



## Household Food Insecurity Scores Are Higher among Adults Infected with COVID-19: A Cross-Sectional Online Study among an Iranian Population

Naser Kalantari<sup>1</sup>, Hassan Eini-Zinab<sup>1</sup>, Neda Ezzeddin<sup>2\*</sup>, Nastaran Miri<sup>3</sup>

<sup>1</sup> Department of Community Nutrition, National Nutrition and Food Technology Research Institute, and Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

<sup>2</sup> Department of Community Nutrition, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

<sup>3</sup> Department of Nutrition, Faculty of Health, Qazvin University of Medical Sciences, Qazvin, Iran.

### ARTICLE INFO

#### ORIGINAL ARTICLE

#### Article History:

Received: 17 August 2021

Accepted: 20 October 2021

#### \*Corresponding Author:

Neda Ezzeddin

Email:

Neda.ezzedin@yahoo.com

Tel:

+982122077424

#### Keywords:

COVID-19,

Pandemics,

Health Personnel,

Food Insecurity.

### ABSTRACT

**Introduction:** Food insecurity has negative impacts on health, including the function of the immune system. The association between food insecurity and COVID-19 infection rates has not been fully understood. This study aimed to examine whether food-insecure households are more vulnerable to COVID-19 infection.

**Materials and Methods:** This online cross-sectional study was conducted on 2,871 Iranian adults (31 provinces), from August to September 2020. Demographic and socio-economic information was collected using a questionnaire. The Household Food Insecurity Access Scale (HFIAS) was used for assessing household food insecurity. The data analysis was performed by SPSS.22, using Chi-square test, ANOVA test, and Multinomial Logistic Regression Model.

**Results:** The findings indicated that healthcare personnel were at higher risk of COVID-19 (CI = 1.90, 7.05; OR = 3.66; P < 0.001). It was also shown that HFIAS scores were significantly higher among infected people compared to non-infected (CI = 1.00, 1.05; OR = 1.03; P < 0.05). Women were at lower risk of infection compared to men (CI = 0.41, 0.87; OR = 0.60; P < 0.05).

**Conclusions:** Based on the results, in addition to long-term policies to improve food security, policymakers are recommended to implement short-term policies to reduce the vulnerability of the community to COVID-19 virus.

**Citation:** Kalantari N, Eini-Zinab H, Ezzeddin N, et al. *Household Food Insecurity Scores Are Higher among Adults Infected with COVID-19: A Cross-Sectional Online Study among an Iranian Population*. J Environ Health Sustain Dev. 2021; 6(4): 1449-58.

### Introduction

The novel COVID-19 virus has had consequences on people's lives all over the world<sup>1</sup>. These effects include not only physical and mental health<sup>2</sup>, but also other risk factors<sup>3</sup> and economic status<sup>4</sup>. Many people, especially those who were self-employed, lost their jobs or suffered a decline in income<sup>5</sup>. The pandemic has also

disrupted food supply chains, including production, processing, distribution, and demand<sup>4</sup>. This has led to reduced access to healthy foods,<sup>6</sup> and/or increased food prices<sup>7</sup>. Unfortunately, these conditions were accompanied with increased food insecurity around the world<sup>7,8</sup>.

Food insecurity is a condition in which people do not have physical, social and/or economic

access to sufficient, safe and nutritious food<sup>9</sup>. Based on various international studies, a rise in food insecurity has been reported, specifically among socio-economically vulnerable populations. In a cohort study among low-income African-Americans, an 80% increase in food insecurity was seen in the first weeks of the outbreak, and government food aid had little effect on reducing it<sup>10</sup>. Another study in an Italian population found that food insecurity doubled during the COVID-19 outbreak<sup>11</sup>. Similar studies have been conducted in other countries, such as Mexico<sup>12</sup>, Brazil<sup>13</sup>, and Iran<sup>14</sup>.

