



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Original Research

Risk perception and resource scarcity in food procurement during the early outbreak of COVID-19

Y. Wang ^a, X. Chen ^{b, c, *}, Y. Yang ^d, Y. Cui ^b, R. Xu ^{c, e}^a Department of Marketing and Management, State University of New York at Oswego, Oswego, NY, 13126, USA^b Department of Geography, University of Connecticut, Storrs, CT, 06269, USA^c Institute for Collaboration on Health, Intervention, and Policy (InCHIP), USA^d Department of Tourism and Hospitality Management, Temple University, Philadelphia, PA, 19122, USA^e Department of Allied Health Sciences, University of Connecticut, Storrs, CT, 06269, USA

ARTICLE INFO

Article history:

Received 10 January 2021

Received in revised form

12 April 2021

Accepted 28 April 2021

Available online 5 May 2021

Keywords:

Food procurement

Food expenditure

Risk perception

Food security

COVID-19

ABSTRACT

Objectives: The retail food industry, a major essential business, is among the very few thriving sectors during the COVID-19 pandemic. However, such prosperity on the store side does not guarantee a sufficient food supply for all populations. This study aims to understand if people's risk perception and food security status shaped their food procurement behaviors during the early outbreak of the pandemic.

Study design: Extended from the theory of risk perception, food consumers may behave differently during a disastrous event in terms of store patronization. The study evaluates how food procurement behaviors are affected by perceived risk aversion, resource scarcity, and consumers' food security status.

Methods: The study examines how people with different food security statuses made grocery shopping decisions at the risk of epidemic exposure based on a nationwide survey of 2590 participants in the U.S. during the early break of the pandemic in April 2020. The study uses a moderated mediation analysis on in-store shopping frequency and food expenditure.

Results: People having a food-secure status before the pandemic spent significantly more as a result of the reduced shopping frequency (i.e., the secure-insecure subgroup $\beta = -0.18, P < .01$; the secure-secure subgroup $\beta = -0.35, P < .01$). The increase in food expenditure was insignificant for people who were food-insecure before the pandemic (i.e., the insecure-insecure subgroup, $\beta = -0.01, P > .05$; the insecure-secure subgroup, $\beta = -0.11, P > .05$).

Conclusions: The study reports that in general people reduced the frequency of grocery shopping trips to avoid epidemic exposure while increasing the food expenditure per trip. The increase in food expenditure was not statistically significant among the food-insecure populations likely due to their budget constraints.

Published by Elsevier Ltd on behalf of The Royal Society for Public Health.

Introduction

The coronavirus disease 2019 (COVID-19) has shaken the world in every possible way, including how people acquire and prepare food to meet nutritional needs. Food consumers play a critical role in the food supply chain, which was considerably undermined by the pandemic.^{1–3} With an increasing number of away-food outlets (e.g., restaurants, school cafeterias) temporarily closed or permanently running out of business due to the pandemic, people had to rely more on food preparation at home.^{4,5} Compared with the pre-

COVID-19 time, the consumer survey by Hunter⁶ reported that 54% of the respondents switched to home cooking during the pandemic, for reasons such as saving money, relaxing, and maintaining a healthy diet. More home cooking also changed people's food procurement behaviors. For example, it was reported that 53% of American consumers stockpiled groceries during the pandemic.⁷ Many also purchased food storage equipment or developed urban gardens to prepare for lasting and unforeseeable impacts.

The changes in food procurement patterns could be perceived as the result of risk aversion against adverse health outcomes.⁸ Specifically, as people were uncertain about whether their interpersonal interactions and contacts with in-store facilities would expose them to the virus, they may break the regularity of food

* Corresponding author.

E-mail address: xiang.chen@uconn.edu (X. Chen).

patronization, such as reducing the frequency of food procurement trips. These behavioral changes have posed formidable challenges for low-income, food-insecure populations, who had difficulty in maintaining healthy diets even before the pandemic.^{9,10} To alleviate the financial hardships for food-insecure populations, the Food and nutrition services (FNS) of the U.S. Department of Agriculture (USDA) increased the coverage of the nutrition assistance programs, such as the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), by increasing onsite free meals and providing meal delivery services during business shutdowns and school closures.¹¹ However, it was reported that more than 54 million people in the U.S. still faced the food insecurity issue as the pandemic evolved,¹² indicating that the imbalance between food provisioning and food demand has been a paramount societal concern. However, little research has explored the impacts of COVID-19 on food-insecure populations given their relative resource scarcity.

