The short-term effects of COVID-19 outbreak on dietary diversity and food security status of Iranian households (A case study in Tehran province)

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ABSTRACT

Currently, the COVID-19 outbreak is spreading fast in 185 countries and has engaged most people around the world. COVID-19 imposes severe and tragic consequences on people's health due to the high rate of spread and potentially fatal impacts. In this study, the association of socio-economic factors with food security and dietary diversity is assessed before and during the COVID-19 pandemic. Data from 299 respondents were collected by an online standard questionnaire. Household Dietary Diversity Score (HDDS) and Household Food Insecurity Access Scale (HFIAS) were calculated. A multinomial regression model was applied to determine factors associated with HDDS and HFIAS before and during COVID-19 outbreak. Food security of Iranian households improved during the initial COVID-19 pandemic period ($P < 0.001$). Households reduced consumption of some food groups during the COVID-19 pandemic compared to the pre-COVID-19 period. Key socio-economic factors associated with food insecurity during the COVID-19 pandemic included personal savings, household income, employment status of head of household, and nutrition knowledge of head of household. During the COVID-19 outbreak, household size, head of household's occupation, personal savings, and number of male children were significantly associated with dietary diversity. Distributing free food baskets to poor households, extending e-marketing, providing nutrition consultations, and organizing donations to support infected households may increase household dietary diversity and improve food security status during a pandemic such as COVID-19. Vulnerable populations in countries experiencing food insecurity, such as Iran, should be supported — not just by providing medical care and personal protective equipment, but also with flexible safety nets and food-based intervention programs to respond to population needs.

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1. Introduction

The COVID-19 pandemic, a new infectious disease with human to human transmission, has had an unprecedented detrimental impact on global healthcare systems, with a ripple effect touching every aspect of human life. The COVID-19 was first identified on December 2019 in Wuhan, China (Vaka et al., 2020; Wu et al., 2020) and is now spreading fast in 185 countries, with particular severity in countries without robust health systems or strong social safety

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Nomenclature			
		Min	Minimum
		n	Number
AIDS	Acquired immune deficiency syndrome	NGOs	Non-Governmental Organizations
COVID-19	Coronavirus Disease 2019	P	Probability
EVD	Ebola Virus Disease	Rials	Iranian currency
FAO	Food and Agricultural Organization	SARS	Severe Acute Respiratory Syndrome
H1N1	Influenza A virus subtype	SD	Standard deviation
HDDS	Household Dietary Diversity Score	Sig	Significant level
HFIAS	Household Food Insecurity Access Scale	SPSS V.25	Statistical Package for the Social Sciences, Version 25
HIV	Human Immunodeficiency Virus	STATA V.16	Statistics and data analysis software, Version 16
Max	Maximum	VIF	Variance Inflation Factor
MERS	Middle East Respiratory Syndrome	Z	Z-statistics

nets (Laborde et al., 2020; Muhammad et al., 2020). Many countries are now reporting increasing numbers of cases and imposing rigorous lockdown regulations in response, which impact all aspects of the economy (Amankwah-Amoah, 2020; O'Connor et al., 2020; Reardon et al., 2020). According to available data, over 23 million COVID-19 cases and over 803,253 deaths have been reported throughout the world and these numbers continue to increase.

The world previously experienced several infectious diseases with the high mortality rates, including the so-called Spanish flu in 1918, Dengue in the 1950s in the Philippines and Thailand, HIV in the early 1980s, Hantavirus in 1993 in the U.S. SARS in 2002 in the Guangdong province of China, and MERS in 2012 in Saudi Arabia and in South Korea in 2015 (Wu et al., 2020). These diseases had dramatic local impacts. For example, from January 1918 to December 1920, 500 million people, a third of the world's population, were infected by Spanish flu. These pandemic diseases imposed severe and tragic consequences on people's health and food security. Table 1, drawn from contemporary studies, shows the impacts of pandemic diseases on human health, including food insecurity.

Due to the mandatory lockdowns, many people around the globe have lost their jobs, creating concerns about stability, availability, accessibility, and usage of food. Little is known about the impact of the COVID-19 outbreak on food security, dietary diversity, and associated demographic and socio-economic factors, particularly in developing countries such as Iran. Based on information as of give date, Iran reported 360,000 cases and 20,502 deaths due to COVID-19. Efforts must be made to understand and control the disease, and now is the time to act (Wang et al., 2020).

This study assesses the association of socio-economic factors with food security and dietary diversity before and during the early stages of the COVID-19 outbreak in Tehran province. The novel outcome of this quick assessment will contribute to understanding the critical needs of the population, which can then be used for designing responsive programs to meet the most urgent needs of households in Tehran province, especially food insecure households. To address the urgent need to determine the impact of the COVID-19 pandemic on food security and dietary diversity status within the context of socio-economic factors, the study has the following objectives:

- To assess the food security status of Iranian households residing in Tehran province before and during the COVID-19 outbreak.
- To determine the dietary diversity score before and during the COVID-19 pandemic in Tehran province.
- To determine factors associated with dietary diversity and food security of households residing in Tehran province of Iran before and during the COVID-19 outbreak.

2. Methods

2.1. Cross-sectional framework

A cross-sectional analysis using both retrospective and current situations was used, as illustrated in Fig. 1. The questionnaires were designed based on world-wide literature on pandemics and on food security and in consultation with subject matter experts. Data were collected through an online survey. Food insecurity and dietary diversity score of the households were determined immediately before and during the COVID-19 outbreak in Tehran province. Finally, the association of socio-economic factors, household characteristics, and nutrition knowledge with the changes of households' dietary diversity and food insecurity were assessed in Tehran province.

