	0.95 (0.65-1.38)	0.789	1	1.68 (1.15-2.45)	1.80 (1.23-2.64)	0.002
Adjusted †	1	1.11 (0.72-1.72)	0.74 (0.47-1.15)	0.161	1	0.77 (0.48-1.23)	0.43 (0.25-0.72)	0.001	1	2.20 (1.37-3.53)	2.47 (1.40-4.38)	0.002
Lung infection												
Crude	1	1.75(1.20-2.54)	1.78 (1.23-2.59)	0.002	1	1.88 (1.28-2.74)	2.75 (1.87-4.05)	<0.001	1	1.28 (0.88-1.86)	1.31 (0.90-1.90)	0.155
Adjusted †	1	1.68 (1.04-2.72)	1.74 (1.06-2.86)	0.041	1	1.96 (1.22-3.16)	2.44 (1.47-4.04)	0.002	1	0.97 (0.59-1.60)	1.09 (0.58-2.03)	0.791
Duration of disease												
Crude	1	1.46 (0.99-2.14)	0.92 (0.63-1.35)	0.674	1	0.67 (0.45-0.97)	0.64 (0.44-0.94)	0.026	1	1.25 (0.85-1.82)	0.83 (0.56-1.21)	0.351
Adjusted †	1	0.80 (0.49-1.28)	0.46 (0.28-0.75)	0.002	1	0.51 (0.32-0.82)	0.36 (0.22-0.60)	0.001	1	2.18 (1.3-3.63)	1.99 (1.08-3.67)	0.030
Hospital duration												
Crude	1	1.10 (0.69-1.74)	0.78 (0.49-1.25)	0.275	1	0.49 (0.31-0.77)	0.57 (0.36-0.92)	0.026	1	1.00 (0.64-1.56)	0.62 (0.39-0.97)	0.048
Adjusted †	1	0.71 (0.41-1.23)	0.44 (0.25-0.78)	0.004	1	0.51 (0.30-0.87)	0.58 (0.32-1.04)	0.079	1	1.12 (0.64-1.97)	1.07 (0.52-2.20)	0.820
Duration of recovery after hospitalization												
Crude	1	1.30 (0.88-1.90)	1.00 (0.69-1.46)	0.998	1	0.78 (0.53-1.14)	0.67 (0.46-0.98)	0.043	1	1.29 (0.89-1.88)	0.76 (0.52-1.11)	0.177
Adjusted †	1	0.86 (0.56-1.32)	0.66 (0.42-1.02)	0.060	1	0.80 (0.52-1.22)	0.54 (0.34-0.87)	0.011	1	2.26 (1.41-3.62)	1.67 (0.95-2.91)	0.087
Duration of respiratory support												
Crude	1	2.91 (1.41-6.00)	2.63 (1.25-5.51)	0.008	1	1.18 (0.52-2.71)	4.07 (1.71-9.65)	<0.001	1	0.39 (0.10-1.48)	0.17 (0.04-0.63)	0.001
Adjusted †	1	2.23 (0.97-5.16)	1.72 (0.64-4.56)	0.284	1	1.04 (0.42-2.53)	3.13 (1.19-8.18)	0.001	1	0.35 (0.07-1.68)	0.16 (0.03-0.92)	0.018

Values are Odds ratio (95% confidence interval). †Adjusted: adjusted for age, sex, energy intake, marital status, physical activity level, education, job, socioeconomic status, covid-19 vaccine injection and anti-viral treatment drug use, treatment and BMI.

Table 5: Association between PDI, hPDI, uPDI and symptoms of COVID-19.