Food insecurity has negative impacts on health<sup>15</sup>, including the function of the immune system<sup>16,17</sup>. The consumption of a healthy and nutritious diet, which is essential for better immune function<sup>18</sup>, is less common in food-insecure households<sup>19</sup>. In a study conducted by Larson among adults in Minnesota, reduced food security was associated with lower consumption of healthy foods, such as fruit and vegetables, and higher consumption of calorie-rich fast foods and snacks<sup>20</sup>. In another study among Brazilian favelas, a 46% decrease was also seen in the consumption of healthy and nutritious food<sup>13</sup>. Psychologically, higher levels of mental illness, including perceived stress, are experienced in food-insecure households<sup>21</sup>, which may also be associated with impaired immune response<sup>22</sup>.

There are various studies among Iranian populations which have tried to assess food insecurity status during the COVID-19 pandemic. For instance, one study was conducted among rural households in Dashtestan county, Bushehr province, by Yazdanpanah et al.<sup>23</sup>; another among households from community health centers in Kerman province by Tezerji et al.<sup>24</sup>; and among a population in Tehran by Pakravan-Charvadeh<sup>14</sup>. These studies only reported food insecurity prevalence and determinants, but not its associations with COVID-19 infection rates. However, there are limited studies which have assessed this relationship<sup>25,26</sup>. Given the novelty of COVID-19, the aim of the current study was to examine whether food-insecure households are

more vulnerable to COVID-19 infection. The results of this study will help policymakers and decision-makers to adopt evidence-based policies to fight such pandemics, by outlining the dimensions of vulnerability to infection.

## Materials and Methods

### *Study design, population, and data collection*

An online cross-sectional study was performed among Iranian adults (the age of over 18 years) across the whole country (31 provinces).

The inclusion criteria were the age of over 18 years; living in Iran; and interest in participating. The exclusion criteria included incomplete data of participants.

The minimum sample size in this study was calculated using OpenEpi software version3 (<http://www.openepi.com/SampleSize/SSPropor.htm>), based on the prevalence of food insecurity reported in a systematic review (49%),<sup>27</sup> with a 95% confidence interval (N = 384). In order to reduce the online sampling error, the minimum sample size was considered for each region (in total, five regions) of the country. According to a national division by the Ministry of Interior, the provinces were divided into five districts, based on criteria, such as proximity, geographical location, and commonalities. The regions were as follows: 1. Tehran (7 provinces), 2. Isfahan (6 provinces), 3. Tabriz (6 provinces), 4. Kermanshah (6 provinces), and 5. Mashhad (6 provinces).

The participants consisted of 2,871 Iranian adults who were invited to participate via popular social networks, such as Telegram Messenger, WhatsApp Messenger, and Instagram (between August and September 2020). Due to the vastly increased use of the internet during recent years in Iranian populations (1), high levels of access to social networks can be assumed.

The data were collected by electronic questionnaire and availability sampling methods. Research information (including research subject, inclusion criteria, and ethical and privacy considerations) were mentioned in the invitation text. The participants were connected to the questionnaire by clicking on the link provided in

the invitation text. The questionnaire was hosted on a private website (<https://porsall.com/>). The informed consent for participation in the study was provided on the first page of the questionnaire, and the participants began to answer the questions if they agreed. The participants were also told that they could drop out at any time. Sampling was carried out until the minimum sample size was collected from each region. When data collection was completed, an Excel output was downloaded from the user page in the website.

### **Measurements**

#### **General information**

This questionnaire contained demographic (age, sex, and family size), socio-economic (educational level, job, and family monthly income), and COVID-19-related health status (infection status and perceived COVID-19 prevention score).

The participants were asked to choose their infection status to COVID-19, including 1. I have been infected (Diagnosis by a physician using PCR test or CT scan tests of the lungs); 2. I have had a suspected infection (Definite infection of someone in close contact; or signs of disease without a diagnostic test in participants); and 3. None of these conditions (considered as non-infected). They were also asked to score their preventive behaviors (frequent hand washing, wearing a mask, keeping social distance, not attending closed public places, not leaving home except when necessary, etc.) against COVID-19. The range of this score was between 1 (lowest) and 10 (highest), and was termed “perceived COVID-19 prevention score” in this study. The questionnaire was designed based on the study goals, and assessed by four experts (in the fields of community and clinical nutrition; and demographics) to ensure content validity.