Table 1
The association of the different virus outbreak with socio-economic factors and food security/health status.

| Surveyed study	Virus name	Location	Socio-economic factors	Was food security/health status measured?	Did it have a significant effect on food security?
Florence and Valstar (1999)	HIV/AIDS	World	No	Yes	Yes
Bahwere et al. (2011)	HIV	Malawi	Yes	Yes	Yes
Dasgupta et al. (2016)	HIV/AIDS	West Bengal	Yes	Yes	No
Anema et al. (2016)	HIV	Canada	Yes	Yes	Yes
Chege et al. (2016)	HIV	Kenya	Yes	Yes	Yes
Pienaar et al. (2017)	HIV	South Africa	Yes	Yes	Yes
Cox et al. (2017)	Hepatitis C	Canada	Yes	Yes	Yes
Hatsu et al. (2017)	HIV	USA	Yes	Yes	Yes
Kelly et al. (2018)	Ebola	Sierra Leone	Yes	No	No
Aibibula et al. (2018)	HIV	Canada	No	Yes	Yes
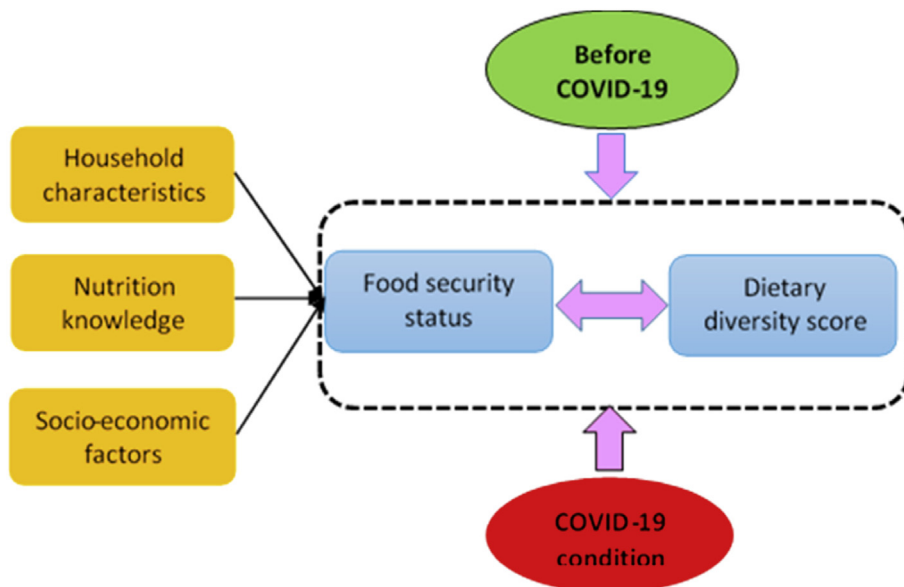
Fig. 1. Cross-sectional design of the study.

2.2. Study area

Data were collected via an online questionnaire in the Tehran province of Iran, the second-largest metropolitan area in the Middle East with a population of about 13 million in 2019. This province was selected due to the following characteristics: high traffic and daily commute, considerable income disparity among people, and high population density (about 962 person/square kilometer) (Tehran Municipality, 2019). This environmental context made this province prone to a COVID-19 outbreak. The geographical position of Tehran province in Iran is shown in Fig. 2.

2.3. Study population

Iranian households residing in Tehran province were enrolled in the study through a non-probability sampling approach where participants were invited through social media and advertisement We had to conduct the study online due to strict government COVID-19 regulations, including travel restrictions, quarantine, isolation, and social distancing during COVID-19 pandemic. The probability that every unit or respondent included in the sample is random cannot be determined, and each individual who reads the invitations choose to participate or not participate in the survey. The online questionnaire was completed by either the head of the selected households or a member, generally a woman, who could respond on behalf of the household head. The respondents were aware of participated household information, including dietary habits and the consumption of all food groups before and during the COVID-19 outbreak.
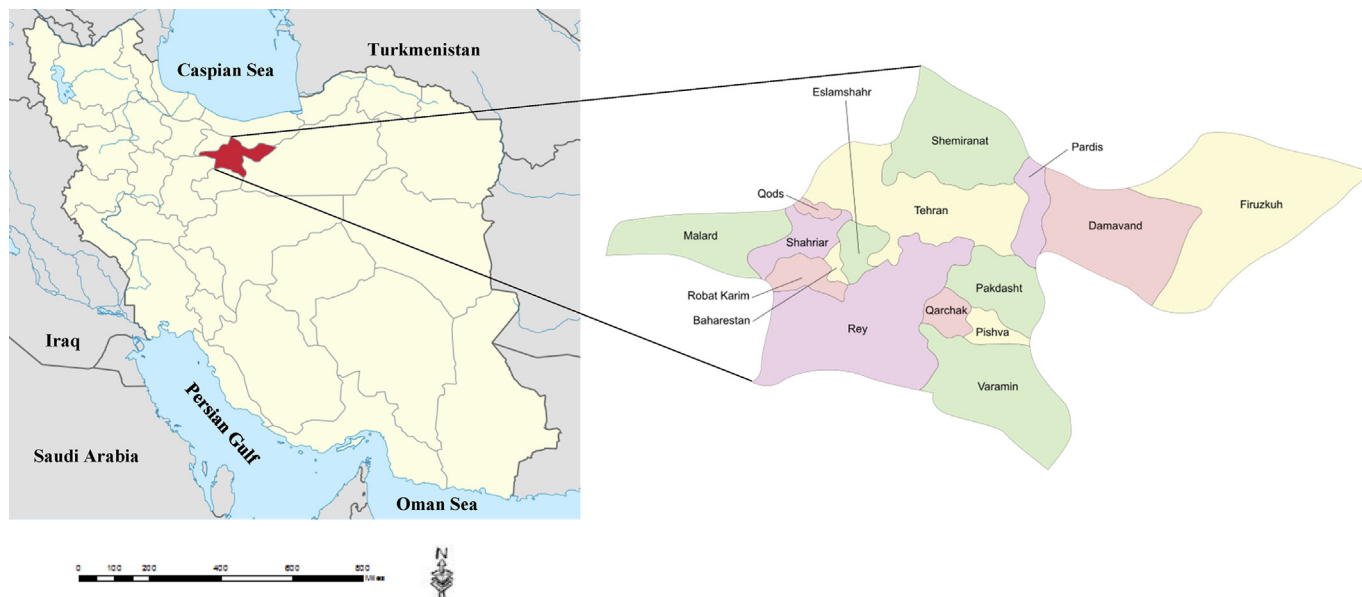