Variable	PDI				hPDI				uPDI			
	Tertile 1	Tertile 2	Tertile 3	*P* trend	Tertile 1	Tertile 2	Tertile 3	*P* trend	Tertile 1	Tertile 2	Tertile 3	*P* trend
Dyspnea												
Crude	1	1.51 (1.04-2.19)	1.20 (0.83-1.74)	0.327	1	0.49 (0.34-0.72)	0.59 (0.41-0.87)	0.008	1	1.14 (0.79-1.66)	0.80 (0.55-1.17)	0.255
Adjusted†	1	1.03 (0.68-1.57)	0.87 (0.56-1.34)	0.513	1	0.47 (0.31-0.72)	0.52 (0.33-0.83)	0.008	1	1.84 (1.16-2.91)	1.62 (0.98-2.66)	0.085
Cough												
Crude	1	2.40 (1.63-3.54)	1.48 (1.02-2.15)	<0.001	1	0.51 (0.34-0.75)	0.58(0.39-0.86)	0.008	1	2.03 (1.38-2.97)	1.60 (1.10-2.34)	0.013
Adjusted †	1	2.99 (1.94-4.63)	1.53 (1.04-2.26)	<0.001	1	0.53 (0.35-0.80)	0.53 (0.34-0.83)	0.006	1	2.39 (1.53-3.75)	2.25 (1.33-3.81)	0.003
Fever												
Crude	1	0.61 (0.40-0.93)	0.58 (0.38-0.89)	0.015	1	0.51 (0.33-0.80)	0.38 (0.24-0.59)	<0.001	1	1.85 (1.21-2.83)	1.05 (0.71-1.57)	0.787
Adjusted †	1	0.50 (0.31-0.79)	0.47 (0.29-0.76)	0.003	1	0.56 (0.35-0.89)	0.45 (0.27-0.74)	0.002	1	2.82 (1.70-4.68)	1.72 (1.03-2.88)	0.105
Chill												
Crude	1	0.80 (0.54-1.17)	0.79 (0.54-1.16)	0.245	1	0.59 (0.40-0.88)	0.42 (0.28-0.63)	<0.001	1	0.99 (0.67-1.46)	0.68 (0.46-1.00)	0.050
Adjusted †	1	0.57 (0.38-0.87)	0.58 (0.38-0.88)	0.013	1	0.67 (0.44-1.02)	0.51 (0.33-0.80)	0.003	1	1.96 (1.21-3.17)	1.72 (1.00-2.96)	0.081
Weakness												
Crude	1	0.41 (0.27-0.61)	0.37 (0.25-0.55)	<0.001	1	0.83 (0.57-1.21)	0.99 (0.67-1.45)	0.974	1	2.86 (1.95-4.19)	6.02 (3.97-9.12)	<0.001
Adjusted †	1	0.50 (0.31-0.80)	0.72 (0.57-0.90)	0.006	1	0.61 (0.38-0.97)	0.55 (0.33-0.92)	0.023	1	1.46 (0.92-2.32)	2.46 (1.39-4.35)	0.002
Myalgia												
Crude	1	0.74 (0.51-1.09)	0.49 (0.34-0.72)	<0.001	1	1.00 (0.69-1.45)	1.05 (0.72-1.53)	0.792	1	1.64 (1.13-2.38)	2.28 (1.55-3.34)	<0.001
Adjusted †	1	0.86 (0.56-1.30)	0.54 (0.35-0.83)	0.005	1	1.00 (0.66-1.50)	0.83 (0.53-1.31)	0.437	1	1.11 (0.72-1.73)	1.45 (0.85-2.45)	0.163
Chest pain												
Crude	1	0.88 (0.59-1.32)	0.76 (0.51-1.15)	0.198	1	0.67 (0.44-1.01)	0.85 (0.57-1.28)	0.454	1	1.05 (0.70-1.58)	0.94 (0.62-1.42)	0.788
Adjusted †	1	0.62 (0.40-0.97)	0.54 (0.34-0.85)	0.009	1	0.77 (0.49-1.20)	0.85(0.53-1.36)	0.509	1	1.41 (0.88-2.26)	1.72 (0.97-3.03)	0.060
Headache												
Crude	1	0.37 (0.25-0.54)	0.36 (0.24-0.53)	<0.001	1	0.66 (0.46-0.97)	0.77 (0.53-1.13)	0.189	1	1.73 (1.17-2.54)	2.79 (1.89-4.11)	<0.001
Adjusted †	1	0.42 (0.27-0.63)	0.38 (0.25-0.59)	<0.001	1	0.60 (0.39-0.91)	0.59 (0.37-0.93)	0.024	1	1.24 (0.79-1.94)	1.81 (1.07-3.06)	0.023
Dizziness												
Crude	1	0.64 (0.42-0.95)	0.49 (0.32-0.73)	0.001	1	0.70 (0.47-1.05)	0.70 (0.47-1.06)	0.092	1	2.48 (1.54-3.98)	4.96 (3.13-7.88)	<0.001
Adjusted †	1	0.78 (0.50-1.22)	0.60 (0.37-0.96)	0.035	1	0.50 (0.32-0.80)	0.35 (0.21-0.58)	<0.001	1	1.50 (0.87-2.56)	2.60 (1.45-4.68)	0.001
Sore throat												
Crude	1	0.42 (0.29-0.63)	0.46 (0.31-0.67)	<0.001	1	0.56 (0.38-0.82)	0.54 (0.37-0.79)	0.002	1	1.61 (1.09-2.39)	2.46 (1.67-3.65)	<0.001
Adjusted †	1	0.45 (0.30-0.68)	0.49 (0.32-0.75)	0.001	1	0.53 (0.35-0.80)	0.55 (0.35-0.86)	0.009	1	1.53 (0.97-2.41)	2.48 (1.46-4.21)	0.001
Nausea and vomiting												
Crude	1	0.82 (0.53-1.26)	0.46 (0.29-0.74)	0.002	1	0.71 (0.45-1.12)	0.86 (0.55-1.33)	0.500	1	2.01 (1.23-3.28)	2.44 (1.51-3.97)	<0.001
Adjusted †	1	0.97 (0.61-1.54)	0.55 (0.32-0.93)	0.030	1	0.57 (0.35-0.93)	0.59 (0.35-1.01)	0.059	1	1.40 (0.80-2.45)	1.38 (0.74-2.60)	0.368
Diarrhea												
Crude	1	0.64 (0.32-1.28)	0.37 (0.17-0.82)	0.012	1	1.35 (0.64-2.81)	0.79 (0.36-1.72)	0.478	1	0.61 (0.26-1.40)	0.51 (0.22-1.16)	0.140