#### **Household food security assessment**

Household Food Insecurity Access Scale

(HFIAS) is a 9-item questionnaire used in examining household food security status. There are four options for each item, which assess the frequency of incidence and are rated on a Likert scale (most of the time = 3, sometimes = 2; rarely = 1; and no = 0). The higher total scores of the questionnaire, the greater the food insecurity level. Two examples of questions are as follows: “Did you or any household member eat just a few different kinds of food daily due to the lack of resources?” or “Did you or any household member go a whole day without eating because there was not enough food?”. Mohammadi et al. developed a standard Persian questionnaire, with acceptable validity and reliability (Cronbach's alpha = 0.85)<sup>28</sup>. This validated questionnaire was used in the current study.

#### **Statistical analysis**

The analysis of data was done by IBM SPSS software, Version 22.0, using Chi-square test, ANOVA test, and Multinomial Logistic Regression model. P-values of less than 0.05 were considered significant. The assessment of data normality was also checked by Kolmogorov–Smirnov test.

#### **Ethical Issue**

This research was approved by the Ethics Committee of the National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences (Ethics code: IR.SBMU.nnftri.Rec.1399.028).

#### **Results**

The general information of participants is provided in Table 1. The prevalence of women (82.8%) was much higher than men (17.2%), so before the data were analyzed, sex weighting was carried out based on the census data of the Statistics Center of Iran (103 men for every 100 women).

**Table 1:** General information of the participants

Quantitative variables	(Mean ± SD <sup>a</sup> )
Age	32.99 ± 8.31
Family size	3.49 ± 1.29
Perceived prevention score	7.73 ± 1.98
HFIAS <sup>b</sup> score	3.60 ± 5.36
Qualitative variables	N (%)
Educational level	
<i>Diploma and lower</i>	621(21.6)
<i>Associate degree and bachelor</i>	1352(47.1)
<i>Masters' degree and higher</i>	897(31.3)
Occupation	
<i>University student</i>	377(13.1)
<i>Housewife</i>	511(17.8)
<i>Employee</i>	709(24.7)
<i>Healthcare personnel</i>	223(7.8)
<i>Manual worker</i>	210(7.3)
<i>Self-employed</i>	539(18.8)
<i>Other</i>	302 (10.5)
Monthly household income	
<i>Under 1800000 Rials</i>	494(17.2)
<i>1800000-3600000 Rials</i>	621(21.6)
<i>3600000-5400000 Rials</i>	670(23.3)
<i>5400000-7200000 Rials</i>	408(14.2)
<i>More than 7200000 Rials</i>	679(23.6)
COVID-19 infection status	
<i>Infected</i>	187(6.5)
<i>Suspected</i>	512(17.8)
<i>Not Infected</i>	2172(75.7)
Living regions	
<i>Tehran region <sup>c</sup></i>	1088(37.9)
<i>Isfahan region <sup>d</sup></i>	509 (17.7)
<i>Tabriz region <sup>e</sup></i>	466 (16.2)
<i>Kermanshah region <sup>f</sup></i>	419 (14.6)
<i>Mashhad region <sup>g</sup></i>	388 (13.5)

<sup>a</sup> Standard Deviation

<sup>b</sup> Household Food Insecurity Access Scale

<sup>c</sup> Includes provinces: Tehran, Alborz, Golestan, Mazandaran, Qazvin, Qom, Semnan

<sup>d</sup> Includes provinces: Bushehr, Chaharmahal and Bakhtiari, Fars, Hormozgan, Isfahan, kohgiluyeh and BoyerAhmad

<sup>e</sup> Includes provinces: Ardabil, East Azerbaijan, Gilan, Kordestan, West Azerbaijan, Zanjan

<sup>f</sup> Includes provinces: Kermanshah, Hamedan, Ilam, Khuzestan, Lorestan, Markazi

<sup>g</sup> Includes provinces: Kerman, North Khorasan, Razavi Khorasan, South Khorasan, Sistan and Baluchestan, yazd

**ANOVA test**

Table 2 indicates the results of the one-way ANOVA test. Mean age and family size were significantly different between the three groups (P < 0.05) (Table 2). The mean perceived prevention

score was statistically higher among the non-infected group (P < 0.001). The mean score of HFIAS was also higher among the infected group, compared to the suspected and non-infected groups (P < 0.05).