This article examines the food procurement behaviors during the early outbreak of COVID-19 using a nationwide survey, with particular attention paid to food-insecure populations. We used a moderated mediation analysis to examine changes in food procurement behaviors, which had not been explored via a thorough literature search at the time of the study.

Methods

Conceptual framework

The emergence of the COVID-19 pandemic imposed a safety barrier on all populations. Owing to the risk of pandemic exposure and the implementation of social distancing orders, food consumers, in general, minimize their essential travel, including grocery shopping trips. Intuitively, when people's needs for food increase and their shopping frequency reduces, the food expenditure per trip would boost.

However, COVID-19's spillover effect on societal issues, especially medical bills and unemployment, may complicate food procurement patterns. By June 2020, 7.7 million workers had lost their jobs because of the pandemic.¹³ The loss of income has forced people to deplete savings and face challenges of sustaining basic nutrition needs. A cascading issue arising from unemployment is food insecurity, referring to the status in which individuals or households lack resources to maintain healthy and affordable diets.¹⁴ Studies have shown that food-insecure populations are regarded as budget shoppers who are more sensitive to price changes and have lower expenditure per shopping trip.^{15–17} During the COVID-19, the loss of income could transform people into food-insecure, budget shoppers, while bringing contingent yet lasting impacts on their nutritional well-being. We thus propose a conceptual framework to explore the impact of risk perception and resource scarcity on food procurement as a result of the pandemic (Fig. 1).

Survey instrument and data

To investigate the impact of risk perception and resource scarcity on food procurement behaviors due to the rise of the pandemic, we operationalized the conceptual framework into measurable items in a questionnaire. The questionnaire included four sections. First, participants were asked to recall their grocery shopping trips during the early outbreak in April 2020. Cognitive and behavioral questions relating to their last grocery shopping trip, including in-store safety perception (in a 5-point Likert scale), in-store duration of stay (in minutes), travel duration from home to store (in

minutes), and total food expenditure (in U.S. dollars) were assessed for each participant. Second, respondents were asked to answer the same set of questions by recalling their grocery shopping trips undertaken in 2019. The '2019 responses' were established as a control condition to evaluate the participant's behavioral changes during the pandemic. Third, we used an existing 2-item screen to identify participants with food-insecure status: 'I worried whether my food would run out before I got money to buy more' and 'the food I bought just didn't last and I didn't have money to get more.'¹⁸ This 2-item screen was assessed using a 5-point Likert scale, where a response of 3 = 'somewhat agree,' 4 = 'agree,' or 5 = 'strongly agree' to either question labeled the participant as food-insecure. Fourth, the questionnaire also asked for respondents' demographic information, including gender, educational attainment, and employment status during the pandemic. To minimize the variance in data collected from the same respondent, the protocols by Kamran-Disfani et al.¹⁹ were applied.

The web-based survey was distributed on Amazon Mechanical Turk and lasted for about one month in May 2020. Responses from 2590 participants living in all 50 U.S. states were collected. A total of 2388 respondents (92.2%) passed the attention check questions and were included as validated responses in the analysis, as shown in Table 1.

We used a series of statistical analyses to examine the people's in-store safety perception change and the resulting food procurement behavioral changes. First, a t-test was conducted to examine the change in perceived in-store safety, shopping frequency, and food expenditure. Then, we used a moderated mediation analysis to identify the associations among the in-store safety perception change, shopping frequency change, and food expenditure change, and how an individual's food security status mediated these changes. Finally, a regression analysis was conducted to quantify the changes in food procurement behaviors by the consumer's food security statuses before and during COVID-19.

Results

We first performed the t-test to compare the changes in food procurement behaviors before and during the pandemic, as shown in Table 2. The table reveals that, in general, food consumers' safety perceptions of the in-store shopping environment significantly decreased by 0.9 point on a 5-point Likert scale ($t = -40.42$, $P < .01$); consumers significantly reduced their shopping frequency ($t = -25.23$, $P < .01$) and increased their food expenditure from \$119.91 to \$131.42 per trip ($t = 8.24$, $P < .01$).