Adjusted †	1	0.64 (0.30-1.35)	0.34 (0.13-0.84)	0.019	1	1.47 (0.67-3.22)	0.99 (0.39-2.49)	0.944	1	0.54 (0.22-1.33)	0.37 (0.14-1.00)	0.056
Anorexia												
Crude	1	0.79 (0.54-1.17)	0.61 (0.41-0.90)	0.014	1	0.60 (0.40-0.89)	0.78 (0.53-1.15)	0.218	1	1.66 (1.12-2.47)	1.68 (1.13-2.51)	0.011
Adjusted †	1	0.77 (0.51-1.16)	0.59 (0.38-0.90)	0.016	1	0.62 (0.41-0.94)	0.70 (0.44-1.11)	0.126	1	1.49 (0.95-2.34)	1.61 (0.95-2.72)	0.086
Loss of taste and smell												
Crude	1	0.56 (0.32-0.98)	1.48 (0.91-2.41)	0.146	1	1.38 (0.78-2.42)	1.47 (0.85-2.54)	0.187	1	0.33 (0.17-0.63)	0.36 (0.19-0.66)	0.012
Adjusted †	1	0.54 (0.29-1.00)	1.48 (0.82-2.70)	0.213	1	2.18 (1.15-4.13)	2.68 (1.34-5.38)	0.007	1	0.40 (0.20-0.81)	0.48 (0.23-1.00)	0.176
Sneeze												
Crude	1	0.50 (0.28-0.87)	0.60 (0.35-1.02)	0.040	1	1.02 (0.58-1.76)	0.61 (0.34-1.07)	0.070	1	0.50 (0.25-0.98)	0.61 (0.32-1.16)	0.371
Adjusted †	1	0.59 (0.32-1.08)	0.69 (0.37-1.29)	0.209	1	1.33 (0.73-2.43)	0.94 (0.48-1.87)	0.849	1	0.49 (0.23-1.01)	0.54 (0.25-1.16)	0.272
Runny nose												
Crude	1	0.42 (0.25-0.70)	0.56 (0.35-0.92)	0.011	1	1.30 (0.68-1.87)	0.53 (0.31-0.89)	0.011	1	1.72 (0.94-3.16)	0.73 (0.47-1.14)	0.386
Adjusted †	1	0.51 (0.28-0.91)	0.70 (0.39-1.27)	0.198	1	1.79 (1.00-3.22)	1.16 (0.60-2.25)	0.715	1	0.40 (0.19-0.82)	0.50 (0.23-1.05)	0.254