Fig. 2. Tehran province position of Iran.

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2.4. Data collection and questionnaires

The study involved a cross-sectional analysis of 292 families residing in Tehran province. The questionnaire included questions about two different periods: 1) before the COVID-19 outbreak (household conditions in February 2020) and 2) during the onset of the COVID-19 pandemic (March 2020). Some items in the questionnaire were identified through published papers pertaining to previous global outbreaks, including SARS, Ebola, HIV, and Influenza. Other items were identified based on COVID-19 conditions, and public and academic experiences. Before finalizing the questionnaire, the validity and reliability of the questionnaires were confirmed by five experts in the field of the food-agriculture-economic-health systems. Informed consent was attained from each respondent. The first page of the online questionnaire outlined the benefits of participating, which focused on raising awareness of household problems during the COVID-19 pandemic among governmental agencies and global organizations to encourage policymakers to take quick responsive action.

2.5. Assessment of food insecurity

Food insecurity before and during the COVID-19 outbreak was assessed through a modified version of the HFIAS, a standard tool validated in Iran (Salarkia et al., 2011). The tool is a nine-item scale, with a reference period of the past four weeks for all included questions (Bhalla et al., 2018; Rezazadeh et al., 2016). Using HFIAS, households were asked to respond to each experience as never, rarely, sometimes, or often, generating a total score from 0 to 27 (Bhalla et al., 2018). A higher score indicates a higher level of household food insecurity. In the HFIAS scale, food insecurity status is categorized as marginal, moderate, or severe, which corresponds to uncertainty about the food supply, and inadequate quality and quantity of food (Fig. 3).

Marginal food insecurity indicates that the representative of the household reports worries about future access to food or food affordability (Mostashari-Rad et al., 2019; Saber et al., 2020). The moderate situation indicates that households lack the means to buy higher nutritional quality foods. Severe food insecurity indicates that food shortages and hunger are occurring, i.e., adults and children in the household skip meals and/or cut portion sizes due to lack of resources available to purchase needed food ingredients (Coates et al., 2007). The difference of the HFIAS score before and during the COVID-19 pandemic was considered as the change of food security status due to pandemic conditions.

2.6. HDDS

To calculate the dietary diversity score of each household in Tehran province, respondents were asked to determine the foods eaten by the family members before and during the COVID-19.

These responses were then used to assess whether the household consumed a food group or not. A household's dietary diversity is described as the number of different food groups consumed by a household over a given reference period. The classification of dietary diversity was based on the approach suggested by Kennedy et al. (Kennedy et al., 2011), dividing all available foods into 16 groups. The HDDS score is between 0 and 12. Some groups, including vegetables, fruits, and meats, are formed by merging several food items. The questionnaire excludes foods consumed away from home or consumed during national holidays/celebrations. Government COVID-19 regulations, including the closure of all food sales and supply centers, as well as restrictions on gatherings during the COVID-19 outbreak, were not obstacles for completing the questionnaires.

2.7. Socio-economic factors and analysis

To obtain comprehensive information, questions regarding household characteristics, nutrition knowledge, and socio-economic factors were included in the questionnaire. All variables used in the survey are shown in Table 2.

2.8. Statistical analysis and the model specification

Descriptive statistics include mean and standard deviation for continuous variables and percentage and frequency for categorical variables. A paired sample t-test, Chi-square, and Pearson's correlation coefficient were calculated to determine the mean, distribution differences, and correlations between food security status and socioeconomic determinants.

After identifying the related factors with the HFIAS and HDDS, the Variance Inflation Factor (VIF) was estimated to test multi-collinearity between independent determinants. The VIF checks a linear relationship among any subset of explanatory factors (Wang et al., 2017; Wooldrige, 2012). If the VIF is less than five for all factors, it demonstrates that the estimated model does not have multi-collinearity (Wang et al., 2017). In two separate multinomial regressions, the food security and household dietary diversity score were considered as the dependent variables. Finally, the association of the factors with food security and dietary diversity was assessed separately by the multinomial logistic regression model.

We used STATA V.16 and SPSS V.25 software for data processing, cleaning and analyses. Alpha was set at 0.05 in all analyses.

3. Results

3.1. Descriptive characteristics

Detailed socio-economic characteristics of the respondents are presented in Table 3. The age of the respondents ranged between 25 and 85 years, with an average of 47.5 years (SD = 13.47). The

Fig. 3. The domains of food insecurity assessed by HFIAS.

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Table 2
The description of factors in the multinomial regression model.

