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A Long-term Interpretation of the Effect of COVID-19 on Food Security: A Lesson for the Future Pandemic Diseases

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Abstract

Background: The global spread of coronavirus disease (COVID-19) could trigger a food security crisis affecting not only impoverished individuals but also urban residents in low- and middle-income countries.

Objectives: Given that various strains of COVID-19 impact food security differently, we assessed the food security status of households in Semnan province, Iran, during and after the containment of the omicron variant.

Methods: Data from 231 households were gathered using a standard questionnaire that evaluated socioeconomic characteristics, food security based on the U.S. Household Food Security Survey Module, and vulnerability to food insecurity. A quantitative model was utilized to identify factors associated with food insecurity during and post-pandemic.

Results: The findings indicated an improvement in household food security following the management of COVID-19, with significant differences observed in food security levels, especially concerning severe food insecurity, during versus after the COVID-19 period. The quantitative model analysis revealed that, with the exception of the head of household's occupation status, personal savings, and the number of educated and employed members within a household, all variables significantly correlated with food security ($P < 0.05$).

Conclusions: These outcomes highlight how the relationship between socioeconomic factors and food security levels may vary depending on the pandemic's timing, environmental conditions, and household resilience, underlining the importance of adaptive policymaking that responds to current circumstances and the evolving links between socioeconomic determinants and food security.

Keywords: Coronavirus Disease 2019, Food Security, Socioeconomic Factors, Pandemics, Future

1. Background

Food security is defined as the condition where all individuals consistently have access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences, enabling them to maintain active and healthy lives (1). Conversely, food insecurity (FINS) emerges due to a variety of factors, including poverty, poor health within households, and inadequate management of livelihoods and household resources. The severity and categorization of food insecurity depend on how household members perceive and prioritize their spending on food (2). Currently, over 821 million people worldwide face hunger every night, attributed to governmental conflicts, such as those in Ukraine, Syria, Yemen, and Afghanistan, along with climate change and human-induced economic downturns. The coronavirus disease (COVID-19) pandemic has exacerbated this issue (3, 4), pushing over 100 million people into severe and extreme hunger. The International Food Policy Research Institute (IFPRI) has, for the first time during the COVID-19 pandemic, issued a warning that without appropriate actions, COVID-19 could precipitate a food security crisis. The pandemic has hit the vulnerable poor hardest, adding a new demographic to the global hunger population,

including urban residents in low- and middle-income countries (5, 6).

While global hunger has traditionally been viewed as a rural issue, COVID-19 has had a disproportionate impact on urban areas in developing countries, exacerbating existing food shortages and heightening the risk of food insecurity. This situation is aggravated by natural disasters such as floods and droughts, along with market forces that elevate food prices (5).

The pandemic has resulted in significant income losses, especially for those in vulnerable groups, such as informal workers and individuals who have been terminated from their jobs. Disruptions in food production and distribution, including market closures and restrictions on transportation, have further exacerbated food insecurity. Those living in slums, homeless individuals, and people with chronic illnesses are especially at risk of food insecurity due to a combination of biological and socioeconomic factors (5). Additionally, the threat of severe illness and death from COVID-19 is higher among those who are malnourished or facing moderate to severe food insecurity, as poor immune function can heighten the risk of complications and the spread of infectious diseases (5).

Addressing these challenges necessitates that governments devise robust and unified strategies to accelerate COVID-19 vaccination campaigns and establish a resilient food system. Understanding the various aspects of the disease and its potential impact on food security and dietary diversity within specific populations is crucial (7). While some research suggests that the COVID-19 outbreak has significantly affected food security, other studies argue that there is no substantial link between these issues (2, 3, 5, 6, 8-24).

Pakravan-Charvadeh et al. (21) emphasized the importance of categorizing the study duration into short, mid, and long-term periods before evaluating the impact of COVID-19 on food security levels. They suggested that the effects of COVID-19 on food security are likely to differ depending on the duration of the study. Furthermore, it was proposed that various strains of COVID-19, such as delta and omicron, might have distinct impacts on food security, warranting further investigation. The objective of this research was to evaluate the food security status of the Iranian population during the omicron outbreak in Semnan province.

