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## *The Role of Policymakers in Potential Strengthening to Improve the Safety of the Vegetable in the Supply Chain: SWOT Analysis during COVID-19*

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### ABSTRACT

**Background:** Fresh vegetables can play an important role in health and food security. This study aimed to assess the safety of the vegetable supply chain in Iran during the COVID-19 pandemic by strengths, weaknesses, opportunities, and threats (SWOT) analysis. **Methods:** A mixed-methods study was conducted in two phases in 2021. First, in the cross-sectional study, 192 staff were randomly selected from five major centers of vegetable retail centers. Then, semi-structured interviews were done with ten stakeholders, and a SWOT analysis was completed.

**Results:** Half of the participants had desirable hygienic practices, 39.6% had acceptable, and 8.9% had weak practice scores. The practice of participants whose educational level was BSc and above was better than that of illiterates (OR =15.38, 95% CI =1.61-14.57,  $P=0.01$ ). SWOT analysis results identified a poor shelf-life of vegetables, weak technology in planting, harvesting, and distributing vegetables. **Conclusion:** Policymakers can utilize the practical solutions for taking action in the potential strengthening of vegetable safety in the supply chain to improve public health during the COVID-19 pandemic.

**Keywords:** Vegetable safety; Supply chain; COVID-19 pandemic; SWOT analysis; Health policy

### Introduction

The global production of fresh vegetables has increased by 30% over the last few years (Hess and Sutcliffe, 2018). Fresh vegetables play an important role in human nutrition due to their high nutrient content. They can also help to provide a healthy and balanced diet that prevents

non-communicable diseases (NCDs), especially in developing countries (Septembre-Malaterre *et al.*, 2018, Yahia *et al.*, 2019). However, fresh and raw consumed vegetables are also increasingly being recognized as important vehicles for the transmission of human pathogens (Ramees *et al.*,

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2017).

Scientists are demonstrating the global consequences of the COVID-19 crisis for humanity, the economy, and consequently, food systems. Food researchers face many fundamental challenges to ensure food safety and food security (Galanakis, 2020). In the COVID-19 pandemic scenario, a new set of challenges forces the person to maintain a healthy diet (Aman and Masood, 2020). A reasonable approach to cope with the COVID-19 pandemic is to improve the immune system. Therefore, as immunity is a part of health and food and nutrition security, it has been recommended that people consume certain types of food that can improve their immune system like fresh vegetables, fruits, whole grains, and meat to combat COVID-19 (Khayyat-zadeh, 2020).

One of the most important concerns of consumers is the food hazard caused by COVID-19 such as the possibility of contamination of food or food packaging with the virus (Malik *et al.*, 2020, Rodriguez-Morales *et al.*, 2020). Foodborne transmission of COVID-19 should be considered. The European Union (EU) Commission has emphasized that the utilization of COVID-19 contaminated packaging by the staff creates a hazard for buyers (European Commission EC, 2020).

Food production is viewed as a fundamental service sector that should continue by any means and at any cost or under any situation despite a COVID-19 lockdown (Moura and Souza, 2020). The COVID-19 pandemic has compromised production chains and put nations on alert for providing potential food supply emergencies in the world (De Paulo Farias and de Araújo, 2020). There is an increasing concern that production limitations are negatively impacting our ability to meet the global demand for food (de Lima *et al.*, 2018). The COVID-19 outbreak has started to upset food supply chains, and thus, has affected the households' livelihoods and diets. Farmers and consumers have been affected; however, the scope of the impacts is not yet known (Tamru *et al.*, 2020).

Undoubtedly, the COVID-19 pandemic is not

only a public health issue but also a food supply issue and brings significant health and economic emergencies. Therefore, it is important how it affects the vegetable sales and production industry (Hailu, 2020). Iran is among the top 10 countries in vegetable production distribution in the world (Food and Agriculture Organization, 2020). Another study in Ethiopia showed that the intake of vegetables amongst people has decreased during the COVID-19 outbreak (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 food for sanitation purposes. A study in Iran demonstrated vulnerable populations in countries experiencing food insecurity, such as Iran during COVID-19 pandemic, 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 (Pakravan-Charvadeh *et al.*, 2021).