Factor	Scale	Definition
Food security score	(0−27)	0 = food secure status; 27 = severe food insecure status
Anxiety and uncertainty score	(2−9)	2 = low anxiety; 9 = high anxiety
Insufficient quality score	(4−14)	4 = low insufficient quality; 14 = high insufficient quality
Insufficient food intake score	(15−27)	15 = low insufficient food intake; 27 = high insufficient food intake
HDDS	0−12	The number of food groups consumed by a household during the past week
Low HDDS (Lower 4.5)	0−4.5	The small number of food groups consumed by a household
Medium HDDS (Between 4.5 and 6)	4.6−6	The medium number of food groups consumed by a household
High HDDS (Higher 6)	6.5−12	The high number of food groups consumed by a household
Age of head of household	Year	Age of head of participated household in online sampling
Size of household	Number	The number of members of a household
Head occupation status	1−3	The status of occupation of the head of household with three-level: employed = 1, unemployed = 2, retired = 3
Household income	1−5	The income group of head of household: first quintile = 1, second quintile = 2, third quintile = 3, fourth quintile = 4, fifth quintile = 5
Personal saving	0−1	Whether a household has personal saving in Iranian banks or not; having personal saving = 1, not having = 0
Number of employed members	Number	The number of members who are working
Number of educated members	Number	The number of members who educated at different level
Number of subsidy recipient members	Number	The number of members who receive direct government payment within a household (subsidy)
Mother's occupation status	1−3	1 = unemployed; 2 = permanent employment; 3 = seasonal employment
Number of disease members	Number	The number of members who suffer from a nun-communicable diseases)
Number of male children	Number	Number of male children under 18 years old
Number of female children	Number	Number of female children under 18 years old
Head education status	1−5	The education level of head of household: illiterate = 1, rudimentary = 2; under diploma = 3, university = 4; technical trainings = 5
Gender of head	0−1	gender of head of household: male = 1, female = 2
Nutrition knowledge	1−5	The level of nutrition knowledge which is self-reported: very low = 1, low = 2, medium = 3, high = 4, very high = 5

average number of members within a participated household was 3.48 (SD = 1.31). Over half of the respondents (n = 193, 66%) were employed part-time or casually. The main source of income for almost all the respondents was wages and salaries (permanent wages, salaries, income from self-employment, income from other sources). About forty percent of selected households earned a monthly wage between 28 and 50 million Rials (150−200 US dollars), and only 2% of the total sample earned more than 200 Million Rials/per month. Of the total sample, 55% had personal savings, and about 30% of them rented rather than owned their home.

Almost 63% of mothers in interviewed households were housewives, while 30% of them were employed outside the home. About 52% of breadwinners stated that they have a medium familiarity with the correct principals of nutrition. Finally, the average number of employed, literate, and disease members within the participated households was 1.52, 0.97, and 0.63, respectively.

3.2. Food insecurity

Table 4 shows the HFIAS questionnaire results both before and during the COVID-19 outbreak in Tehran province. The COVID-19 outbreak led to an increase in households' worrying about providing enough food in Tehran province.

There was a significant difference between insufficient quality and quantity of food intake before and during the start of the COVID-19 pandemic. The mean of questions 8 and 9, which show the level of household hunger, was higher in COVID-19 condition compared to before. Food security of households in Iran's Tehran Province improved at the early stage of COVID-19 (P < 0.001), which demonstrates the short-term effect of the pandemic as people gathered provisions in anticipation of reduced opportunities for food shopping. Fig. 4 shows that about 35% of interviewed households were food secure before the COVID-19 pandemic, which increased to 43% during the COVID-19 outbreak. There was a significant difference (p < 0.05) between food security status before and during pandemic new coronavirus disease. The percent of participated households who faced severe food insecurity

decreased from 21% to 17% during COVID-19. There was no significant difference between marginal and moderate food insecurity in COVID-19 pandemic compared to the previous time.

We asked households in Tehran province to report the change of their consumption patterns of food groups, including increasing, decreasing, or fixing due to spreading COVID-19 pandemic. Table 5 presents the change in dietary diversity scores before and during the COVID-19 outbreak. There was a significant difference between the number of households who consumed certain food groups during the COVID-19 pandemic compared to the pre-COVID-19 time. Consumption of white roots and tubers, dark green leafy vegetables, other fruits, organ meat, legumes, nuts and seeds, sweets, spices, condiments, and beverages all declined, despite the household preference express for legumes, nuts, seeds, spices, condiments, and beverages during the COVID-19 pandemic. The experience-based change also confirmed the results of dietary diversity analysis. In fact, we asked households to report the change of their consumption patterns of food groups, including increasing, decreasing, or fixing due to spreading COVID-19 pandemic.

Fig. 5 shows that the greatest difference of consumed food groups between the two distinct times was related to organ meat, white roots, and dark green leafy vegetables. Both before and during the COVID19 outbreak, the lowest consumption was related to other fruits, including wild fruits and 100% fruit juice made from these fruits. On the other hand, the highest level of consumption was related to cereals and vitamin A-rich vegetables at both time points.

Table 6 demonstrates that the relationship between decrease/increase or no change of dietary diversity and food security level due to COVID-19 outbreak. The Chi-square test revealed no significant difference between the change of food security and dietary diversity score during the onset of COVID-19. During the initial spread of the novel coronavirus, 47% of households improved their food security, while 17% experienced worsened food security. Also, 27% of household experienced an increase in dietary diversity score during the COVID-19 outbreak, while 20% of households decreased dietary diversity.

Table 3
Descriptive demographic and socio-economic characteristics of Iranian households in Tehran province.