**Table 2:** Comparison of quantitative and qualitative variables in three groups of COVID-19 infection status

Quantitative variables	COVID-19 infection status			P-value <sup>b</sup>
	Infected Mean ± SD <sup>a</sup> (n = 187)	Suspected Mean ± SD (n = 512)	Non-infected Mean ± SD (n = 2172)	
Age	32.7 ± 6.6	32.1 ± 7.6	33.1 ± 8.5	0.045
Family size	3.4 ± 1.3	3.6 ± 1.41	3.4 ± 1.2	0.047
Perceived prevention score	7.4 ± 2.1	7.3 ± 2.0	7.8 ± 1.9	<0.001
Household food insecurity score	4.5 ± 6.4	3.6 ± 5.1	3.5 ± 5.3	0.034
Qualitative variables	Infected N(%)	Suspected N(%)	Non-infected N(%)	P-value <sup>c</sup>
Gender				
Women	68(4.8)	248(17.6)	1090(77.5)	0.001
Educational level				
Diploma and lower	44(7.1)	110(17.7)	467(75.2)	
Associate degree and Bachelor	91(6.7)	241(17.8)	1021(75.5)	
Masters' degree and higher	51(5.7)	162(18)	685(76.3)	0.883
Occupation				
Student	11(2.9)	84(22.3)	281(74.7)	
Housewife/househusband	24(4.7)	100(19.6)	387(75.7)	
Employee	58(8.2)	116(16.3)	536(75.5)	
Healthcare personnel	31(13.9)	39(17.5)	153(68.6)	
manual worker	24(11.4)	37(17.5)	150(71.1)	
Self-employed	23(4.3)	89(16.5)	427(79.2)	<0.001
other	17(5.6)	47(15.6)	238(78.8)	
Family income (per month)				
Under 1800000 Rials	37(7.5)	83(16.8)	374(75.7)	
18000000-36000000 Rials	43(6.9)	102(16.4)	476(76.7)	
36000000-54000000 Rials	36(5.4)	121(18.1)	513(76.6)	
54000000-72000000 Rials	28(6.9)	79(19.4)	300(73.7)	
More than 72000000 Rials	43(6.3)	126(18.6)	509(75.1)	0.808

<sup>a</sup>Standard Deviation    <sup>b</sup>ANOVA    <sup>c</sup> Chi-square test

### Chi-square test

Chi-square test did not show any significant association between educational levels and COVID-19 infection status ( $P > 0.05$ ) (Table 2). The prevalence of infected, suspected, and non-infected individuals by job status was also examined by Chi-square test. The prevalence of infected individuals was statistically higher among healthcare personnel and employees ( $P < 0.001$ ) (Table 2). There was also a significant difference between groups by gender: the infection status was found to be lower among women ( $P < 0.05$ ) (Table 2). Finally, there was no difference observed between groups in terms of monthly family income ( $P > 0.05$ ) (Table 2).

### Multinomial logistic regression models

Based on the results (ANOVA test and Chi-

square test), significant predictors were included in multinomial logistic regression models. As shown in Table 3, the first category of coefficients compared infected versus non-infected groups; the next category compared suspected versus infected groups. The first column shows the effect of the variables individually (unadjusted model). The second column predicts COVID-19 infection status based on the household food insecurity score, by controlling confounding factors (adjusted model).

The results indicated that food insecurity score, job status, and gender were all significantly different between infected and non-infected people ( $P < 0.05$ ). The comparison between suspected and non-infected individuals only indicated differences in perceived COVID-19 prevention scores ( $P < 0.05$ ).