Then, we conducted a moderated mediation analysis using the PROCESS Model 14 to explore variables associated with the food expenditure change (i.e., dependent variable). The PROCESS model is an advanced macro built in the SPSS software to perform customized mediation and moderation analyses.²⁰ The independent variable was the in-store safety perception change, the mediator variable was the shopping frequency change, and the moderator was the food security status during the pandemic (secure or insecure). The control variables included travel time change (in minutes), shopping duration change (in minutes), online food procurement during the pandemic (Y/N, dummy variable), the difference in free time (in minutes), gender (male/non-male, dummy variable), employment status (Y/N, dummy variable), education attainment (college or above/else, dummy variable), residential neighborhood (urban/rural, dummy variable), local infection rate (infections per total population), and local death rate (deaths per total population). The result is shown in Table 3.

Table 3 reveals the relationships among the behavioral changes: the increase in in-store safety perception was associated with both the decrease in shopping frequency ($\beta = 0.18$, $P < .01$) and the

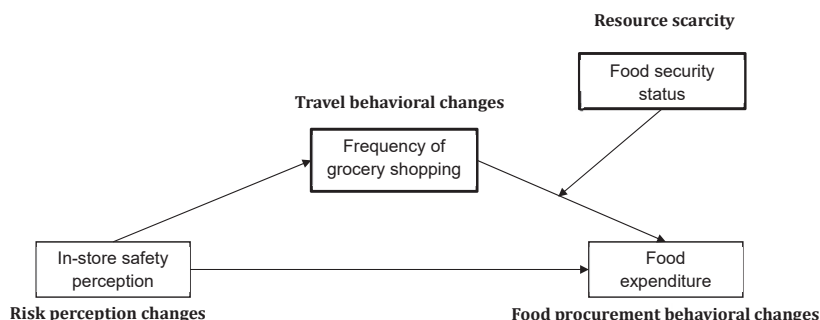


Fig. 1. Conceptual framework of the study.

Table 1 Demographics of survey participants.

Variable	Subgroup	N (percentage)
Gender	Male	1359 (56.9%)
	Non-male	1029 (43.1%)
Age in years	18–24	156 (6.53%)
	25–34	1039 (43.51%)
	35–44	595 (24.92%)
	45–54	365 (15.28%)
	55–64	177 (7.41%)
Ethnicity	65 and above	56 (2.35%)
	Caucasian	1692 (70.85%)
	African American	342 (14.32%)
	Latino	129 (5.40%)
	Asian	160 (6.70%)
	Native American	37 (1.55%)
Educational attainment	Other	28 (1.17%)
	Finished middle school	8 (0.34%)
	Finished high school	201 (8.42%)
	Some college	398 (16.67%)
	Completed 2-year college	220 (9.21%)
	Completed 4-year college	1278 (53.52%)
	Attended graduate school	283 (11.85%)
Employment	Employed for wages	1998 (83.67%)
	Not employed for wages	390 (16.33%)
Food security status (before-during the pandemic)	Secure-secure	1535 (64.28%)
	Secure-insecure	438 (18.34%)
	Insecure-secure	24 (1.01%)
	Insecure-insecure	1535 (64.28%)

increase in food expenditure ($\beta = -7.00, P < .01$). In addition, people’s food security status during the pandemic further impacted the relationship between shopping frequency and food expenditure, as shown by the interaction term ($\beta = -22.68, P < .01$). This result indicates that the mediation effects on food procurement differ among people in different food security statuses.

We further examined how people’s food security statuses before and during the pandemic (before-during) affected their food procurement behaviors. Based on Fig. 2, we categorized the subjects into four subgroups: insecure-insecure ($N = 1,535, 64.28%$), insecure-secure ($N = 24, 1.00%$), secure-insecure ($N = 438, 18.34%$),

and secure-secure ($N = 391, 16.37%$). We found that people who experienced the transition in food security status during the pandemic reduced the frequency of food trips (i.e., the green and red lines in Fig. 2), compared with other two subgroups.

