ORIGINAL ARTICLE

The association between food insecurity status and COVID-19 in an Iranian population: a case–control study

Sepideh Badri-Fariman[1] · Milad Daneshi-Maskooni[2] · Mahtab Badri-Fariman[3] · Bahram Pourghassem Gargari[4]

Abstract

Aim The 2019 novel coronavirus epidemic (COVID-19) is a highly contagious viral disease with a high rate of morbidity and mortality. Food insecurity has frequently been linked to the emergence of infectious diseases. The present study was conducted to determine the association of food insecurity and socioeconomic status with COVID-19 in the Iranian population.

Subject and methods The study was a case–control study including 248 participants (124 COVID-19-infected people with a positive PCR test and a history of clinical symptoms of COVID-19 and 124 non-infected people with a negative PCR test and no history of clinical symptoms of COVID-19 infection) aged 20 to 60 years. The participants in the two groups were matched based on age, sex, and BMI. Anthropometric and socioeconomic data were collected. Individuals' food insecurity status during the previous 12 months (before the disease for the case group) was assessed using a validated 18-item USDA questionnaire.

Results About 44% of the controls and 76% of the case group were food-insecure ($P < 0.001$). After controlling for any possible confounders, only food insecurity and poor economic level increased the risk of COVID-19, by about three times (OR = 3.10; 95% CI = 1.44–6.68; $P = 0.004$) and 9.5 times (OR = 9.53; 95% CI = 3.73–24.30; $P < 0.001$), respectively.

Conclusion Food insecurity and poor economic status are linked to an increased risk of COVID-19. Future prospective studies are needed to confirm these outcomes and identify the underlying mechanisms.

Keywords COVID-19 · Demographic status · Food insecurity · Iran

Introduction

In late 2019 in Wuhan, China, a novel coronavirus infection epidemic began. Coronavirus disease 2019 (COVID-19), which is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is an extremely contagious

and potentially fatal viral infection. The direct cause of death in this emerging disease is unusually severe pneumonia. However, there are other unusual features that lead to death (Chen et al. 2020; Huang et al. 2020; Wang et al. 2020; Zhu et al. 2020). The pathogen, the host, and the environment all play a role in determining risk factors for the severity of infectious diseases (Mouliou et al. 2021). COVID-19 encompasses a range of disease symptoms, from asymptomatic infection to severe pneumonia. Risk factors related to disease severity include aging, diabetes, immunosuppression, and organ failure (Li et al. 2021). The death rate is estimated at between 1 and 5%, but it varies according to the age and health conditions of infected individuals (Verity et al. 2020).

Food is one of the fundamental needs of human society and an integral part of people's lives, and the provision of adequate food is described by the term "food security" (Shaw 2007). The concept of food security at the household level has been taken into consideration by the efforts of international institutions, including the Food and Agriculture

✉ Bahram Pourghassem Gargari
pourghassemb@tbzmed.ac.ir; bahrampg@yahoo.com

1 Department of Biochemistry and Diet Therapy, Nutrition Research Center, Faculty of Nutrition and Food Sciences, Tabriz University of Medical Sciences, Tabriz, Iran

2 School of Public Health, Jiroft University of Medical Sciences, Kerman, Jiroft, Iran

3 Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran

4 Nutrition Research Center, Department of Biochemistry and Diet Therapy, Faculty of Nutrition and Food Sciences, Tabriz University of Medical Sciences, Tabriz, Iran

Organization (FAO) in the 1980s (FAO 2001). Today, the issue of food security has taken on new dimensions and has become one of the most important discussions in all countries of the world. According to the definition of the World Health Organization (WHO), "food security is the physical and economic access to healthy and nutritious food sufficient to meet the needs and food preferences for an active and healthy life," which includes the availability of healthy and nutritionally sufficient food and the ability and confidence in obtaining acceptable foods through socially acceptable means (Bickel et al. 2006). According to the presented definition, the nutritional status of a household is determined by four factors: (1) availability of food, (2) access to food, (3) stability in supply and accessibility, and (4) safe and nutritious degree of food (Peng and Berry 2019). Lack of food security, or in other words "food insecurity," can cause many socioeconomic issues or have negative effects on people's health, such as weakening the functioning of the immune system (Dorosty 2016; Weigel et al. 2007; Kelly et al. 2018).

In Iran, the overall prevalence of food insecurity in families is estimated between 20 and 60% in different provinces (Alimoradi et al. 2015). Recent studies show the widespread prevalence of food insecurity in Iran, with average prevalence reported to be about 49% (Daneshi-Maskooni et al. 2017).