Demand for ready-to-eat food from food service markets has significantly increased, and factories have moved more towards food processing and preparation in Iran. However, restaurant sales have declined due to public fears and restricted religious ceremonies, celebrations, and parties (Hailu, 2020). While some activities are required to combat the spread of the illness, they will probably have significant impacts on vegetable producers and distributors. Therefore, to the best of the authors' knowledge, this is the first study that employs strengths, weaknesses, opportunities, and threats (SWOT) analysis during the COVID-19 pandemic to help policymakers to make appropriate strategies and find practical solutions for improving vegetable safety in the supply chain.

## Materials and Methods

### Study design and population

#### Phase I

The cross-sectional study was conducted among five major vegetable production, supply, and retail centers in the north, south, west, east, and center of

Tehran, including 53 greengroceries and fresh vegetable markets, 41 vegetable shops, and 3 vegetable factories selected through cluster sampling. All participants aged >18 years working in the vegetable supply chain and had access to the WhatsApp messenger. The questionnaire was developed based on the Center for Disease Control and Prevention (CDC) and World Health Organization (WHO) guidance for food businesses under the COVID-19 pandemic condition (centers for disease control and prevention CDC, 2020, World Health Organization, 2020).

**Data collection:** The research team contacted the quality manager of each center to invite their staff to participate in this study by phone call and inform them about the research aim based on their consent. The participants were enrolled in the study through a non-probability sampling approach where participants were invited through phone or social media. Then, 214 people were contacted; 197 of them admitted to collaborate and the electronic questionnaire link was sent to them. All of the subjects filled out the form, and five of them were excluded because of the technical problem of the platform. Finally, 192 staff were selected from these centers. The questionnaire was completed through the online link sent to the participants by the WhatsApp messenger (Facebook, Inc., California, USA) from March to July 2021.

The first part of the questionnaire included the questions about the staff's gender, age, educational level, workplace, and nationality. The second part of it consisted of:

- Two questions about the symptoms and tests of COVID-19 and having symptoms in the last two weeks. This section of the questionnaire was assessed using *yes/no* questions.
- Eight 5-Likert-item questions about their practice related to COVID-19, with the responses of *never*, *rarely*, *sometimes*, *often*, and *always*, each rated 1–5, respectively. The scores were classified as *weak* [8-20], *acceptable* [20-30], *desirable* [30-40].

**Validation and pilot study:** The questionnaire was developed based on the CDC and WHO

guidelines and reports on COVID-19 (centers for disease control and prevention CDC, 2020, World Health Organization, 2020). However, it was adjusted by a formerly distributed tool for the evaluation of practice toward the prevention of the pandemic. Before using the questionnaire, a pilot study was performed to evaluate its face and content validity by an expert panel and some people similar to the study participants. The reliability of the questionnaire was also assessed by retesting at a time interval of 20 days (European Commission EC, 2020). Four experts in food safety from Shahid Beheshti University of Medical Sciences Tehran, Iran were first asked to assess the questions. The final version of the questionnaire was obtained after eliminating the disagreed parts between the researchers.

**Data analysis:** The collected data were analyzed by using the SPSS software (ver. 26.0). Data were reported as frequencies (n), proportions (%), and means ( $\pm$ standard deviations) for variables. Chi-squared test was performed to assess the relationship between the variables. In addition, the relationship between the independent (demographic characteristics) and dependent (practice) variables was tested using the multivariate logistic regression analysis. The p-value less than 0.05 was considered statistically significant.

### **Phase II**

In the second part, semi-structured interviews were conducted with 10 experts in the vegetable industry (three officers in the Ministry of Agriculture-Jihad, two faculty members in the food safety field, one manager of Tehran Central Fruit and Vegetable Market, two managers of vegetable factories, and two quality control managers), who were selected through purposive sampling. Four questions about their opinions on the SWOT of the vegetable supply chain were sent to the stakeholders through their email to determine the challenges of the vegetable supply chain by SWOT analysis.

The SWOT analysis is a method for investigating the internal and external

environmental influencing factors in a project. The steps used in the SWOT analysis include the advantageous and disadvantageous aspects, characterization of the internal aspects and classifying them into strengths and weaknesses, identification of the external aspects, and sorting out of opportunities and threats (Leigh, 2009).

*Ethical considerations:* The study was affirmed by the Ethics Committee of National Nutrition and Food Technology Research Institute (NNFTRI), Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.nnftri.Rec.1399.031). The anonymity of all respondents was guaranteed and all of them provided informed consent.