**Table 3:** Unadjusted and adjusted multinomial logistic regression models to predict the COVID-19 infection determinants among the studied population

COVID-19 infection status		Unadjusted		Adjusted	
		Exp (B)	95% CI* lower ,upper	Exp (B)	95% CI lower ,upper
Infected	Age	0.99	0.97, 1.01	0.98	0.96, 1.00
	Perceived COVID-19 prevention score	0.91	0.84, 0.97**	0.96	0.89, 1.03
	Household food insecurity score	1.03	1.00, 1.05**	1.03	1.00, 1.05**
	Gender(Ref: male)				
	<i>female</i>	0.57	0.41, 0.77***	0.60	0.41, 0.87**
	Occupation (Ref: other )				
	<i>Student</i>	0.57	0.264, 1.248	0.59	0.26, 1.34
	<i>Housewife/househusband</i>	0.87	0.45, 1.67	1.35	0.66, 2.72
	<i>Employee</i>	1.55	0.88, 2.74	1.78	0.99, 3.20
	<i>Healthcare personnel</i>	2.89	1.54, 5.43**	3.66	1.90, 7.05***
Suspected	<i>Manual worker</i>	2.27	1.17, 4.39**	1.84	0.93, 3.61
	<i>Self-employed</i>	0.75	0.39, 1.45	0.75	0.38, 1.47
	Age	0.98	0.97, 0.99**	0.99	0.97, 1.00
	Perceived COVID-19 prevention score	0.88	0.84, 0.93***	0.88	0.84, 0.93***
	Household food insecurity score	1.00	0.98, 1.02	0.99	0.97, 1.01
	Gender(Ref: male)				
	<i>female</i>	0.93	0.76, 1.13	0.89	0.70, 1.13
	Occupation (Ref: other )				
	<i>Student</i>	1.50	1.01, 2.23**	1.38	0.91, 2.10
	<i>Housewife</i>	1.29	0.88, 1.90	1.43	0.95, 2.15
<i>Employee</i>	1.08	0.74, 1.57	1.07	0.73, 1.57	
<i>Healthcare personnel</i>	1.28	0.80, 2.05	1.29	0.79, 2.08	
<i>Manual worker</i>	1.23	0.76, 1.98	1.02	0.62, 1.66	
<i>Self-employed</i>	1.04	0.71, 1.53	0.97	0.65, 1.44	

Note 1: The reference is COVID-19 non-infected status

Note 2: Model control variables (in adjusted model) included: age, perceived COVID-19 prevention score, gender, employment status

\*Confidence Interval

\*\* P-value < 0.05

\*\*\*P-value < 0.001

**Discussion**

The current study was conducted among an Iranian adult population in order to assess the associations between COVID-19 infection status and household food insecurity scores. The results indicated that men and healthcare personnel were at higher risk of contracting COVID-19. It was also shown that the household food insecurity score was significantly higher among infected people, compared to non-infected people. This finding is consistent with the study by Escobar et al. conducted on the Californians<sup>26</sup>. The higher infection rates of people with food insecurity can be explained via different dimensions. Firstly, it has been shown that food insecurity can be associated with a weaker immune system response<sup>16</sup>. Food insecurity is also associated with greater inflammation in the body<sup>29</sup>. In a study conducted

by Kelly et al., Ebola deaths was much higher among food-insecure individuals<sup>17</sup>. HIV-infected people who suffered from food insecurity and malnutrition were also found to be more vulnerable to disease progression<sup>30,31</sup>. There was a similar study on the vulnerability of food-insecure children to frequent colds<sup>32</sup>. Leddy et al. also showed that antiretroviral drug function was significantly affected by food security status<sup>33</sup>.

The food quality and dietary diversity of food-insecure households are lower than food-secure ones<sup>19,34</sup>. A healthy diet that provides the micronutrients needed by the body contributes to the better functioning of the immune system<sup>35</sup>. Low-quality diets cause a lack of vital micronutrients for proper bodily function<sup>36</sup>. Selenium deficiency, for instance, has been shown to be associated with severe status of COVID-19

infections<sup>37</sup>, due to its important role in immune system function<sup>38</sup>. Vitamin D deficiency has also been related to higher mortality and morbidity from COVID-19 infection<sup>39-41</sup>; this deficiency has been correlated with food insecurity<sup>42</sup> and low family income<sup>43</sup>.