Only a few studies have assessed the relationship between food insecurity and COVID-19 infection (Escobar et al. 2021; Kimani et al. 2021). In light of the scarcity of data on the subject among Iranians, the objective of this study was to assess and compare the status of food insecurity and socioeconomic status among COVID-19-infected and non-infected people.

Methods

Study design and population

In this case–control study, we examined 248 participants (124 COVID-19-infected patients and 124 non-infected), aged 20–60 years, from North Khorasan province, Iran. The case group subjects were considered infected with the coronavirus if they had a positive polymerase chain reaction (PCR) test together with a history of clinical symptoms of disease. The case group was included in the study if a maximum of 3 months had passed since the onset of the disease. The control group subjects were considered non-infected with the coronavirus if they had a negative PCR test and no history of clinical symptoms of disease. No participant in either group had mental or physical disabilities. The study sample was selected from office workers, factories, administrative departments of universities and hospitals, and those

who were referred to public and private laboratories from March to August 2021.

The exclusion criteria included presenting symptoms or history of COVID-19 infection during the completion of the questionnaires (for the control group) and incomplete answers to questionnaires.

The case and control groups were matched according to their age (divided into four groups of 10 years each: 20–29, 30–39, 40–49, 50–59 years), gender, and body mass index (BMI, based on the WHO definition: underweight, ≤18.5; normal weight, 18.5–24.9; overweight, 25–29.9; obesity class I, 30–34.9; obesity class II, 35–39.9).

For sample size determination, a pilot study was performed on cases ($n = 13$) and controls ($n = 13$). According to the results, food insecurity was experienced by 46% of healthy people and 69% of infected patients. A sample size of 118 was calculated. However, the sample size was increased to 124 in order to ensure reliability and to account for the probability of sample loss.

Data collection

Data on general characteristics (anthropometric and socioeconomic factors) and food insecurity status were collected from all participants using validated and reliable questionnaires through face-to-face interviews after a full explanation of the study's goals and methodology and after receiving written consent.

General characteristics

A generic questionnaire that asked about education, marital status, employment status, number of children, health insurance coverage, whether participants were receiving benefits from public and private organizations, and medical history was used to examine socioeconomic and anthropometric data. Family economic status was assessed using a nine-item questionnaire. A family's economic level was classified as follows: ≤ 3 items as poor, 4–6 items as moderate, and ≥ 7 items as wealthy. A seca scale with accuracy of 0.1 kg was used to weigh the participants when they were wearing light clothing. Height was also measured by a measuring tape with accuracy of 0.5 cm. Then, for each participant, BMI was calculated by dividing the weight by the square of height (kg/m^2). In addition, the waist circumference was measured between the chest and the hips with participants wearing light clothing, with accuracy of 0.1 cm (Taylor et al. 2000).

18-Item food security questionnaire

To assess the status of household food insecurity over the previous 12 months, the 18-item United States Department of Agriculture (USDA) food security questionnaire, which

has already been validated in Iran (Ramesh et al. 2010), was used. The case group was specifically asked about food insecurity before the definitive diagnosis of COVID-19. The participants were stratified into two groups based on their scores from positive answers (score 1) or negative answers (score 0). Answers of "often," "sometimes," "almost every month," "some months," and "yes" were considered positive, and answers of "not correct," "refused" or "did not know," "only once or twice a month," and no" were considered negative." For better comparison, participants were divided into four groups based on the number of positive answers obtained from the questionnaire: score of 0–2, food-secure; 3–7, food-insecure without hunger; , 8–12, food-insecure with moderate hunger; and 13–18, food-insecure with extreme hunger (Table 1).

Statistical analysis

Quantitative and qualitative variables were presented as mean (standard deviation) and frequency (percentage), respectively. In addition, the t-test and chi-square or Fisher's exact test were used for quantitative and qualitative data analysis, respectively. All significant variables in the primary analysis models were entered into the final analysis (multiple logistic regression) to identify independent risk factors for COVID-19. Statistical analyses were performed using IBM SPSS software (version 24). Values were considered significant for $P < 0.05$.

Results

A total of 248 participants who met the study inclusion criteria, including 124 infected patients with COVID-19 as the case group and 124 non-infected participants as the control group, were included in the study (Fig. 1).