## Results

### Phase I

A total of 192 people participated in this study; they were working in green groceries (33.9%), fresh vegetable markets (17.8%), vegetable shops (26%), and vegetable factories (22.3%). The majority of the participants were men (80.7%) in the age range of 25- 35 years (32.8%) with the educational level of diploma and below (78.1%). Most of the participants (97%) stated they did not have any symptoms of the disease in the past two weeks and did not perform a COVID-19 test (82.3%). Only two of them had formerly been infected with coronavirus, which had been treated before entering the study (**Table 1**).

The results of self-reported practice questions showed that only about 21% of the participants reported always washing their hands for 20 seconds at least 4 times a day and 40% of them sometimes, clean and disinfect surfaces frequently during the day. In addition, more than half of the participants (53%) always wear a mask in their workplace, 25% of them keep social distancing (two meters). The responses of the subjects towards practice questions to prevent the spread of COVID-19 are shown in **Table 2**.

More than half of the respondents had desirable practices score (52%) toward the COVID-19 pandemic, whereas acceptable and weak practice was found in 40% and 52% of them, respectively.

Nationality, gender, educational level, and workplace were significantly associated with their practices ( $P < 0.05$ , **Table 3**).

The regression analysis results revealed that the practice of staff in vegetable shops (OR = 2.34, 95% CI = 1.04–5.24,  $P=0.04$ ) was better than in greengrocers and production line workers in vegetable factories. Also, the practice of participants whose educational level was BSc and above (OR =15.385, 95% CI =1.615-14.56,  $P=0.01$ ) was better than in the illiterate participants.

### Phase II

*SWOT analysis of vegetable supply chain safety during the COVID-19 pandemic:* The fresh vegetable supply chain in Iran includes suppliers of inputs, wholesalers, retailers, processors, and consumers, who are directly or indirectly related to each other. Internal strengths and weaknesses, as well as external opportunities and threats in vegetable supply and retail centers in Iran, based on the stakeholders' opinions, are summarized in **Table 5**.

#### Internal factors

- **Strengths:** The major strengths included available vegetable sales centers for diverse and fresh vegetables, creating direct and indirect employment, and the existence of skilled human resources.
- **Weaknesses:** The significant weaknesses included poor shelf-life of vegetables, poor technology in planting, harvesting, and distributing vegetables, and non-observance of technical points (temperature, and humidity) in vegetable storage.

#### External factors

- **Opportunities:** The key opportunities included facilitating and promoting agricultural activities and increasing the strength of industry at national and regional levels.
- **Threats:** The significant threats included lack of water, the residue of pesticides, and herbicides and reduced consumption of vegetables for fear of being infected with COVID-19.

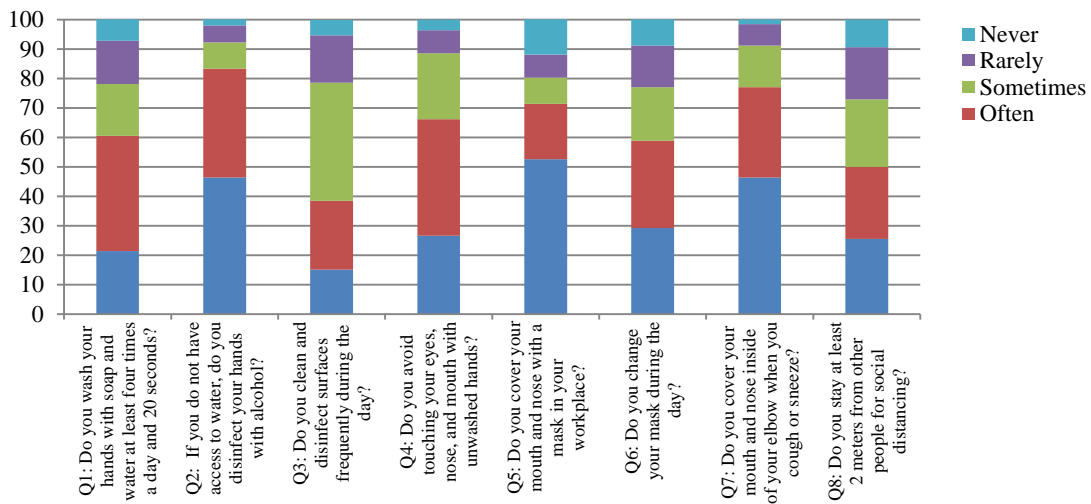


Figure 1. Participants' responses to the practice questions toward COVID-19.