Values were presented as Odds ratio (95% confidence interval). †Adjusted: adjusted for age, sex, energy intake, marital status, physical activity level, education, job, socioeconomic status, covid-19 vaccine injection and anti-viral treatment drug use, treatment and BMI.

Discussion

We found that a greater adherence to a healthy plant-based diet was associated with lower inflammatory levels and less severity and duration of COVID-19; as well as lower time and need for respiratory support. Also, symptoms such as weakness, cough, sore throat, headache and dizziness were significantly less frequent among patients with more adherence to a healthy plant-based diet. The statistical findings of this study showed that people at the highest hPDI tertile had lower levels of C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) when compared to individuals who were at the lowest tertile. Contrary, subjects in the top tertile of uPDI had significantly higher levels of the two inflammatory factors of CRP and ESR. Pourreza *et al.* conducted a cross-sectional study on 390 healthy obese and overweight women and observed that following a healthy plant-based diet was associated with lower hs-CRP levels, while following an unhealthy plant-based diet was associated with higher concentration of hs-CRP (21). In another cross-sectional study conducted by Mohajeri *et al.* on 600 Iranian patients with COVID-19 demonstrated the serum levels of tumor necrosis factor, interleukin 1 beta (IL-1β), hs-CPR, and malondialdehyde (MDA) to be significantly lower in patients with more adherence to the Mediterranean diet (22). In a systematic review that included 6 studies, a low-calorie, high-fiber Mediterranean diet was significantly correlated with a decrease in BMI and inflammatory markers including hs-CRP among overweight/obese adults at risk for severe COVID-19 outcomes (23).

Our study showed no significant association between healthy or unhealthy plant-based diet with systolic and diastolic blood pressures. So far, no observational study investigated relationship between diet and blood pressure among COVID-19 patients. However, several studies have pointed to blood pressure in patients with COVID-19 (24). According to observational studies, patients with history of underlying diseases such as high blood pressure, diabetes mellitus, and cardiovascular diseases are more susceptible to COVID-19 infection and its complications (25). Plant-based diets are sodium restricted and might be effective in preventing hypertension in these patients (26). In addition, more intake of potassium in these diets can modulate blood pressure (27). Lack of significant association between plant-based diet scores and risk of blood pressure in our study might be partially explained by other confounding factors that influence blood pressure, such as patients' physical activity, history of chronic diseases in the patients or their families and medicines they used. More comprehensive studies should be done to find exact association between plant-based diets and blood pressure among COVID-19 patients.

Healthy or unhealthy plant-based diet and the overall score of plant-based diet were not significantly associated with the life satisfaction of our patients. Contrary to our findings, most earlier studies reported significant association between plant-based diets and a better life satisfaction. Findings of a cross study showed that subjects who followed a vegetarian diet had a higher level of life satisfaction than those who consumed meat. It should be noted that those participants were not suffering from a stressful disease like COVID-19 (28). In another study by Martí *et al.* on 351 people older than 60 years of age, a direct relationship was found between the Mediterranean diet score and life satisfaction only among women (29). Lack of this finding among men who are more susceptible to social stresses shows that the association between whole diet and life-satisfaction must be investigated among different peapoles with different levels of stress.