According to the data in Table 2 on the food security, anthropometric, and socioeconomic status of both groups, the prevalence of food insecurity was significantly higher in the case group than the control group ($P < 0.001$). Seventy-six percent of infected patients ($n = 94$) had food insecurity,

and approximately 39% of them ($n = 48$) experienced food insecurity with hunger. In contrast, only 44% of the control group ($n = 55$) had food insecurity, and the majority ($n = 42$) had no hunger (Fig. 1).

Table 2 shows that the case group had a significantly poorer economic level and lower education level and house ownership than the control group ($P < 0.05$). There were no significant differences in waist circumference, ethnicity, employment status, insurance support, receiving benefits from public and private organizations, marriage, children and family numbers, or disease history between infected patients and healthy people ($P > 0.05$).

The final analysis model for the association between significant independent risk factors for COVID-19 is presented in Table 3. The odds ratios (OR) and confidence intervals (CI) indicated a significant positive association between the risk of COVID-19 and food insecurity (OR = 3.10, 95% CI = 1.44–6.68; $P = 0.004$) and poor economic level (OR = 9.53, 95% CI = 3.73–24.30; $P < 0.001$) after controlling for the potential confounders.

Discussion

In the present study, the results showed that food insecurity was significantly higher among COVID-19-infected patients than healthy individuals. Moreover, the COVID-19 risk was positively associated with food insecurity and poor economic level even after controlling for any potential confounders (Table 3). We demonstrated that participants with food insecurity and poor economic level had about 3 and 9.5 greater odds of being infected with COVID-19. To the best of our knowledge, this is the first such case–control study in Iran.

We assessed the impact of food insecurity in the previous year on the probability of COVID-19 infection. Based on the results of our study, 76% of COVID-19-infected patients and 44% of non-infected people were food-insecure. In agreement with the results of the present study, an online cross-sectional study showed that Household Food Insecurity Access Scale (HFIAS) scores were significantly higher

Table 1 The status of household food security according to the USDA food insecurity questionnaire

			Code	With children < 18 years old*	Without children < 18 years old**
Household food security/insecurity status	Secure		0	0–2	0–2
	Insecure	Without hunger	1	3–7	3–5
		Moderate hunger	2	8–12	6–8
		Severe hunger	3	13–18	9–10

*Number of positive answers out of 18 items. **Number of positive answers out of 10 items. The maximum score is 18 if both sections were completed.

Fig. 1 Study flowchart
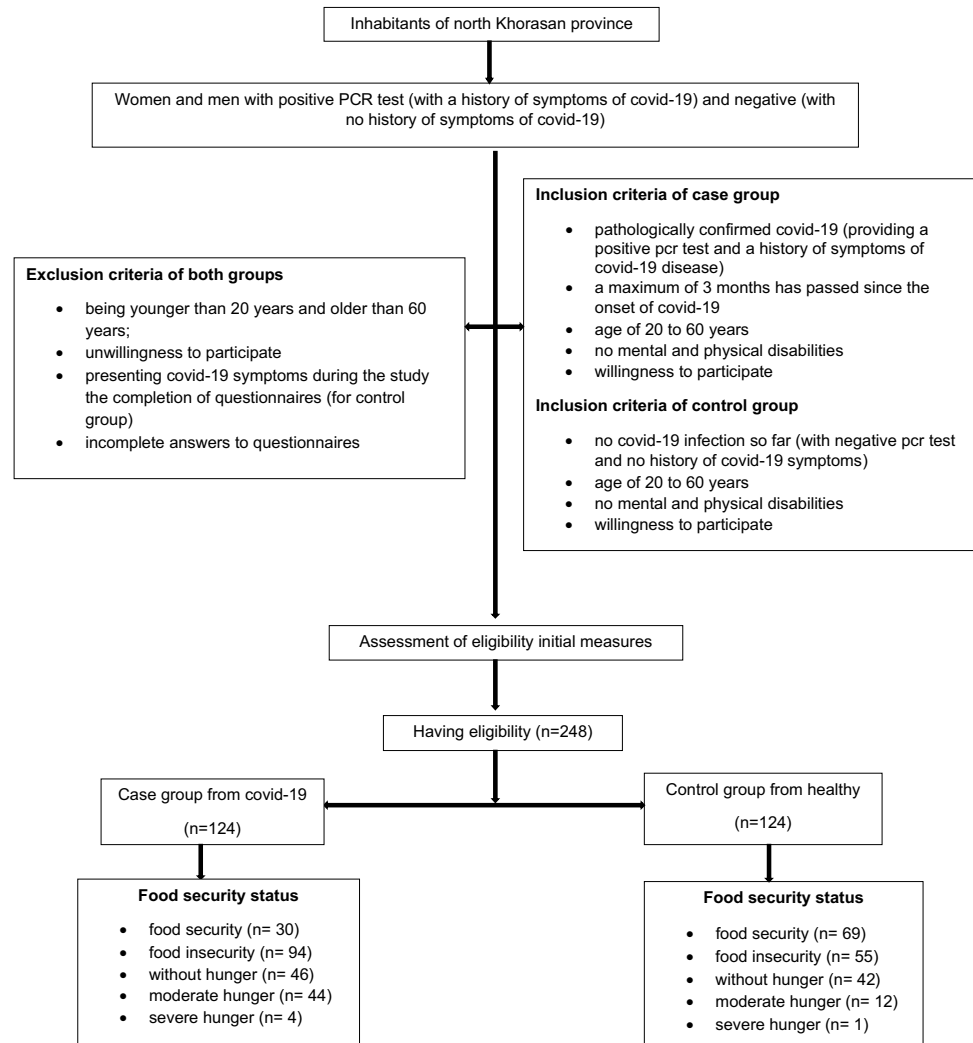
among a COVID-19-infected group than those who were not infected (OR = 1.03, 95% CI = 1.00–1.05; $P < 0.05$) (Kalantari et al. 2021). Escobar et al. in a study on Californians showed that food insecurity score trended towards association with house-hold COVID-19 infection (OR = 1.25, 95% CI = 0.97–1.61) (Escobar et al. 2021). In another cross-sectional study, Kimani et al. reported that the rate of COVID-19 infection in counties of the United States with large black, American Indian, or Alaska Native populations increased as the level of food insecurity increased (Kimani et al. 2021). Also, an Iranian cross-sectional study showed that the probability of being hospitalized for COVID-19 was about four times greater (OR = 3.93, 95% CI = 1.30–11.90; $P < 0.05$) in patients with food insecurity than in food-secure people (Ariya et al. 2021).