Table 1. Characteristics of the participants in the processing and retail centers of vegetables.

Variables	N (%)
<b>Gender</b>	
Female	37(19.3)
Male	155(80.7)
<b>Age (years)</b>	
18-25	50(26)
25-35	63(32.8)
35-45	53(27.6)
≥ 45	26(13.5)
<b>Educational level</b>	
Illiterate/primary	13(6.8)
High school/diploma	150(78.1)
BSc and MSc	29(15.1)
<b>Workplace</b>	
Greengrocers	65(33.9)
Fresh vegetable markets	34(17.8)
Vegetable shops	50(26)
Production line worker in vegetable factories	43(22.3)
<b>Nationality</b>	
Iranian	178(92.7)
Afghan	14(7.3)
<b>Having symptoms of COVID-19 (in the last two weeks)</b>	
Yes	6(3)
No	186(97)
<b>Having COVID-19 tested</b>	
No	158(82.3)
Yes, negative	32(16.7)
Yes, positive	2(1)
<b>Total</b>	<b>192(100)</b>

**Table 2.** Participants' responses to the practice questions toward COVID-19 (n= 192).

Questions	Always	Often	Sometimes	Rarely	Never
Do you wash your hands with soap and water at least four times a day and for 20 seconds?	41(21.4) <sup>a</sup>	75(39.1)	34(17.7)	28(14.6)	14(7.3)
If you do not have access to water, do you disinfect your hands with alcohol?	89(46.4)	71(37.0)	17(8.9)	11(5.7)	4(2.1)
Do you clean and disinfect surfaces frequently during the day?	29(15.1)	45(23.4)	77(40.1)	31(16.1)	10(5.2)
Do you avoid touching your eyes, nose, and mouth with unwashed hands?	51(26.6)	76(39.6)	43(22.4)	15(7.8)	7(3.6)
Do you cover your mouth and nose with a mask in your workplace?	101(52.6)	36(18.8)	17(8.9)	15(7.8)	23(12)
Do you change your mask during the day?	56(29.2)	57(29.7)	35(18.2)	27(14.1)	17(8.9)
Do you cover your mouth and nose inside of your elbow when you cough or sneeze?	89(46.4)	59(30.7)	27(14.1)	14(7.3)	3(1.6)
Do you stay at least 2 meters away from other people for social distancing?	49(25.5)	47(24.5)	44(22.9)	34(17.7)	18(9.4)

<sup>a</sup>: N (%)**Table 3.** Relationship between the participants' demographic characteristics and their practice scores towards COVID-19 (n=192).

Variables	Practice score			P-value <sup>b</sup>
	Weak (8-20)	Acceptable (20-30)	Desirable (30-40)	
Nationality				
Iranian	14(7.9) <sup>a</sup>	68(38.2)	96(53.9)	<0.05
Afghan	3(21.4)	8(57.1)	3(21.4)	
Gender				
Female	1(2.7)	9(24.3)	27(73)	<0.05
Male	16(10.3)	67(43.2)	72(46.5)	
Educational level				
Illiterate/primary	4(30.8)	7(53.8)	2(15.4)	<0.05
High school/diploma	13(8.7)	59(39.3)	78(52)	
BSc and MSc	0.0	10(34.5)	19(65.5)	
Workplace				
Greengrocers	12(18.5)	29(44.6)	24(36.9)	<0.05
Fresh vegetable markets	2(5.9)	17(50.0)	15(44.1)	
Vegetable shops	2(4.0)	18(36.0)	30(60.0)	
Production line worker in vegetable factories	1(2.3)	12(27.9)	30(69.8)	
Total	17(8.9)	76(39.6)	99(51.6)	

<sup>a</sup>: N (%); <sup>b</sup>: Chi-square test.

**Table 4.** Regression model of the participants' demographic characteristics and their behavior about COVID-19 in the processing and retail centers of vegetables (n=192).