We then conducted a regression analysis on each subgroup to quantify how the changes in food procurement behaviors differ by food security status, where the food expenditure change was the dependent variable and the shopping frequency change was the independent variable (Table 4). It is found that the people having a food-secure status before the pandemic spent significantly more as a result of the reduced shopping frequency (i.e., the secure-insecure

Table 2 Comparison of food procurement behaviors before and during the pandemic ($N = 2388$).

	Before COVID-19	During COVID-19	Difference	t-value (t)
In-store safety perception ^a	4.66 (.01)	3.76 (.02)	-0.90**	-40.42
Shopping frequency ^b (standard error [S.E.])	4.43 (.02)	3.95 (.02)	-0.47**	-25.23
Food expenditure ^c (S.E.)	4.35 (.02)	4.47 (.02)	0.12**	8.24

**Difference is significant at .01.

^a On a 5-point Likert scale, where one denotes ‘very unsafe’ and five denotes ‘very safe.’

^b Evaluated by the frequency of in-store visits per month.

^c Evaluated by U.S. dollars in natural logarithm.

Table 3
Moderated mediation analysis of changes in food procurement behaviors.

Mediator: Shopping frequency change					
Type	Variable	Coefficient (β)	S.E.	t	
Independent variable	In-store safety perception change	0.18^b	0.02	10.59	
Control variable	Travel time change	0.01	0.01	-1.15	
	Shopping duration change	0.01 ^b	0.01	5.01	
	Online food procurement (Y)	0.01	0.04	0.31	
	Difference in free time	-0.02 ^b	0.01	-3.17	
	Gender (male)	0.07	0.04	1.85	
	Employment status (Y)	-0.08	0.05	-1.53	
	Education (college or above)	-0.02	0.01	-0.42	
	Residential neighborhood (urban)	-0.04	0.04	-0.87	
	Local infection rate	-4.73	8.14	-0.58	
	Local death rate	108.94	101.62	1.07	
Intercept	Intercept	-0.18 ^a	0.07	-2.49	
Dependent variable: Food expenditure change					
Type	Variable	β	S.E.	t	
Independent variable	In-store safety perception change	-7.00^b	1.53	-4.59	
Mediation term	Shopping frequency change	-9.98^b	1.89	-5.27	
	Food security status	-9.30	4.91	-1.90	
Control variable	Interaction term	-22.68^b	4.84	-4.68	
	Travel time change	0.01	0.01	0.16	
	Shopping duration change	1.05	0.09	11.65	
	Online food procurement (Y)	3.87	3.32	1.17	
	Difference in free time	-0.41	0.61	-0.67	
	Gender (male)	2.18	3.16	0.69	
	Employment status (Y)	6.38	4.34	1.47	
	Education (college or above)	2.41	3.68	0.65	
	Residential neighborhood (urban)	0.22	3.82	0.06	
	Local infection rate	-557.45	697.20	-0.80	
	Local death rate	13866.50	8704.23	1.59	
	Intercept	Intercept	-2.98	6.17	-0.48

^a Difference is significant at .05.

^b Bold text indicates numbers mentioned in the text. Difference is significant at .01.

subgroup $\beta = -0.18, P < .01$; the secure-secure subgroup $\beta = -0.35, P < .01$). The increase in food expenditure was insignificant for people who were food-insecure before the pandemic (i.e., the insecure-insecure subgroup, $\beta = -0.01, P > .05$; the insecure-secure subgroup, $\beta = -0.11, P > .05$).

The results signify that those in a food-secure status before the pandemic were more likely to spend on and stockpiling food because of their relative financial advantages. In contrast, those subject to food insecurity before the pandemic were less likely to increase spending on food even if they tentatively reduced the frequency of store patronization. The finding further suggests that although risk perception can significantly influence people's food procurement behaviors, such as food expenditure, these influences

do not manifest on food-insecure populations because of the resource scarcity or the lack of financial resilience to disastrous events.