The findings of our study showed that following a hPDI was linked to 44% reduction in the severity of COVID-19. Following a hPDI diet was assoicated to reduction in odds of some symptoms such as cough by 47%, fatigue by 45%, sore throat by 45%, headache by 55%, and dizziness by 55%, while following an uPDI was associated to 85% increment in the severity of COVID-19. Merino *et al.* showed that a dietary pattern rich in healthy plant foods was associated with a lower risk of occurance and severity of COVID-19 (30). The dietary intake of the subjects in that study was collected using a short 27-item questionnaire. In another cross-sectional study investigating the relationship between adherence to the Mediterranean diet and the severity and symptoms of COVID-19 on 250 Iranian hospitalized due to COVID-19, an inverse relatationship was noticedd between this dietary pattern and the reduced risk of some symptoms, including shortness of breath, cough, fever, chills, weakness, myalgia, nausea and vomiting, and sore throat. Additionally, Mediterranean diet was associated with shorter hospital stay, recovery period, as well as reduced severity and inflammatory status (lower CRP and ESR levels) in COVID-19 patients (31). In a cross-sectional study on 236 COVID-19 outpatients in the Mexican population, an increase in the frequency of consumption of some food groups including “legumes” and “cereals, bread and cereals” could reduce the overall severity of symptoms among those patients (32).

After controlling for confounding factors, our study revealed no significant association between hPDI or uPDI with the risk of COVID-19 hospitalization. In a cross-sectional study conducted on 141 patients with confirmed COVID-19 in the Iranian population, participants who had higher PDI and hPDI scores had a lower chance of being admitted to the hospital (33). In another cross-sectional study, the score of DASH diet was calculated in these patients, and it was shown that consuming more fruits, vegetables and low-fat dairy products and less consumption of sodium and processed red meat were significantly associated with a reduced risk of hospitalization due to COVID-19 (34). Although the design of mentioned study was similar to our study, theier findings might be due to the much smaller population of that study. Patients with the highest adherence to a hPDI had 57% less chance for respiratory support in the current study. Contrary, following an uPDI resulted in 47% increment in the risk of respiratory support in our patients. In a cross-sectional study, it was found that older patients who were non-vegetarian had higher risk of respiratory support need after COVID-19 (35). Unfortunately, their study had no validated questionnaire to determine the adherence of the participants to a plant-based diet.

Plant-based diets comprise a diverse range of dietary patterns that emphasize on foods derived from plant sources together with reduced consumption or elimination of animal products (36). Some of the health benefits of plant-based diets are their role in modulating inflammatory pathways and immune responses; but the association of plant-based diets with the risk of severe infection, especially respiratory infection, is still less clear (37). According to the findings of a previous study, it can be said that if these foods could be consumed instead of animal foods, favorable effects might be expected to reduce the level of inflammatory markers such as CRP and IL-6 (38). Plants containing certain antioxidants, including polyphenols and carotenoids, modulates the growth of tumors, and increases the protective power of the immune system (39). They are also rich in antioxidant vitamins such as A, C and E. The influence of these vitamins in reducing the risk of respiratory infections such as colds and pneumonia and shortening the duration of these diseases has been documented previously (40).

The variety of outcomes of COVID-19 in this study is a strenght factor. We used accurate criteria from international guidelines to categorize our participants’ disease status. We adjusted our statistical analyses for a large range of potential confounders. However, due to the nature of cross-sectional studies, it was impossible to confer the causal relationship. In addition, the food frequency questionnaire relies on people’s memory, and suffers from lack of some specific foods. The differences between viral variants also could affect the severity and symptoms of the disease and we were unable to control this concern. Finally, despite adjustments for a large number of confounding factors, there might be still other variables that influence our results.