Variables	OR (95% CI)	P value
<b>Workplace</b>		
Greengrocers (ref)		0.104 <sup>a</sup>
Fresh vegetable markets	1.150 (0.466-2.835)	0.762
Vegetable shops	2.341 (1.045-5.244)	0.039
Production line worker in vegetable factories	3.309 (0.889-12.314)	0.074
<b>Gender</b>		
Female (ref)		0.544 <sup>a</sup>
Male	0.687 (0.204-2.315)	
<b>Nationality</b>		
Iranian (ref)		0.272
Afghan	0.445 (0.105-1.888)	
<b>Age (years)</b>		
18-25 (ref)		0.760 <sup>a</sup>
25-35	1.220 (0.464-3.207)	0.687
35-45	1.719 (0.603-4.905)	0.311
≥ 45	1.396 (0.419-4.652)	0.587
<b>Educational level</b>		
Illiterate/primary (ref)		0.057 <sup>a</sup>
High school/diploma	3.295 (0.648-16.751)	0.151
BSc and MSc	15.385 (1.615-14.566)	0.017

Practice scores were divided into two levels. The scores of >30 were considered as a desirable practice and a score of <30 demonstrated a weak practice. The score range was 8-40.

<sup>a</sup> : P trend

**Table 5.** SWOT analysis of vegetable safety in the supply chain during the COVID-19 pandemic.

<b>Internal factors</b>
<b>Strengths</b>
<ul style="list-style-type: none"> <li>• Available vegetable sales centers for diverse and fresh products</li> <li>• Creating direct and indirect employment</li> <li>• Existence of skilled human resources</li> <li>• Large domestic consumer markets</li> <li>• Export of vegetables to other countries</li> </ul>
<b>Weaknesses</b>
<ul style="list-style-type: none"> <li>• Weak technology in planting, harvesting, and distributing vegetables</li> <li>• Poor managerial skills of farmers and producers</li> <li>• Lack of management skills and leadership</li> <li>• Non-compliance with technical points (temperature, humidity, ...) in the vegetable storage</li> <li>• Short and poor shelf- life of vegetables</li> <li>• Limited technical knowledge</li> <li>• Poor innovation in supply chain</li> <li>• Poor storage of refrigerated warehouses</li> <li>• Poor implementation of HACCP standards</li> <li>• Inadequate packaging and labeling</li> <li>• Limitations and high costs of raw materials and packaging machinery</li> </ul>

## External factors

## Opportunities

- Creating new job opportunities in rural areas
- Development of vegetable exportation
- New takeover or partnership opportunities
- Moderately cheap cost
- Facilitating and promoting agricultural activities and increasing the strength of the national and regional industries

## Threats

- Lack of water
- The residue of pesticides and herbicides
- Reduced consumption of vegetables due to fear of getting COVID-19
- Economic cycle downturn during COVID-19
- Decrease of export borders closure due to COVID-19 pandemic
- High losses in vegetables
- Volatile prices
- Expensive processing machines
- Sanctions

Table 6. Strategies of vegetable safety in the supply chain.

Invasive strategies (SO)	Conservative strategies (WO)
<ul style="list-style-type: none"> <li>• Implementation of traceability in supply chain</li> <li>• Increasing political attention to this issue</li> <li>• Increasing public awareness by campaign</li> </ul>	<ul style="list-style-type: none"> <li>• Using modern technology and new regulation</li> <li>• A thorough inspection from farm to consumer</li> <li>• Development of vegetable exportation</li> </ul>
Competitive strategies (ST) <ul style="list-style-type: none"> <li>• Implementation specific licensing system in place for management skills and leadership</li> <li>• More interaction with the governmental sectors</li> <li>• Using modern technology and equipment</li> </ul>	Defensive strategies (WT) <ul style="list-style-type: none"> <li>• Implementation methods to decrease the residue of pesticides and herbicides</li> </ul>

## Discussion

The food system is among the main sectors affected by epidemics in the community. Since the outbreak of COVID-19, quarantine and social distance measures to prevent the transmission of the COVID-19 virus have not so impressed the vegetable supply chain. However, it was observed that vegetable distributors and manufacturers have suffered the most from declining sales due to lock-down and price volatility during the epidemic.

The results of the present study on the practice of staff in vegetable retail centers towards the COVID-19 disease showed that half of the respondents had desirable practices, and most of them did not have a COVID-19 virus test. Given that limited screening had been done because of the insufficient income of the participants, some tests and screening have to be done routinely.