Household stress, inflammatory cytokines, and behavioral pathways are three mechanisms by which food insecurity is considered a risk factor for short- and long-term health consequences (Leddy et al. 2020). People with food insecurity, especially women and families with children under 5 years old, are more afraid of contracting COVID-19 than others (Ezzeddin et al. 2022). In addition, lack of access to sufficient food and the expectation of food insecurity are especially toxic stressors. It is possible that the stress and changes in dietary patterns associated with food insecurity cause an inflammatory state and alter immune function in food-insecure individuals that not only increases the risk of chronic diseases, but also increases the risk of facing complications related to infections and greater susceptibility to infections themselves (Suardi et al. 2021). In addition, as shown in a review study, the effectiveness of antiviral drugs in food-insecure patients with HIV is lower than that in food-secure patients (Aibibula et al. 2017).

On the other hand, it has been shown that food-insecure and low-income people are less inclined to stay at home during a pandemic because they are the provider of food and basic family needs (Wolfson and Leung 2020). People who live in households with more severe food insecurity may eat less food or skip meals entirely, thus reducing the essential nutrients available for the proper functioning of the body's

Table 2 Characteristics of the studied subjects in a COVID-19-infected group and non-infected group

Factors			Cases (n= 124)	Controls (n= 124)	P-value*
Food security	Secure		30 (24%)	69 (56%)	**< 0.001[a]**
	Insecure	Without hunger	46 (37%)	42 (34%)	
		Moderate hunger	44 (36%)	12 (9%)	
		Severe hunger	4 (3%)	1 (1%)	
Education level	Bachelor's and higher		70 (56.5%)	88 (71%)	**0.025[a]**
	Less than bachelor's		54 (43.5%)	36 (29%)	
Economic level	Wealthy and moderate		53 (42.7%)	101 (81.5%)	**< 0.001[a]**
	Poor		71 (57.3%)	23 (18.5%)	
Employment status	Employee		70 (56.5%)	74 (59.7%)	0.77[a]
	Free, worker, or other		29 (23.4%)	24 (19.3%)	
	Unemployed		25 (20.1%)	26 (21%)	
Marital status	Married		94 (75.8%)	84 (67.7%)	0.20[a]
	Unmarried or other		30 (24.2%)	40 (32.3%)	
Number of children	0		49 (39.5%)	48 (38.7%)	1.000[a]
	≥ 1		75 (60.5%)	76 (61.3%)	
Waist circumference (cm)			99.12 (±19.96)	97.35 (±15.98)	0.44[c]
Number of family members	≤ 2		33 (26.6%)	27 (21.8%)	0.45[a]
	≥ 3		91 (73.4%)	97 (78.2%)	
House ownership	Personal or free		61 (49.2%)	78 (62.9%)	**0.04[b]**
	Rent or own		63 (50.8%)	46 (37.1%)	
Receiving benefits from public and private organizations	No		110 (88.7%)	114 (91.9%)	0.52[a]
	Yes		14 (11.3%)	10 (8.1%)	
Medical services (health insurance)	No		26 (21%)	18 (14.5%)	0.24[a]
	Yes		98 (79%)	106 (85.5%)	
Disease history	No		75 (60.5%)	86 (69.4%)	0.18[a]
	Yes		49 (39.5%)	38 (30.6%)	