Another reason for the higher food insecurity scores among infected individuals may be due to their increased exposure to the virus, because of non-compliance with quarantine. It has been shown that people with lower economic status were less likely to stay at home during the pandemic<sup>44</sup>. One explanation for this finding might be the need to provide food and basic needs for their families. As seen in the United States, racial and socio-economic inequalities were evident in terms of COVID-19 infection rates<sup>45</sup>. People with lower socio-economic status have encountered more concerns about employment, income, access to health care, and sufficient food during the pandemic<sup>46</sup>. Therefore, economically vulnerable people may need immediate financial<sup>4</sup> or food assistance in critical situations, including in a pandemic outbreak<sup>3</sup>. However, in the present study, no significant relationship was found between job status and COVID-19 infection (except for health personnel), but further studies are recommended in this area.

The online nature of the study has some inevitable limitations, including participation bias. In this study, the participation of young people was higher. The involvement of individuals with very low socio-economic status might be lower, due to less access to, or use of, a smartphone or the internet. Therefore, food insecurity may be under-reported, which should be considered when interpreting the results. The self-reporting method of data collection may also have biases. Some people with severe COVID-19 status may not have been able to participate in the study, or may not have reported their infection; thus, there may be underreporting in the number of infected people. It is recommended to conduct similar studies, focusing on hospitals and health centers to further examine the associations between food insecurity and COVID-19 infection status. An interesting

future research direction may aim to collect data on disease severity, too.

### Conclusion

In the current study, food insecurity scores were higher among infected vs. non-infected individuals. This indicates the higher vulnerability of food-insecure households to COVID-19. Therefore, in addition to reducing food insecurity and hunger, which is the No. 2 UN sustainable development goal<sup>47</sup>, policymakers and planners should plan and implement short-term policies (financial or food assistance) to reduce social vulnerability to COVID-19, and increase social resilience to the pandemic.

### Acknowledgment

This research grants related to COVID-19, from Vice-Chancellor of Research Affairs, Shahid Beheshti University of Medical Sciences (code: 413, date of approval: 2 August 2020). Thanks are owed to the subjects participated in the study and shared the questionnaire link at Social Networks.

### Funding

This research grants related to COVID-19, from Vice-Chancellor of Research Affairs, Shahid Beheshti University of Medical Sciences (code: 413, date of approval: 2 August 2020).

### Conflict of Interest

The authors declare that there is no conflict of interest.

This is an Open-Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) license, which permits others to distribute, remix, adapt, and build upon this work, for commercial use.

### References

1. World Health Organization. Coronavirus disease (COVID-19) advice for the public: mythbusters. 2020.
2. Hamadani JD, Hasan MI, Baldi AJ, et al. Immediate impact of stay-at-home orders to control COVID-19 transmission on socioeconomic conditions, food insecurity, mental health, and intimate partner violence in