It is noteworthy that about 80% of people with COVID-19 infection possess only mild symptoms. These patients can act as "carriers" or as a "reservoir" for reinfection. For this reason, the respondents were requested for their information on the symptoms of COVID-19, and the majority of them stated that they were aware of their symptoms (Ather *et al.*, 2020).

There is an obvious concern for the food industry staff. They should be tested for COVID-19 to eliminate the potential risk of cross-contamination of food with the virus. In food handling and processing sections where food is just marginally prepared, contaminated workers may adulterate food items. Furthermore, person-to-person transmission in sections where staffs are in close contact with each other is another risk (European Commission EC, 2020). Hence, the



present study focused on staff who were in direct contact with vegetables.

Most of the participants had high school levels of education and diplomas, and many admitted that they did not understand the importance of the COVID-19 outbreak and its transmission. Therefore, there seems to be a significant relationship between compliance with health protocols like social distance and educational level.

They stated that they washed their hands frequently and had restricted personal contact. Due to the mandatory mask-wearing in Iran, the respondents mostly used masks. Shi *et al.* reported that almost all subjects in their research wore face masks when going out/in public during the pandemic (Shi *et al.*, 2020).

Handling of food packages must be done after extensive hand washing or disinfecting to minimize any hazard from touching the food exposed to the COVID-19 virus (Giacomelli *et al.*, 2020). In addition, the FDA has proposed that disinfecting and cleaning surfaces is a favored safeguard for restaurants rather than environmental testing for COVID-19. Another essential precaution to prevent the spread of the disease is the use of alcohol hand sanitizer. The disinfectant information question data in the present research indicated that 41.7% of the respondents were using hand sanitizer solutions containing varying percentages of alcohol. However, because of the rapid spread of the disease in Iran and the high prevalence of the disease, surface disinfection has been frequently used (>60%) and the use of appropriate hand sanitizer (>30%) have not provided an appropriate level of safety.

During the production, transportation, and sale of fresh vegetables, necessary precautions of washing and disinfection should be taken. Vegetables should be minimally manipulated as much as possible. Routine COVID-19 screening of workers is also very important though this requires government support. In a situation where sales have dropped due to the COVID-19 pandemic, the government can provide hand and surfaces sanitizers to vegetable centers.

Reduction in the exports of fresh vegetables due

to the border closing is another challenge. Some nations have enforced travel limitations, shut borders, and closed factories, leading to distributions in the worldwide exchange and supply chains (De Paulo Farias and de Araújo, 2020). The export market in Iran, in addition to the COVID-19 issue, has been equally affected by imposed sanctions. In the face of demand slumps due to restaurant closures, as well as slowdowns in the exports because of border measures by some countries, many food processing companies will inevitably switch supply efforts from food service to retail channels. Therefore, vegetable exchange and utilization will decrease. There is less exchanging action in the vegetable discount market since the beginning of the COVID-19 epidemic (Chowdhry *et al.*, 2020, Richards and Rickard, 2020, Samadi *et al.*, 2021).

Assessment of vegetable chains in Ethiopia indicated an increase in farm losses, along with a lack of inputs and work, marked down maker costs for vegetables. However, retail costs have remained unaltered so far; and both vegetable exchange and utilization have decreased (Tamru *et al.*, 2020). An investigation on retail costs in India revealed that these costs have expanded and afterward balanced out in India on a national level, yet have been fluctuated by the specific kind of vegetable (Pingali and Mittra, 2020). Similarly, another study in India reported issues with discovering harvest work, transport to market, marked down interest by purchasers and retailers, and expanded retail costs for vegetables in various states (Pothan *et al.*, 2020).

The COVID-19 pandemic has affected vegetable processors. In this business, development in the retail market for processed foods, decrease in foodservice interest for processed foods, and reduced export and import activities have occurred. The overall impact of the disease on the economic activities of fresh vegetables and the related gross domestic products depends on the magnitude and persistence of the consequences of COVID-19. Hence, initiators and investors are committed to disruptions. Since people are terrified of the outbreak and the governments have taken the

initiative to lock in, people attempt to stockpile daily necessities, resulting in the soaring prices of the basic ware.