Variable	Statistical outputs for continuous factors			
	Min	Max	Mean	SD
I. Continuous				
(a). Age of head of household (year)	25	85	47.5	13.47
(b). Size of household	1	9	3.48	1.31
(c). Number of employed members	0	5	1.52	0.89
(d). Number of educated members	0	5	0.97	0.98
(e). Number of disease members	0	8	0.63	1.04
(f). Number of male children	0	3	0.28	0.57
(g). Number of female children	0	3	0.33	0.60
II. Categorical	Statistical outputs for categorical factors			
	Category	Frequency	Percentage	Mode
(a). Household Head occupation status	1−3			
1. Employed		193	66.1	☑
2. Unemployed		33	11.3	
3. Retired		66	22.6	
(b). Household income	1−5			
1. Quintile (1)		79	22.1	
2. Quintile (2)		116	39.7	☑
3. Quintile (3)		68	23.3	
4. Quintile (4)		23	7.9	
5. Quintile (5)		6	2	
(c). Personal saving	1−2			
1. Yes		161	55.1	☑
2. No		131	44.9	
(d). Mother's occupation status	1−3			
1. Employed		87	29.8	
2. Housewife		186	63.7	☑
3. Retired		19	6.5	
(e). Household head education status	1−5			
1. Illiterate		17	5.8	
2. Under diploma		53	18.1	
3. Diploma		60	20.5	
4. University		162	55.6	☑
(f). Residential status	1−3			
1. Rental		88	30.1	
2. Owner		196	63.7	☑
3. Other		18	6.2	
(g). Gender of head	1−2			
1. Male		263	90.1	☑
2. Female		29	9.9	
(h). Nutrition knowledge	1−5			
1. Very low		5	1.7	
2. Low		18	6.2	
3. Medium		152	52.1	☑
4. High		95	32.5	
5. Very high		22	7.5	

Table 4
The brief results of HFIAS questionnaire to assess food insecurity status before and during COVID-19 outbreak in Tehran province of Iran.

Level	Question	Before COVID-19 outbreak					During COVID-19 outbreak					P-value
		Never	Rarely	Sometimes	Often	Mean	Never	Rarely	Sometimes	Often	Mean	
Anxiety and uncertainty	Q1) Worry about food	52.7	26.3	14.3	6.5	0.7	61.6	19.8	10.6	7.8	0.6	0.046
Insufficient quality	Q2) Unable to eat preferred foods	40.7	27.7	21.9	9.5	0.9	51.0	25.6	15.0	8.2	0.8	0.001
	Q3) Eat a limited variety of foods	41.7	27.0	22.9	8.2	0.9	52.0	24.3	14.7	8.9	0.8	0.001
	Q4) Eat foods that you did not want to eat	51.3	28.4	14.3	5.8	0.7	58.9	21.9	11.6	7.5	0.6	0.036
Insufficient food intake	Q5) Eat a smaller meal	55.8	23.6	14.0	6.5	0.7	60.2	21.9	10.9	6.8	0.6	0.049
	Q6) Eat fewer meals in a day	69.1	18.8	7.1	4.7	0.4	74.3	14.7	6.8	4.1	0.4	0.030
	Q7) No food to eat of any kind in the household	81.8	10.2	5.4	2.4	0.2	85.2	8.2	3.4	3.0	0.2	0.035
	Q8) Go to sleep at night hungry	86.9	8.5	3.7	0.6	0.1	87.6	6.1	4.1	2.0	0.2	0.049
	Q9) Go a whole day and night without eating	92.8	4.4	1.7	1.0	0.1	88.0	6.5	2.7	2.7	0.2	0.001

The association of socio-economic factors with food security level and dietary diversity was assessed through multinomial logistic regression. Table 7 shows the results of this model for food security status before and during the COVID-19 outbreak. Breusch-pagan/Cook-Weisberg test confirmed that there was no heteroscedasticity problem in the estimated model (Statistics = 3.15, Sig = 0.075). Before COVID-19, family size, number of educated members, number of household members who have diagnosed chronic diseases, household head's educational status and gender were negatively and significantly associated with food security status. Occupational status of the household head, household income, personal saving, mother's occupation status, and nutrition
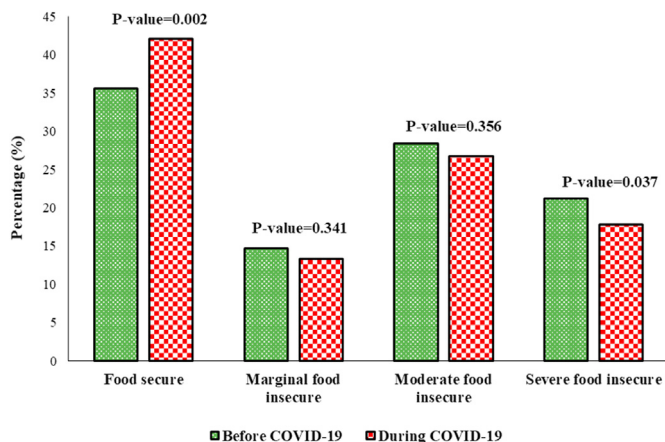
Fig. 4. Food security status of households before and during COVID-19 outbreak in Tehran province of Iran.

knowledge were positively associated with food security level. During the COVID-19 outbreak, household head's age, head's occupation status, income, personal saving, number of male children, and nutrition knowledge were directly associated with the food security, while the number of educated members, number of diseased members, number of female children, renting rather than owning a home, and female headed household had lower food security. We found some factors significantly changed with the onset of the pandemic, including head occupation status, household income, number of subsidy recipient members, number of household members with diagnosed chronic diseases, head's educational status, home tenure status, and nutrition knowledge before and during the COVID-19 virus outbreak.

Table 8 demonstrates that the VIFs of all factors were less than five, indicating no multi-collinearity among independent factors in the dietary diversity model. Breusch-pagan/Cook-Weisberg test confirmed no heteroscedasticity problem in the estimated model (Statistics = 2.54, Sig = 0.111). The multinomial regression model for households' dietary diversity showed that some determinants, including the age of household head, head occupation, number of

educated members, and nutrition knowledge, were directly associated with dietary diversity score before the COVID-19 pandemic. During the COVID-19 outbreak, household size, head's occupation, personal saving, and number of male children were significantly associated with dietary diversity. A significant difference was found between dietary diversity and some parameters, including household size, occupation status, number of disease and educated members, and nutrition knowledge before and during the COVID-19 outbreak.