Conclusion

Our study showed less inflammation and lower severity and duration of disease as well as less needs for respiratory support among COVID-19 patients who followed a plant based diet. In addition, some symptoms of the disease such as weakness, cough, sore throat, headache and dizziness were significantly less frequent among patients with higher adherence to a healthy plant-based diet.

Acknowledgment

The authors appreciate financial support of this study by Kashan University of Medical Sciences.

Funding

This study was financially supported by Kashan University of Medical Sciences (grant no. of 403048).

Authors' Contribution

FA, MN, and AE contributed in conception, design, search, statistical analyses, data interpretation and manuscript drafting. NI and MMH contributed in design and data interpretation. AM and FB contributed in conception, design, statistical analyses. AM supervised the study. All authors approved the final manuscript for submission.

Conflict of Interest

All of authors do not have any of conflict of interest.

References

1 Ahmadi S, Firoozi D, Masoumi SJ. The Effect of Micronutrients on COVID-19 Disease: A Review of Available Evidences. *Int J Nutr Sci*. 2022;7:10-18. DOI: 10.30476/IJNS.2022.94162.1169.
2 Mehrdad M, Eftekhari MH. Concerns on Obesity during COVID-19 Pandemic. *Int J Nutr Sci*. 2021;6:111-112. DOI: 10.30476/IJNS.2021.90311.1125.
3 Mirzay Razaz J, Nosrati-Oskouie M, Hassan Qomi M, Elham-Kia M, et al. Nutritional Support for Rehabilitation of Survived COVID-19 Patients: A Review. *Int J Nutr Sci*. 2021;6:1-5. DOI: 10.30476/IJNS.2021.87600.1085.
4 Chilosi M, Doglioni C, Ravaglia C, et al. COVID-19. Biology, pathophysiology, and immunology: a pathologist view. *Pathologica*. 2023;115:248-56. DOI: 10.32074/1591-951X-954. PMID: 38054899.
5 Almasi F, Nemati M, Aminianfar A. Dietary Recommendations for Glioma: A Mini-Review. *Curr Nutr Rep*. 2024;13:966-71. DOI: 10.1007/s13668-024-00577-1. PMID: 39292335.
6 Nemati M, Shayanfar M, Almasi F, Mohammad-Shirazi M, Sharifi G, Aminianfar A, Esmaillzadeh A. Dietary patterns in relation to glioma: a case–control study. Cancer & Metabolism. 2024;12(1):8.
7 Ahmadi S, Mehrabi Z, Zare M, et al. Efficacy of nanocurcumin as an add-on treatment for patients hospitalized with COVID-19: A double-blind, randomized clinical trial. *Int J Clin Pract*. 2023;2023:5734675. DOI: 10.1155/2023/5734675. PMID: 37547100.
8 Almasi F, Nemati M, Akbarzadeh Morshedi M, et al. Association of dietary insulinemic potential with disease severity and symptoms in patients with COVID-19. *Nutr Clinique et Métab*. 2024;38:259-70.
9 Almasi F, Nemati M, Rabiee R, et al. The Correlation between Nuts Consumption and Severity and Symptoms of COVID-19. *Int J Nutr Sci*. 2024;9:236-44. DOI: 10.30476/ijns.2024.102820.1327.
10 Nemati M, Almasi F, Barforoush F, et al. Dietary inflammatory potential in relation to COVID-19 severity and symptoms among individuals recovered from COVID-19: A cross-sectional study. *Nutr Clinique et Métab*. 2024;38:203-13.
11 Satija A, Bhupathiraju SN, Rimm EB, et al. Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. *PLoS Med*. 2016;13:e1002039. DOI: 10.1371/journal.pmed.1002039. PMID: 27299701.
12 Kim H, Rebholz CM, Hegde S, et al. Plant-based diets, pescatarian diets and COVID-19 severity: a population-based case–control study in six countries. *BMJ Nutr Prev Health*. 2021;4:257-266. DOI: 10.1136/bmjnph-2021-000272. PMID: 34308134.
13 Vu TT, Rydland KJ, Achenbach CJ, Van Horn L, Cornelis MC. Dietary Behaviors and Incident COVID-19 in the UK Biobank. *Nutrients*. 2021;13:2114. DOI: 10.3390/nu13062114. PMID: 34203027.
14 Abdulah DM, Hassan AB. Relation of Dietary Factors with Infection and Mortality Rates of COVID-19 across the World. *J Nutr Health Aging*. 2020;24:1011-8. DOI:10.1007/s12603-020-1434-0. PMID: 33155630.
15 Esfahani FH, Asghari G, Mirmiran P, et al. Reproducibility and relative validity of food