2. Objectives

This study sought to assess the food security status of the Iranian population amid the omicron outbreak in Semnan province. This rapid assessment aimed to identify the critical needs of the population, which could inform the development of targeted programs, particularly for households facing food insecurity in Semnan province, Iran. To fulfill these goals, the study was organized into multiple sections. The following section detailed the materials and methods, including the study location, population, sample size, and analytical approaches used. The results section then provided a descriptive analysis and quantitative models. Finally, the discussion offered an interpretation of the findings and proposed policy recommendations.

3. Methods

3.1. Study Location

This study, designed as a cross-sectional survey, was conducted in Semnan province, located on the alluvial fan of Golrudbar Creek in north-central Iran, home to approximately 702,000 residents. The province spans 96,816 square kilometers, nestled south of the Alborz Mountain range and north of the Kavir plain.

3.2. Study Sample and Data Collection Process

Data collection was facilitated through a structured questionnaire at the study site. Employing the Cochran formula, 231 households were randomly selected between December and April 2022. The questionnaire comprised three parts: The first section detailed households' socioeconomic characteristics; the second focused on a food security survey based on the U.S Household Food Security Survey Module; and the third section featured questions derived from the literature to assess an indicator of households' vulnerability to food insecurity (21). Six trained experts conducted the questionnaire remotely using an online platform, both before and during the COVID-19 pandemic. Following the assessment of food insecurity severity across these periods, the study explored the correlation between socioeconomic factors and household food insecurity in Semnan province. Before data collection, the validity of the questions in the third section was verified by a panel of experts, including an agricultural economist, psychologists, public health and social science professionals, as well as three nutritionists. A pilot study with 20 households in the target area was carried out to minimize errors in questionnaire completion. Additionally, interviewers from the public health department underwent a two-day workshop to ensure

uniformity and minimize inter-personal variations during the data collection process, with questionnaires completed via face-to-face interviews with household heads.

3.3. Food Security Analysis

The Household Food Insecurity Access Scale (HFIAS) is adapted from the methodology currently utilized in the United States for estimating household food insecurity at both household and national levels. It serves to gauge the extent of a household's concerns about food insecurity (25). The HFIAS questionnaire comprises nine questions aimed at evaluating household food insecurity over the span of one month (4 weeks). This tool assesses three distinct aspects of household food security (26, 27): The initial question addresses the household's uncertainty and worries about securing needed food; questions 2 to 4 focus on the quality of household food, including dietary diversity and food preferences; and questions 5 to 9 cover food consumption and its physical implications (28, 29). Through the HFIAS index calculation, food security status is categorized into four levels: Food secure, marginally food insecure, moderately food insecure, and severely food insecure. The index ranges from 0 to 27, where 0 indicates the highest level of food security and 27 denotes severe food insecurity (25).

3.4. Quantitative Model

The logit function is mathematically tied to the standard logistic distribution and finds extensive application in data analysis and machine learning, particularly for data transformation. Logistic regression is employed to depict the relationship between a categorical outcome (response factor) and a set of predictor variables. The categorical outcome might be binary (e.g., the presence or absence of an event) or ordinal (e.g., mild, marginal, and severe categories). Predictor variables can be either continuous or categorical. Mathematically, the logit is the inverse of the standard logistic function $\sigma(x) = \frac{1}{(1+e^{-x})}$; thus, the logit is defined as:

$$\text{Logit}(p) = \sigma^{-1}(p) = \text{Ln}\left(\frac{p}{1-p}\right) \; for \; p \in \left(0,\ 1\right) \qquad (1)$$

The parameters of the Logit Model are determined using the maximum likelihood estimation method, which stands as the predominant approach for estimating the Logit Model. Consequently, the logit function converts probability values ranging from (0, 1) to real numbers in (-∞, +∞), operating similarly to the probit function (Figure 1) (27-30).