Discussion

The study is situated within the unique context of the COVID-19 pandemic, during which food consumers, in general, perceived that shopping groceries at a brick-and-mortar store may pose considerable health risks because of the potential epidemic exposure. Therefore, examining how people behaved differently for food procurement during the pandemic in terms of their trip frequencies

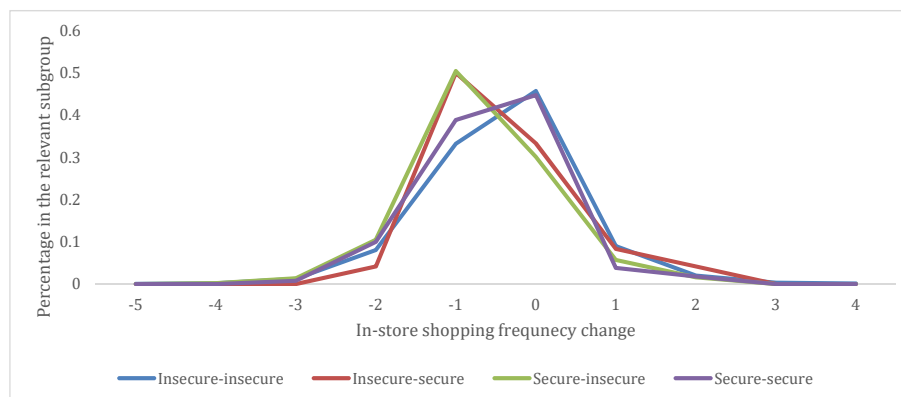


Fig. 2. In-store shopping frequency change categorized by food security status before and during the pandemic (before-during).

Table 4
Regression analysis of changes in food procurement behaviors by food security status subgroup.

Independent variable	Insecure–insecure ^a (N = 1535)			Insecure–secure ^b (N = 24)			Secure–insecure (N = 438)			Secure–secure (N = 391)		
	β	S.E.	t	β	S.E.	t	β	S.E.	t	β	S.E.	t
Shopping frequency change	-0.01	0.02	-0.14	-0.11	0.17	-0.66	-0.18^c	0.03	-5.41	-0.35^c	0.04	-9.76
In-store safety perception change	-0.06^c	0.02	-2.48	0.22	0.10	2.30	-0.11^c	0.03	-4.07	-0.08^c	0.02	-3.53
Travel time change	0.01	0.01	6.80	-0.01	0.03	-0.35	-0.01^c	0.01	-1.08	0.01	0.01	0.68
Shopping duration change	0.01 ^c	0.01	8.97	0.02	0.01	2.88	0.01 ^c	0.01	6.67	0.01 ^c	0.01	6.42
Online food procurement (Y)	0.11 ^b	0.03	3.03	0.33	0.24	1.35	-0.03	0.04	-0.62	0.01	0.05	0.24
Difference in free time	-0.01	0.01	-0.49	-0.03	0.02	-1.33	-0.01	0.01	-0.15	0.01	0.01	1.20
Gender (male)	-0.04	0.04	-1.03	-0.32	0.20	-1.64	-0.04	0.05	-0.93	0.06	0.05	1.21
Employment status (Y)	0.04	0.05	0.78	0.21	0.29	0.73	0.15 ^b	0.07	2.14	0.03	0.07	0.46
Education (college or above)	0.04	0.05	0.89	0.39	0.19	2.11	-0.04	0.05	-0.84	0.05	0.05	1.02
Residential neighborhood (urban)	-0.03	0.05	-0.68	-0.80	0.63	-1.28	0.05	0.06	0.98	0.01	0.05	0.04
Local infection rate	-4.47	7.90	-0.57	-34.83	69.94	-0.50	-11.95	9.06	-1.32	-6.47	9.87	-0.66
Local death rate	91.30	97.50	0.94	939.25	2370.16	0.40	229.95	125.45	1.83	6.54	171.76	0.04
Intercept	0.07	0.08	0.97	0.81	0.73	1.10	-0.13	0.09	-1.46	-0.19 ^b	0.10	-1.86

^a Less than 1% of respondents declared insecure–secure. The small sample size did not warrant the significance of the result in the subgroup.

^b Difference is significant at .05.

^c Bold text indicates numbers mentioned in the text. Difference is significant at .01.

and expenditures could help evolve the theory of risk perception and has important health policy implications.