- Bangladeshi women and their families: an interrupted time series. *Lancet Glob Health*. 2020;8(11):e1380–9.
3. Workie E, Mackolil J, Nyika J, et al. Deciphering the impact of COVID-19 pandemic on food security, agriculture, and livelihoods: A review of the evidence from developing countries. *Current Research in Environmental Sustainability*. 2020;2:100014.
  4. Aday S, Aday MS. Impacts of COVID-19 on food supply chain. *Food Quality and Safety*. 2020;4 (4):167-180.
  5. Mathew N, Deborah I, Karonga T, et al. The impact of COVID-19 lockdown in a developing country: narratives of self-employed women in Ndola, Zambia. *Health Care Women Int*. 2020; ;41(11-12):1370-83.
  6. Pereira M, Oliveira AM. Poverty and food insecurity may increase as the threat of COVID-19 spreads. *Public Health Nutr*. 2020;23(17): 3236–40.
  7. FAO. Policy Brief: The impact of COVID-19 on food security and nutrition. ETHIOPIA: United Nations. Available from: [https://ethiopia.un.org/sites/default/files/202006/SG%20Policy%20Brief%20on%20COVID%20Impact%20on%20Food%20Security\\_1.pdf](https://ethiopia.un.org/sites/default/files/202006/SG%20Policy%20Brief%20on%20COVID%20Impact%20on%20Food%20Security_1.pdf). [Cited 10 September 2020]
  8. Parolin Z, Wimer C. Forecasting estimates of poverty during the COVID-19 crisis. *Poverty and social policy brief* New York, NY: Center on Poverty and Social Policy at the Columbia School of Social Work. 2020;4(6):20-46.
  9. Clay E. Trade Reforms and Food Security. FAO; 2002.
  10. Dubowitz T, Dastidar MG, Troxel WM, et al. Food insecurity in a low-income, predominantly African American cohort following the COVID-19 pandemic. *Am J Public Health*. 2021;111(3):494–7.
  11. Dondi A, Candela E, Morigi F, et al. Parents' perception of food insecurity and of its effects on their children in Italy six months after the COVID-19 pandemic outbreak. *Nutrients*. 2021;13(1):121.
  12. Gaitán-Rossi P, Vilar-Compte M, Teruel G, et al. Food insecurity measurement and prevalence estimates during the COVID-19 pandemic in a repeated cross-sectional survey in Mexico. *Public Health Nutr*. 2021;24(3):412–21.
  13. Manfrinato CV, Marino A, Condé VF, et al. High prevalence of food insecurity, the adverse impact of COVID-19 in Brazilian favela. *Public Health Nutr*. 2021;24(6):1210–5.
  14. Pakravan-Charvadeh MR, Savari M, Khan HA, et al. Determinants of household vulnerability to food insecurity during COVID-19 lockdown in a mid-term period in Iran. *Public Health Nutr*. 2021;24(7):1619–28.
  15. Darling KE, Fahrenkamp AJ, Wilson SM, et al. Physical and mental health outcomes associated with prior food insecurity among young adults. *J Health Psychol*. 2017;22(5):572–81.
  16. Weiser SD, Young SL, Cohen CR, et al. Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. *Am J Clin Nutr*. 2011;94(6):1729S–1739S.
  17. Kelly JD, Richardson ET, Drasher M, et al. Food insecurity as a risk factor for outcomes related to ebola virus disease in kono district, sierra leone: A cross-sectional study. *Am J Trop Med Hyg*. 2018;98(5):1484–8.
  18. Wimalawansa SJ. Fighting against COVID-19: Boosting the immunity with micronutrients, stress reduction, physical activity, and vitamin D. *Nutrition and Food Science Journal (Sci Literature)*. 2020;3:1–4.
  19. Davison KM, Gondara L, Kaplan BJ. Food insecurity, poor diet quality, and suboptimal intakes of folate and iron are independently associated with perceived mental health in Canadian adults. *Nutrients*. 2017;9(3):274.
  20. Larson N, Slaughter-Acey J, Alexander T, et al. Emerging adults' intersecting experiences of food insecurity, unsafe neighbourhoods and discrimination during the coronavirus disease 2019 (COVID-19) outbreak. *Public Health Nutr*. 2021;24(3):519–30.
  21. Martin MS, Maddocks E, Chen Y, et al. Food insecurity and mental illness: disproportionate