group intake in a food frequency questionnaire developed for the Tehran Lipid and Glucose Study. *J Epidemiol*. 2010;20:150-8. DOI: 10.2188/jea.je20090083. PMID: 20154450.

16 Ghaffarpour M H-RAKHTMfHM, Cooking Yields Factors and Edible Portion of Foods. Tehran: Keshaverzi Press; in Persian.

17 US Department of Agriculture. National nutrient database for standard reference release 17 (database on the Internet). USDA W, DC. http://www.nal.usda.gov/fnic/ foodcomp. (Accessed 15 March, 2015).

18 Clinical Spectrum of SARS-CoV-2 Infection. Available online at: https://www.covid19treatmentguidelines.nih.gov/overview/clinical-spectrum/ (Accessed 10 June, 2021)

19 Bayani A KA, Guderzi H. Validity of the Satisfaction with Life Scale (SWLS). Transformational psychology (Iranian psychologists). 2016;3. (in Persian)

20 Vasheghani-Farahani A, Tahmasbi M, Asheri H, et al. The Persian, last 7-day, long form of the International Physical Activity Questionnaire: translation and validation study. *Asian J Sports Med*. 2011;2:106-16. DOI: 10.5812/asjsm.34781. PMID: 22375226.

21 Pourreza S, Khademi Z, Mirzababaei A, et al. Association of plant-based diet index with inflammatory markers and sleep quality in overweight and obese female adults: A cross-sectional study. *Int J Clin Pract*. 2021;75:e14429. DOI: 10.1111/ijcp.14429. PMID: 34081826.

22 Mohajeri M, Mohajery R, Cicero AFG. Adherence to the Mediterranean Diet Association with Serum Inflammatory Factors Stress Oxidative and Appetite in COVID-19 Patients. *Medicina (Kaunas)*. 2023;59:227. DOI: 10.3390/medicina59020227. PMID: 36837428.

23 Moore E, Fadel A, Lane KE. The effects of consuming a Mediterranean style diet on associated COVID-19 severity biomarkers in obese/overweight adults: A systematic review. Nutr Healh. 2022;28:647-67. DOI: 10.1177/02601060221127853. PMID: 36131504.

24 Gallo G, Calvez V, Savoia C. Hypertension and COVID-19: Current Evidence and Perspectives. *High Blood Press Cardiovasc Prev*. 2022;29:115-23. DOI: 10.1007/s40292-022-00506-9. PMID: 35184271.

25 Kunal S, Gupta K, Sharma SM, et al. Cardiovascular system and COVID-19: perspectives from a developing country. *Monaldi Arch Chest Dis*. 2020;90. DOI: 10.4081/monaldi.2020.1305. PMID: 32380802.

26 Brown RB. Low dietary sodium potentially mediates COVID-19 prevention associated with whole-food plant-based diets. *Br J Nutr*. 2023;129:1136-41. DOI: 10.1017/S0007114522002252. PMID: 35912674.