4. Discussion

This is the first study to evaluate the short-term effect of COVID-19 outbreak on food security and dietary diversity in Iran's Tehran province, using an online survey. We found food security status of this specific sample was improved during the initial COVID-19 outbreak. The food group consumption pattern was changed during COVID-19 outbreak among participating households. Some socio-economic factors were inversely associated with food security and dietary diversity before and during COVID-19, while others were directly associated with food security at both points in time.

During the COVID outbreak, the government issued health policies, including quarantine, isolation, and social distancing, and the closure of some public facilities. Our results may be related to the participating households' effort to purchase and store their needed foods and supplies for a short-term period. Although the FAO confirmed that there is enough food for everyone in Iran (Food and Agriculture Organization, 2020), this situation may change as the pandemic continues. The COVID-19 pandemic has the potential to dramatically disrupt food security, impacting all dimensions of food security from production and supply to accessibility, availability and usage (Laborde et al., 2020). Every day we hear the closure of food production plants due to the virus outbreak and consequent decreased availability and increase in food cost. Our data were collected at the primary phases of the epidemic. As the pandemic progresses, it will reshape society, economy, politics, accessibility and variability of food (Haddad et al., 2020). Household food stocks in Tehran province will be depleted soon, and COVID-19 may also disrupt food supply chains (Reardon et al., 2020). The consequences of pandemic may harm people's

Table 5
Change of diet diversity score of Iranian households before and during the COVID-19 outbreak in Tehran province.

| Row	Food group	Before COVID-19 (Number)	During COVID-19 (Number)	P-value	Experience-based change (Number)		
					Increase	Decrease	Not change
1	Cereals	292	292	0.999	75	19	200
2	Vitamin A-rich vegetables and tubers	289	288	0.252	58	30	206
3−1	White roots and tubers	243	224	0.001	59	91	144
3−2	Dark green leafy vegetables	256	229	0.001	60	103	131
3−3	Other vegetables	284	280	0.321	74	44	178
3	Vegetable	291	285	0.050	-	-	-
4−1	Vitamin A-rich fruits	266	274	0.051	136	40	118
4−2	Other fruits	74	65	0.123	15	67	212
4	Fruits	274	268	0.090	-	-	-
5−1	Organ meat	121	70	0.001	15	128	151
5−2	Flesh meats	284	283	0.325	72	49	173
5	Meats	285	283	0.185	-	-	-
6	Eggs	268	273	0.205	58	46	190
7	Fish	202	183	0.154	41	79	174
8	Legumes, nuts, and seeds	238	253	0.001	118	49	127
9	Milk and milk products	269	266	0.192	70	58	166
10	Oils and fats	259	254	0.091	25	55	214
11	Sweets	267	251	0.001	62	99	133
12	Spices, condiments, and beverages	257	285	0.001	103	31	100
1	Low HDDS (Lower 4.5)	2	5	-	-	-	-
2	Medium HDDS (Between 4.5 and 6)	3	2	-	-	-	-
3	High HDDS (Higher 6)	287	285	-	-	-	-
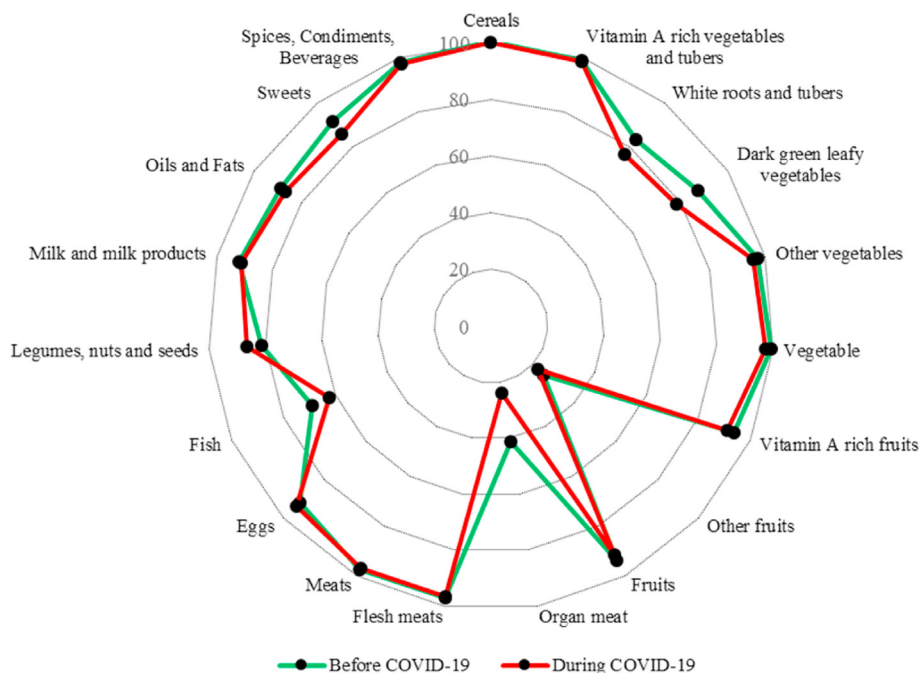
Fig. 5. Percent of households consumed each food group before and during COVID-19 virus outbreak in Tehran province of Iran.

Table 6
The relationship between Dec/increase or not change of food security level and dietary diversity due to COVID-19 outbreak in Tehran province.