For vegetable supply and retail centers, the impacts of the COVID-19 pandemic are not equal for all types of vegetables; rather they vary according to the assortment of components, including international exchange, seasonality, simplicity of preparation, and fresh and processed products. There have been many cases where vegetable gardeners have unknowingly used manure and composts that are usually contaminated with herbicides. In Iran, fluctuations in the production, processing, and supply of vegetables over the recent years have caused various problems, including the dissatisfaction of both producers and consumers.

Official statistical reports, however, show that more than 35% of this product goes to waste on an annual basis. High losses in agricultural products are due to improper harvesting and transportation methods, unsuitable storage of products after harvest, poor sorting, and improper packaging and distribution. Losses also occur during retail sales, consumption, and processing. Upgrading of systems, designed to minimize losses, could provide the country with an opportunity to preserve its resources and increase its vegetable exports. In general, inappropriate post-harvest handling can cause: 1) product losses, 2) high costs and low profit, 3) losses of market opportunity, and 4) low competitiveness (Baghkhanda, 2006).

It seems that the major factors that contribute to supply chain waste include:

1. Use of improper technology for harvesting, processing, and storage.
2. Lack of product cooling after harvest and shortage of cold warehouse.
3. Inappropriate transportation.
4. Lack of product grading.
5. Lack of washing/cleaning systems.
6. Lack of awareness of suitable methods of preservation.
7. Lack of suitably-integrated vegetable chains for transportation storage, sorting, grading, packaging, and marketing.

8. Lack of producer awareness of markets and fresh product prices.

Based on the results of SWOT analysis (**Table 6**), the following strategies and practical solutions for the development of vegetable safety in the supply chain as COVID-19 pandemic priorities are presented:

- 1) Developing new technologies and methods of producing ready-to-eat vegetables
  - 2) Organizing and coordinating diverse parts of the supply chain.
  - 3) Improving the technical and marketing skills of the distributors and processors of the vegetable supply chain.
  - 4) Production stability and control of domestic market prices
  - 5) Increasing the quality of vegetables (production of organic and healthy vegetables without the use of chemical fertilizers) at minimum prices and unlimited access for consumers.
  - 6) Meeting industrial needs by directing investment to produce suitably-prepared and processed vegetables.
  - 7) Variety in processed products and expansion of the share of processed products in the consumption pattern of households.
  - 8) Paying due attention to the packaging and classification of export products
  - 9) Expanding the export markets by improving quality and complying with the national and international standards like GAP [Good Agricultural Practice] and HACCP [Hazard Analysis and Critical Control Point].
  - 10) Development of logistics and complementary activities like storage, refrigeration, transportation facilities, especially railways, research and development, and grading and packaging industries of vegetable products.
- Policymakers can make use of the above-recommended strategies and solutions for setting laws and regulations to increase public health. This is the first study that uses SWOT analysis during the COVID-19 pandemic to help policymakers to make appropriate strategies and find practical solutions for improving vegetable

safety in the supply chain. The only limitation of the present study was the COVID-19 pandemic which makes conducting the field study very hard.

### Conclusion

The results of the present study showed that near half of the respondents had desirable practices towards COVID-19. The SWOT analysis results revealed that significant weaknesses included poor shelf-life of vegetables, poor technology in planting, harvesting, and distributing vegetables, and non-observance of technical points in the vegetable storage. In addition, lack of water, the residue of pesticides, and herbicides, and reduced consumption of vegetables due to the fear of being infected with COVID-19 were recognized as threats. It seems necessary to develop strategies to improve the current situation in the vegetable industry. Price stability, ensuring the availability of fresh and healthy vegetables and the use of modern technology to vegetables market through social media are at the top of the strategies that policymakers can make use of to increase vegetable consumption and promote public health. They can utilize the practical solutions for taking action in the potential strengthening of vegetable safety in the supply chain to improve public health during the COVID-19 pandemic.

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### Authors' contributions

The study's design, supervision, data collection, experimental measuring, statistical analysis, and manuscript drafting were all carried out by

Eskandari S, Rashidimehr A, and Esfarjani F. Salmani Y helped with the study design, data collection, and manuscript drafting, while Mohammadi-Nasrabadi F helped with the conceptualization, methodology, and data interpretation.

### Conflicts of interest

The authors have no conflict of interest that might be perceived as affecting the objectivity of this publication.

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