27 Crouch SH, Botha-Le Roux S, Delles C, et al. Inflammation and salt in young adults: the African-PREDICT study. *Eur J Nutr*. 2021;60:873-82. DOI: 10.1007/s00394-020-02292-3. PMID: 32494865.

28 Nesterok MD. The Differences in Life Satisfaction between Individuals Following Plant-Based Diets and Those Consuming Animal Products. *Rozprawy Społeczne*. 2023;17:97-113. DOI: 10.29316/rs/168794.

29 Zaragoza-Martí A, Ferrer-Cascales R, Hurtado-Sánchez JA, Laguna-Pérez A, et al. Relationship Between Adherence to the Mediterranean Diet and Health-Related Quality of Life and Life Satisfaction Among Older Adults. *J Nutr Health Aging*. 2018;22:89-96. DOI: 10.1007/s12603-017-0923-2. PMID: 29300427.

30 Merino J, Joshi AD, Nguyen LH, et al. Diet quality and risk and severity of COVID-19: a prospective cohort study. *Gut*. 2021;70:2096-104. DOI: 10.1136/gutjnl-2021-325353. PMID: 34489306.

31 Zargarzadeh N, Tadbir Vajargah K, Ebrahimzadeh A, et al. Higher Adherence to the Mediterranean dietary pattern is inversely associated with severity of COVID-19 and related symptoms: A Cross-Sectional Study. *Front Med*. 2022;9:911273. DOI: 10.3389/fmed.2022.911273.

32 Salazar-Robles E, Kalantar-Zadeh K, Badillo H, et al. Association between severity of COVID-19 symptoms and habitual food intake in adult outpatients. *BMJ Nutr Prev Health*. 2021;4:469-78. DOI: 10.1136/bmjnph-2021-000348. PMID: 35024547.

33 Soltanieh S, Salavatizadeh M, Ghazanfari T, et al. Plant-based diet and COVID-19 severity: results from a cross-sectional study. *BMJ Nutr Prev Health*. 2023;6:182-7. DOI: 10.1136/bmjnph-2023-000688. PMID: 38618542.

34 Zamanian A, Yari Z, Soltanieh S, et al. The association of dietary approach to stop hypertension (DASH) diet with hospitalization risk in patients with COVID-19. *Clin Nutr Open Sci*. 2023;48:55-63. DOI: 10.1016/j.nutos.2023.02.001. PMID: 36922984.

35 Hou YC, Su WL, Chao YC. COVID-19 Illness Severity in the Elderly in Relation to Vegetarian and Non-vegetarian Diets: A Single-Center Experience. *Front Nutr*. 2022;9:837458. DOI: 10.3389/fnut.2022.837458. PMID: 35571931.

36 Plant-based diets and their impact on health,

sustainability and the environment: a review of the evidence. WHO Regional Office for Europe. 2021.
37 Kendrick KN, Kim H, Rebholz CM, et al. Plant-Based Diets and Risk of Hospitalization with Respiratory Infection: Results from the Atherosclerosis Risk in Communities (ARIC) Study. *Nutrients*. 2023;15:4265. DOI: 10.3390/nu15194265. PMID: 37836549.
38 Craddock JC, Neale EP, Peoples GE, et al. Vegetarian-Based Dietary Patterns and their Relation with Inflammatory and Immune Biomarkers: A Systematic Review and Meta-Analysis. *Adv Nutr.* 2019;10:433-51. DOI: 10.1093/advances/nmy103. PMID: 30947338.
39 Molncr J, Pal M. The role of plant-based diet in protecting the immune system during the COVID-19 pandemic. www.foodnbeveragesprocessing.com. Accessed August 10, 2021.
40 Kim H, Rebholz CM, Hegde S, LaFiura C, Raghavan M, Lloyd JF, et al. Plant-based diets, pescatarian diets and COVID-19 severity: a population-based case-control study in six countries. *BMJ Nutr Prev Health*. 2021;4:257-66. DOI: 10.1136/bmjnph-2021-000272. PMID: 34308134.