Food security change	Number	Percent	HDDS change	Number	Percent
Increase	136	47	Increase	79	27
No change	106	36	No change	155	53
Decrease	50	17	Decrease	58	20

nutrition quality and quantity in a long-term, particularly in at risk population, although the results showed that food quality was not changed during the initial spreading the COVID-19 in Tehran province.

Notwithstanding the early stage of this pandemic and the modest increase in food security level among those who participated in online sampling, the consumption of some food groups has changed. The consumption of vegetable groups decreased during the COVID-19 outbreak, as occurred in Ethiopia (Tamru et al., 2020). This behavior of the participating households may be related to their fear of this food group infecting the household with COVID-19. Thus they sought canned food and avoided perishable foods for sanitation purposes. On the other hand, the households preferred to consume more vitamin A-rich fruits because of their availability and accessibility. These fruits, which could be cleaned with disinfectants and peeled, decreased the anxiety and uncertainty related to consumption of this food group. Consumption of other fruits decreased in Tehran province. Fruits and vegetables demand is very elastic, and COVID-19 is likely to increase fruit and vegetable prices (Reardon et al., 2020), both as a cause and consequence of food shortages. Affordability changes

Table 7
Factors associated with food security before and during COVID-19 outbreak and its' difference using multinomial regression model in Tehran province.

Variable	VIF	Before COVID-19		During COVID-19		Parameter difference (P-value)
		Coefficient	Z	Coefficient	Z	
Household head	2.63	−0.005	−0.31	0.004	2.64***	0.710
Size of household	2.21	−0.057	−9.50***	0.014	0.84	0.321
Head occupation status	1.95	0.166	30.69***	0.059	6.04***	0.002
Household income	1.58	0.116	3.70***	0.150	2.77***	0.041
Personal saving	1.56	0.399	4.97***	0.251	2.70***	0.421
Number of employed members	1.52	−0.175	−1.07	0.356	1.02	0.623
Number of educated members	1.47	−0.231	−6.96***	−0.387	−14.31***	0.132
Number of subsidy recipient members	1.44	−0.283	−4.88***	−0.098	−5.08***	0.001
Mother's occupation status	1.43	0.167	44.4***	0.022	0.33	0.254
Number of disease members	1.34	−0.073	−0.38	−0.108	−5.59***	0.049
Number of male children	1.29	0.045	0.73	0.468	23.45***	0.523
Number of female children	1.24	0.014	0.32	−0.287	−28.94***	0.141
Head's educational status	1.19	−0.231	−6.69***	−0.087	−1.81	0.032
Home status	1.17	0.014	0.21	−0.219	−59.32***	0.001
Gender of head	1.14	−1.36	−1.98**	−0.647	−18.15***	0.161
Nutrition knowledge	1.11	0.324	4.65***	0.340	27.99***	0.001
Constant	1.27	0.380	1.08	−0.777	−0.59	-

*, **, ***: Significant at 10%, 5%, and 1%, respectively.

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Table 8
Factors associated with dietary diversity score due to COVID-19 outbreak using multinomial regression model in Tehran province.

Variable	VIF	Before COVID-19		During COVID-19		Parameter difference (P-value)
		Coefficient	Z	Coefficient	Z	
Age of head of household	2.80	0.007	5.25***	0.067	3.66***	0.010
Size of household	2.53	−0.178	−2.81***	−4.70	−11.41***	0.021
Head occupation status	2.02	0.214	10.00***	2.61	2.88***	0.002
Household income	1.95	−0.087	−0.72	−0.125	−0.30	0.141
Personal saving	1.62	−0.229	−2.56**	1.33	2.91***	0.421
Number of employed members	1.53	−0.149	−1.55	1.05	2.72***	0.623
Number of educated members	1.51	0.037	2.26**	1.10	5.04***	0.032
Number of subsidy recipient members	1.48	−0.732	−5.25***	−1.45	−15.54***	0.001
Mother's occupation status	1.46	0.100	1.31	−0.436	−0.81	0.254
Number of disease members	1.44	−0.347	−18.42***	−0.058	−0.32	0.049
Number of male children	1.43	0.018	0.67	0.903	1.61	0.523
Number of female children	1.39	0.106	1.97**	1.20	5.15***	0.041
Head education status	1.33	−0.316	−2.46**	−0.412	−1.22	0.032
Home status	1.19	0.417	2.95***	−0.148	−0.62	0.001
Gender of head	1.14	−1.41	−4.10***	−1.39	−1.82	0.161
Nutrition knowledge	1.13	0.286	11.86***	−0.175	−1.37	0.001
Constant	1.09	3.71	2.25**	4.22	1.37	-

*, **, ***: Significant at 10%, 5%, and 1%, respectively.

may alter dietary patterns, with consumers preferring cheaper staples or less perishable processed foods (Harris, 2020).

We found that households reduced the consumption of sweets and sugars during the COVID-19 pandemic disease, which may be related to the dietary recommendations showing that eating sugar can weaken the immune system. One of the most common practices during the COVID-19 outbreak in Tehran province is the consumption of warm beverages (tea and herbal-tea), and condiments. Participating households began to consume more legumes, unlike their regular dietary habit. This may be related to the low price and high availability in Tehran province. The high cost of fresh meat, which was caused by weak supply chain and many obstacles in the process of producing and marketing after the COVID-19 outbreak, reduced meat consumption.