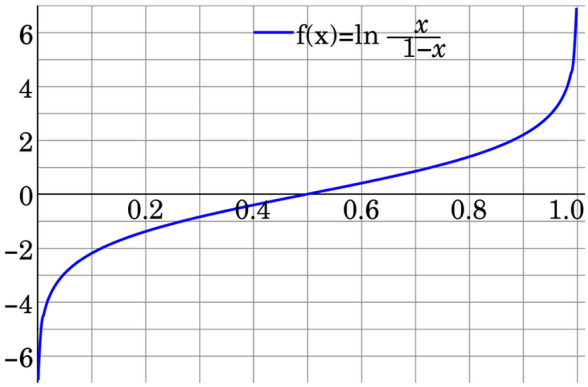

Figure 1. The plot of logit(p) in the domain of 0 to 1, where the base of the logarithm is e.

4. Results

The descriptive analysis of socio-economic factors revealed that 88% of household heads are male, with females constituting only 12%. The majority of household heads (64%) have attained university-level education, while 21% hold a diploma. Regarding employment status, 73% of the sample were employed, and 21% were retired. As for mothers' occupational status, approximately 54% were homemakers, and 39% were employed outside the home. Nearly 78% of participating households owned their homes, and 57% lacked personal savings in either government or private banks. Additionally, 71% of the households reported not receiving any form of government subsidy support, such as financial aid or food packages.

In terms of continuous variables, the study found that the average age of household heads was 46 years, with the oldest being 83 years old. Household sizes ranged from 1 to 8 members, with an average size of 3.4 (Table 1).

The descriptive analysis indicated that households had an average of 0.73 sick members and 1.03 educated members, with typically more than one individual working within each household.

The evaluation of the food security levels among participating households showed that food security status post-COVID-19 improved compared to during the disease outbreak, with this difference being statistically significant. While the percentage of households experiencing marginal and moderate food insecurity

Table 1. Descriptive Analysis of Socio-Economic Factors at the Study Location

Discrete Factors and Category	No. (%)	Mode
Gender of the HH		
Male = 1	205 (88)	✓
Female = 2	26 (12)	
The education level of the HH		
Illiterate = 0	3 (1)	
Under diploma = 1	32 (14)	
Diploma = 2	48 (21)	
Collegiate (academic) = 3	148 (64)	✓
Occupation of the HH		
Unemployed = 0	11 (4.7)	
Employed = 1	170 (73.6)	✓
Retired = 2	50 (21.7)	
Occupation of the MH		
Employed = 0	90 (39)	
Housewife = 1	126 (54.5)	✓
Retired = 2	15 (6.5)	
The status of home ownership		
Rental = 0	51 (22)	
Personal = 1	180 (78)	✓
Personal saving		
Not having = 0	98 (42.5)	
Having = 1	133 (57.5)	✓
Government subsidy support		
Not receiving = 0	67 (29)	✓
Receiving = 1	164 (71)	
Continuous factors and scale	**Min - Max**	**Mean**
Age of the HH (y)	23 - 83	46.5
Household size (N)	1 - 8	3.4
Number of sick members (N)	0 - 4	0.73
Number of educated members (N)	0 - 4	1.03
Employed members (N)	0 - 4	1.45

Abbreviation: HH, heads of households.

decreased following the omicron variant, the proportion of households facing severe food insecurity remained unchanged across both periods (Figure 2).

Table 2 displays the statistical analysis comparing the relationship between socioeconomic factors and food security during versus after the COVID-19 pandemic. The findings reveal that with the exception of the head of the household's occupation status, personal savings, and number of educated and employed members within a household, all other factors were significantly related to food security. These outcomes suggest that the impact of various socioeconomic factors on food security levels may vary with the pandemic's timeline, environmental conditions, and household resilience. For example, while the male gender of a household head was positively and significantly related to food security during the COVID-19 outbreak, it did not significantly influence food security after the pandemic. These findings emphasize the need for policymakers to tailor their strategies to the prevailing circumstances, adjusting their focus on relevant factors as conditions evolve.