*P-value < 0.05 was considered statistically significant (values shown in bold). Data are mean (± standard deviation) for quantitative variables and number (%) for qualitative variables. [a] Fisher's exact test. [b] Chi-square test. [c] Independent-samples t-test

Table 3 Final analysis of the association of food insecurity and socio-economic risk factors with COVID-19

Factors		OR* (95% CI)	P-value**
Food security	Secure	1	**0.004**
	Insecure	3.10 (1.44–6.68)	
Economic level	Moderate and wealthy	1	**< 0.001**
	Poor	9.53 (3.73–24.30)	
Education level	Bachelor's and higher	1	0.58
	Less than bachelor's	1.35 (0.45–4.02)	
House ownership	Personal or free	1	0.15
	Rent or own	1.72 (0.86–3.64)	

OR odds ratio, CI confidence interval.

*Controlled for potential confounders.

**P-value for multiple logistic regression; P-value < 0.05 was considered statistically significant (values shown in bold).

immune system, which can weaken the host's defense mechanisms and help reduce immunity and subsequently increase susceptibility to infectious and viral diseases (Weigel et al. 2007; Seligman and Berkowitz 2019).

Considering the results of the present study, about 57% of the case group and 19% of the control group were living at a poor economic level. Contrary to the results of the present study, a study in France reported that participants infected with COVID-19 had higher income than non-infected participants (Deschasaux-Tanguy et al. 2021). Also, two other studies did not observe a significant difference in income between COVID-19-infected and non-infected subjects (Mohseni et al. 2021; Kalantari et al. 2021). In the present study, participants were not asked to provide their income level, as people generally do not report their true income. Usually, people who live in poor economic conditions also have low levels in various other aspects such as nutritional status, food security, health status, and other factors, all of which can lead to nutritional deficiencies and subsequently

increase the likelihood of infectious and viral disease, including COVID-19 (Ecob and Smith 1999; Bhattacharya et al. 2004).

Several studies have shown that poor economic level is associated with increased food insecurity (Asadi-Lari et al. 2019; Dastgiri et al. 2006). Food insecurity by itself can disrupt the immune system function and increase susceptibility to infection (Seligman and Berkowitz 2019; Weiser et al. 2011).

There are several major strengths in the present study. First, this case–control study examined the relationship between food insecurity and COVID-19 for the first time in Iran. Second, compared with cross-sectional studies, this study makes it possible to compare COVID-19-infected and uninfected individuals in a case–control design. Third, this study provided a fairly comprehensive review of participants' socioeconomic information and allowed them to be compared. However, our study had some limitations, including a relatively small sample and the risk of dishonesty in completing the questionnaires.

Conclusion

In general, this case–control study has shown that the risk of COVID-19 was positively associated with food insecurity and poor economic level, even after controlling for potential confounders. Further prospective studies with larger sample sizes are needed to confirm our findings and increase our understanding of the association of food security and socioeconomic status with COVID-19.

Data availability The datasets that were used and/or analyzed during the current study are available from the corresponding author on a reasonable request.

Declarations

Ethical consideration and approval The protocol of the study was approved by the Medical Ethics Committee at the Tabriz University of Medical Sciences (Registration No.: IR.TBZMED-REC.1399.1053).

All stages of this research were performed according to the tenets of the Helsinki Declaration.

Ethical statement The authors declare that this manuscript has been submitted to the *Journal of Public Health* only and that they accept all ethical statements of the journal.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Not applicable.

Conflict of interest The authors declare that they have no conflict of interest.

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