- impacts in the context of perceived stress and social isolation. *Public Health*. 2016;132:86–91.
22. Assaf AM. Stress-induced immune-related diseases and health outcomes of pharmacy students: A pilot study. *Saudi Pharm J*. 2013;21(1):35–44.
  23. Yazdanpanah M, Tajeri Moghadam M, Savari M, et al. The impact of livelihood assets on the food security of farmers in southern Iran during the COVID-19 pandemic. *Int J Environ Res Public Health*. 2021;18(10):5310.
  24. Tezerji S, Nazari Robati F. Status of food security in Kerman, Iran during the COVID-19 pandemic. *Journal of Arak University of Medical Sciences*. 2020;23(5):774–85.
  25. Kimani ME, Sarr M, Cuffee Y, et al. Associations of race/ethnicity and food insecurity with COVID-19 infection rates across US counties. *JAMA Netw Open*. 2021;4(6):e2112852–e2112852.
  26. Escobar M, Mendez AD, Encinas MR, et al. High food insecurity in Latinx families and associated COVID-19 infection in the Greater Bay Area, California. *BMC Nutr*. 2021;7(1):23.
  27. Behzadifar M, Behzadifar M, Abdi S, et al. Prevalence of food insecurity in Iran: A Systematic Review and Meta-analysis. *Arch Iran Med*. 2016;19(4):288–94.
  28. Mohammadi F, Omidvar N, Houshiar-Rad A, et al. Validity of an adapted household food insecurity access scale in urban households in Iran. *Public Health Nutr*. 2012;15(1):149–57.
  29. Gowda C, Hadley C, Aiello AE. The Association Between Food Insecurity and Inflammation in the US Adult Population. *Am J Public Health*. 2012;102(8):1579–86.
  30. Aibibula W, Cox J, Hamelin AM, et al. Association between food insecurity and HIV viral suppression: A Systematic Review and Meta-Analysis. *AIDS Behav*. 2017;21(3):754–65.
  31. Ivers LC, Cullen KA, Freedberg KA, et al. HIV/AIDS, undernutrition, and food insecurity. *Clin Infect Dis*. 2009;49(7):1096–102.
  32. Alaimo K, Olson CM, Frongillo EA, et al. Food insufficiency, family income, and health in US preschool and school-aged children. *Am J Public Health*. 2001;91(5):781–6.
  33. Leddy AM, Sheira LA, Tamraz B, et al. Food insecurity is associated with lower levels of antiretroviral drug concentrations in hair among a cohort of women living with human immunodeficiency virus in the United States. *Clin Infect Dis*. 2020;71(6):1517–23.
  34. Singh DR, Ghimire S, Upadhayay SR, et al. Food insecurity and dietary diversity among lactating mothers in the urban municipality in the mountains of Nepal. *PLoS one*. 2020;15(1):e0227873.
  35. Richardson DP, Lovegrove JA. Nutritional status of micronutrients as a possible and modifiable risk factor for COVID-19: a UK perspective. *Br J Nutr*. 2021;125(6):678–84.
  36. Kazemi A, Ghaemmaghami Hezaveh SJ, Nikniaz L, et al. Is food insecurity associated with iron deficiency anemia and Vitamin D deficiency among women of reproductive age?. *Top Clin Nutr*. 2020;35(3):240–7.
  37. Moghaddam A, Heller RA, Sun Q, et al. Selenium deficiency is associated with mortality risk from COVID-19. *Nutrients*. 2020;12(7):2098.
  38. Bae M, Kim H. Mini-Review on the Roles of Vitamin C, Vitamin D, and selenium in the immune system against COVID-19. *Molecules*. 2020;25(22):5346.
  39. Meltzer DO, Best TJ, Zhang H, et al. Association of vitamin D status and other clinical characteristics with COVID-19 test results. *JAMA netw open*. 2020;3(9):e2019722–e2019722.
  40. Radujkovic A, Hippchen T, Tiwari-Heckler S, et al. Vitamin D deficiency and outcome of COVID-19 patients. *Nutrients*. 2020;12(9):2757.
  41. Jain A, Chaurasia R, Sengar NS, et al. Analysis of vitamin D level among asymptomatic and critically ill COVID-19 patients and its correlation with inflammatory markers. *Sci Rep*. 2020;10(1):20191.
  42. Wahlqvist ML. Vitamin D status and food security in North-East Asia. *Asia Pac J Clin Nutr*. 2013;22(1):1–5.

43. Mark S, Lambert M, O'Loughlin J, et al. Household income, food insecurity and nutrition in Canadian Youth. *Can J Public Health.* 2012;103(2):94-9
44. Lou J, Shen X, Niemeier D. Are stay-at-home orders more difficult to follow for low-income groups?. *J Transp Geogr.* 2020;89:102894.
45. Wolfson JA, Leung CW. Food insecurity during COVID-19: An acute crisis with long-term health implications. *Am J Public Health.* 2020;110(12):1763–5.
46. Sharma SV, Chuang RJ, Rushing M, et al. Peer reviewed: social determinants of health-related needs during COVID-19 among low-income households with children. *Prev Chronic Dis.* 2020;17:e119.
47. The Sustainable Development Goals Report. New York: United Nations; 2017. Available from:<https://unstats.un.org/sdgs/files/report/2017/TheSustainableDevelopmentGoalsReport2017.pdf>. [Cited 25 March 2017]