5. Discussion

In this research, we conduct a comprehensive long-term evaluation of how the COVID-19 pandemic affected food security, aiming to derive insights applicable to future outbreaks. The study progresses through multiple phases. Initially, a descriptive analysis of socio-economic factors within the study area is performed. This analysis shows that the heads of the majority of

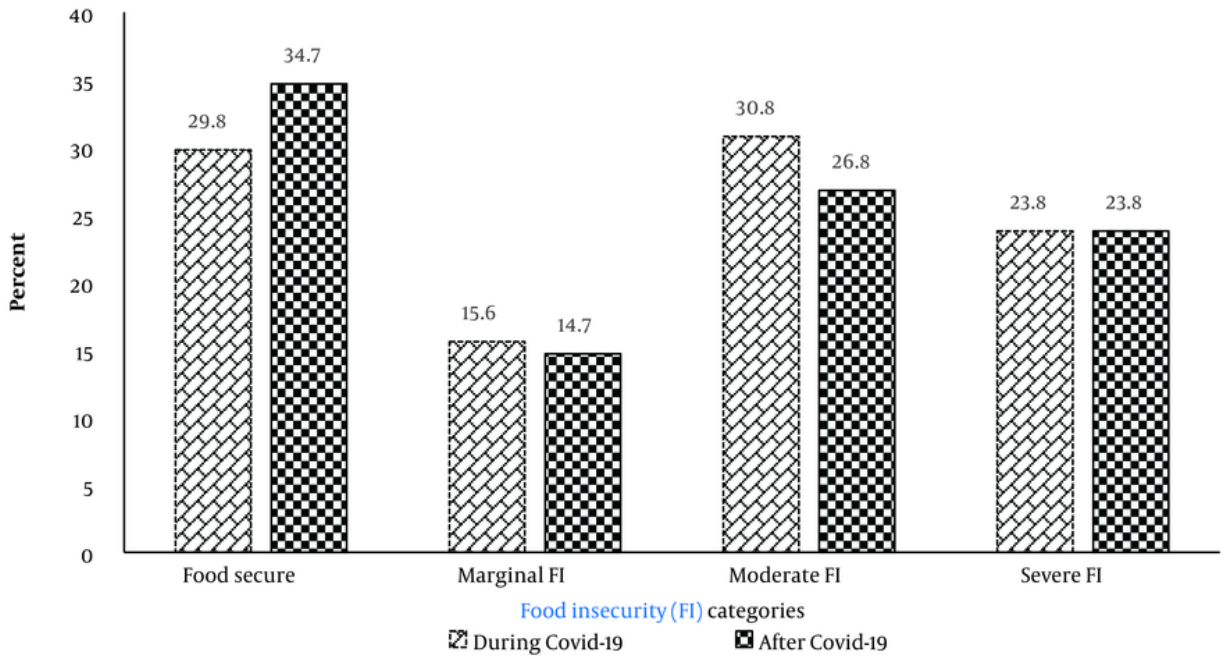

Figure 2. The status of food security level during omicron and after finishing the outbreak

households are of middle age, suggesting they have the requisite knowledge and experience to manage during a pandemic. Following this, the study examines the food security status of households both prior to and following the outbreak of COVID-19. Over time, there was a noticeable improvement in the food security status among Iranian households, a change that can be linked to various factors. Pakravan-Charvadeh et al. highlighted an enhancement in food security among Iranian households shortly after the commencement of the Coronavirus pandemic (21).

One primary observation was that at the start of the pandemic, households were initially unprepared and lacked critical information about the disease, which led to inefficient financial management (3, 21).

Over time, households learned to better allocate their income towards improving nutrition. Additionally, as more information about COVID-19 control measures and reducing transmission risk became available, households could repurpose funds from non-essential expenses to essential food purchases, thereby enhancing food security. Furthermore, the pandemic-induced shifts in dietary patterns, influenced by television and social media health and nutrition promotion programs, along with health authority initiatives, likely contributed to improved food security. Initially, the pandemic led to significant job losses and financial strain due to government-imposed lockdowns, resulting in decreased food security (7, 21). However, post-pandemic recovery allowed many individuals to resume employment and sustain their households, improving food security levels. Pakravan-Charvadeh et al. highlighted an increase in food security among Iranian households shortly after the onset of the coronavirus (21).