Finally, a significant difference between the association of some socio-economic factors with food security was confirmed before and during the COVID-19 outbreak in the study area. Participated households' income and head's occupation were potentially considered as improvers of food security level before and during the new coronavirus. The household's income was significantly and directly associated with food security as expected. Participating households whose income was in the top quintiles were more likely to be food secure than those in the first quintile. This result is consistent with the results of other studies (Adeniyi and Dinbabo, 2019; Hosseini et al., 2017). The household income plays a key role in purchasing food ingredients and preparing the needed dietary mix. The importance of household income during COVID-19 was lower than before this pandemic disease. Most of the households provided the needed foods for their members before the imposition of strict government regulations to control the disease. Food consumption is the most important amusement of families during the quarantine period. The outbreak of the COVID-19 has led Iranian households in Tehran province to conclude that in addition to income, there are other important factors that can improve quality of life (Pei et al., 2018). Occupation of the head of the household was directly associated with food security before and during the COVID-19 pandemic disease in Tehran province, with its association reduced once the pandemic was underway. Due to COVID-19, most occupations and jobs were closed, and people were not allowed to continue their income generating activities. Some studies demonstrate the direct association between the head's occupation and household's food security (Abdullah et al., 2018; Pakravan-Charvadeh et al., 2020, 2015). The number of subsidy

recipient members, which is a proxy for low income households, was inversely associated with food security before and during the COVID-19 outbreak. The households who receive subsidy payments are always sensitive to high expenditures, and COVID-19 conditions prevent most of the poor households from doing different activities, which may impose more costs.

Nutrition knowledge is important to improve the status of food security during an epidemic (Florence and Valstar, 1999). This factor was identified as one of the most immediate needs for people living in a pandemic disease spread (Mengie et al., 2018). The correlation between knowledge of nutrition and dietary diversity in Tehran province suggests the need to increase it among all households. Comparing the parameter of this factor before and during the COVID-19 outbreak in this province demonstrated its importance during this pandemic. Improvement in the level of nutrition knowledge of the head of the household could help a family identify which behavior and reaction are appropriate during the pandemic, and therefore, the greater the effect of this factor on food security and dietary diversity once the virus began spreading.

The number of diseased members increased the probability of being food insecure during the COVID-19 outbreak. Households affected by a chronic disease are nutritionally at risk, as they have difficult access to food. Preserving health status is progressively problematic, especially during a virus outbreak, which imposes more anxiety and uncertainty (Florence and Valstar, 1999).

The results showed that the head's age was directly associated with dietary diversity, and the impact was greater during the spread of COVID-19 compared to before the virus outbreak in Tehran province. Elder household heads may have a greater knowledge of combining different food ingredients properly and be more aware of food quality and food choices. Other scholars have also reported a direct association of the age of the household head and dietary diversity score (Abdulai and Aubert, 2004; Abebaw et al., 2010; Akerele, 2011; Anríquez et al., 2013; Aromolaran, 2004; Migotto et al., 2007; Owusu et al., 2011). As human nutrition plays a key role in the care and management of COVID-19 and is intrinsically linked to immune functions. Improving nutrition knowledge increased the probability of having a high rate of dietary diversity in Tehran province. Some studies contend that a low level of nutrition knowledge led to a decrease in dietary diversity level (Bukusuba et al., 2010).

Recognizing socio-economic factors and nutrition status is important to finding the best ways for coping with the different

harmful effects of epidemic disease such as COVID-19 on health status in a country. Most developing countries faced several economic, financial, social, and political challenges, thus identifying associated factors with food security may help policymakers and nutrition and health experts to manage the catastrophic issues during the COVID-19 outbreak.

4.1. Limitations

This study has several limitations. First, because of the cross-sectional design, this study does not allow to draw causality, despite the use of retrospective data. Second, due to the government's outbreak regulation requiring social isolation, the data were collected through an online survey, which has limitations including potentially misleading and confusing aspects of some questions, vague grading system of some questions, and not having an option for respondents to clarify their answers. Finally, due to outbreak related regulations, we were not able to have representation of all class of society in our sample because of the need for internet access. Our sampling approach likely included mainly families with higher education and income, missing the main at risk population, such as those with low education and income, those with no access to internet, etc. Therefore, our results are affected by this limitation.

5. Conclusion

Understanding the effects of the COVID-19 outbreak on households' food security and dietary diversity status can contribute to governments, internal and international NGOs, health systems, and global organizations to control its negative consequences on people's quality of life. Because of closing most of the occupations, increasing rate of unemployment, and potentially decreasing economic situation with the passing of time, prescribing long-term policies to help households cope with this pandemic disease is inevitable. Sustainable intervention by the government to assure availability and accessibility of food is warranted.

Some government actions may contribute to household dietary diversity to improve food security status, including distributing free food baskets for poor households, extending e-marketing, providing nutrition consultative and encouraging donors to support infected households.

Finally, increasing the level of nutrition knowledge of Iranian people through social media, press meetings, radio and television can contribute to food security and dietary diversity during the COVID-19. Health interventions to reduce the destructive effects of food and economic crisis during the COVID-19 pandemic outbreak as well as policies for sustaining economic status and food security are required in this area. Importantly, populations and countries vulnerable to food insecurity, such as Iran, should be supported — not just in providing medical care, but also support via safety nets and food-based intervention program that have the flexibility to respond to shocks.

CRediT authorship contribution statement

Mohammad Reza Pakravan-Charvadeh: Formal analysis, Methodology, Supervision, Writing - original draft, preparation. **Fatemeh Mohammadi-Nasrabadi:** Data curation, Resources, Validation. **Saeid Gholamrezai:** Data curation, Investigation, Validation. **Hassan Vatanparast:** Methodology, Interpretation, Writing-Reviewing and Editing, Writing - review & editing. **Cornelia Flora:** Conceptualization, Writing-Reviewing and Editing, Writing - review & editing, Validation. **Ashkan Nabavi-Pelesaraei:** Conceptualization, Software, Writing-Reviewing and Editing, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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