The study's second phase underscores the distinct socio-economic factors influencing food security during versus after the COVID-19 pandemic, aligning with findings from other research (31, 32). The employment status of household heads significantly correlated with food insecurity during the pandemic but was inversely related post-pandemic, underscoring the importance of stable employment in maintaining household income and food supply. Pandemic-related restrictions hindered work opportunities for many, escalating stress and anxiety levels (21). Moreover, the study confirmed that government subsidies effectively mitigated food insecurity, though this support was not directly linked to food insecurity levels. Government assistance was crucial in addressing food insecurity in a developing

Table 2. The Results of the Quantitative Model to Determine the Associated Factors with Food Insecurity

Factors	During		After		Parameter Difference (P-Value)
	Coeff [a]	Z	Coeff [a]	Z	
Gender of the HH	0.648 **	2.59	0.293	0.86	0.001
The education level of the HH	0.006	0.09	-0.263 *	-2.16	0.020
Age of the HH	-0.04 **	-4.58	-0.019 **	-4.65	0.090
Occupation of the HH	0.256 **	77.71	-0.144 **	-2.82	0.120
Occupation of the MH	0.165	1.60	0.860 **	90.65	0.020
The status of home ownership	-0.493 *	-2.26	-0.719 **	-3.40	0.080
Personal saving	-2.681 **	-44.78	-2.046 **	-36.84	0.230
Government subsidy support	-0.223 **	-10.60	0.126	0.70	0.001
Household size	0.738 **	12.01	0.441 **	6.62	0.091
Sick members	0.371 **	7.74	0.012	0.07	0.036
Educated members	-0.138 **	-6.05	-0.102 **	-4.74	0.241
Employed members	-0.154	-2.98	0.188 **	11.89	0.130
Constant	-3.183	-1.35	-2.269	-0.83	0.109

Abbreviations: HH, heads of households; Coeff, coefficient.

[a] Signs (**, *) indicate significant at 10% and 5% respectively.

country amidst a pandemic, serving as a vital substitute for the lost income of many household heads during the COVID-19 crisis (21).

During the COVID-19 pandemic, the presence of sick individuals in households was positively linked to food insecurity, a correlation that diminished once the pandemic was controlled (6). In Iran, where medical expenses are high, an increase in sick household members necessitated a reallocation of household spending from food to medical needs, heightening the risk of food insecurity for these families (33).

Self-reporting surveys, while cost-effective and convenient, present inherent limitations. They depend on the respondents' subjective assessments, reflecting personal perceptions of food insecurity. In this study, the focus on the quantity of meals consumed during quarantine failed to account for how food was obtained. Conducted within a specific demographic, this cross-sectional study underscores the importance of broader governmental research due to its limitations.

This research delved into the long-term effects of COVID-19 on food security, finding an overall improvement post-pandemic. Besides the occupation of household heads, personal savings, and the presence of educated and employed members within households, all variables were significantly linked to food security. With 65% of households in the province experiencing food insecurity, there's a pressing need for immediate measures such as government aid, distribution of support packages to the needy, and healthful eating campaigns on television. Educating households on the potential of future pandemics could enhance preparedness for such events. It is advised that educational initiatives be initiated and information on epidemic readiness be distributed. Our study showed that socioeconomic factors' impact on food insecurity varied at different stages of the COVID-19 pandemic. Understanding these dynamics in relation to the pandemic's timeline is vital for crafting effective health policies. The employment status of household heads was a notable determinant of food security after the pandemic, suggesting that policy interventions could include easing business operations, offering temporary tax breaks, and providing low-interest, long-term financing. Additionally, our findings stress the importance of supportive policies during pandemics, such as both conditional and unconditional cash grants, unemployment benefits, better access to credit, food aid, and price regulation, to robustly address food insecurity.

Footnotes

Authors' Contribution: Malihe Sadeghi and Atefeh As'habi participated in the collection and analysis of data. Atefeh As'habi drafted the manuscript. All authors contributed to the conception and design of the study and approval of the final version of the article.

Conflict of Interests: We declared that two of our authors (Atefeh As'habi and Elahe Ghods, reviewers) are of the editorial board. The journal confirmed that the

authors with CoI were excluded from all review processes.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication. The data are not publicly available due to compliance with ethical issues and maintaining confidentiality.

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