The results show that, on average, food consumers chose to reduce the frequency of visits to grocery stores during the pandemic. The reduction in food procurement trips did not lower the demand for food among food-secure consumers; instead, food-secure consumers tended to stockpile food by spending more during each trip, likely due to the fear of epidemic exposure and the preparation for food shortage events.²¹ Specifically, the study reveals the mediating effects of two important factors on food procurement, referring to risk perception and resource scarcity. First, the study identifies that all people intentionally undertook fewer in-store shopping trips to avoid epidemic exposure. This avoidance behavior, as a result of the change in risk perception, manifested the most among those characterized as food-secure before and during the pandemic (i.e., the secure-secure subgroup). Second, the study reveals that food-insecure populations had a significantly smaller margin in food expenditure. Thus, the food-insecure populations may not have changed their food procurement behaviors due to their budget constraints and the lack of resources to prepare for emergencies.

The study provides evidence for stakeholders to develop strategic initiatives and support populations who were victimized by the pandemic. Specifically, food-insecure populations had to reduce the frequency of regular grocery shopping because of the elevated risk perception and safety concerns. However, they could not afford a large expenditure on food purchases due to their deteriorating financial situations in the pandemic and could thus suffer from a potential food shortage crisis. To ameliorate these situations, public health policymakers should customize and implement nutrition assistance programs that prioritize food-insecure populations in a more flexible and timely manner. Some of the ongoing efforts include lifting the qualification requirements for numerous nutrition assistance programs, providing temporary benefits for schools (i.e., P-EBT), and allowing online food purchasing for SNAP benefits.¹¹

Nonetheless, the study is subject to limitations. The foremost issue is the short duration of the survey period, which was limited to only the early outbreak in May 2020. With the escalating cases of infection, federal and local governments have stressed the importance of social distancing on possible occasions.^{22,23} As these non-pharmaceutical interventions became widespread, food consumers developed a herd mentality of avoiding virus exposure, increased awareness of health consequences, and complied with authoritative suggestions to reduce out-of-home activities, including food procurement. Follow-up surveys on the same group of participants and the employment of a latent growth model could reveal these evolving food procurement patterns in a changing pandemic situation. Second, using the survey method alone is unable to reveal the context where food is procured.²⁴ For the socio-economically disadvantaged populations, considerable difficulties (e.g., more responsibility for childcare, lack of health insurance) arising from the resource scarcity may exacerbate food insecurity. Therefore, a mixed-method study to incorporate individual interviews and focus-group discussions with food-insecure populations will help recognize these acute challenges in food procurement and will better justify health inequity. Finally, as the study was situated in the U.S., the conclusion is not applicable to other world regions. Future research could replicate data collection and methods in low- and middle-income countries. This extended effort can facilitate the understanding of food procurement behavioral changes among populations in low- and middle-income countries, eventually providing evidence to ameliorate global food insecurity during and post COVID-19.

Author statements

Ethical approval

The field survey in the study was approved by the Institutional Review Board at University of Connecticut under Protocol X20-0096.

Funding

This work was supported by the University of Connecticut Institute for Collaboration on Health, Intervention, and Policy (InCHIP) Covid-19 Rapid Grant. This work was based in part upon the work of the Geospatial Fellows program supported by the National Science Foundation (NSF) [grant number: 1743184]; any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.

Competing interest

No potential conflict of interest was reported by the authors.

References

1. Aday S, Aday MS. Impact of COVID-19 on the food supply chain. *Food Quality and Safety* 2020;**4**(4):167–80.
2. de Sousa Jabbour ABL, Jabbour CJC, Hingley M, Vilalta-Perdomo EL, Ramsden G, Twigg D. Sustainability of supply chains in the wake of the coronavirus (COVID-19/SARS-CoV-2) pandemic: lessons and trends. *Modern Supply Chain Res App* 2020;**2**(3):117–22.
3. Espitia A, Rocha N, Ruta M. *Covid-19 and food protectionism: the impact of the pandemic and export restrictions on world food markets*. The World Bank; 2020.
4. Askew K. *Life in lockdown: coronavirus prompts half of French consumers to reappraise "value" of food*. 2020. <https://www.foodnavigator.com/Article/2020/05/29/Life-in-lockdown-Coronavirus-prompts-half-of-French-consumers-to-reappraise-value-of-food>. [Accessed 12 April 2021].
5. Sheth J. Impact of Covid-19 on consumer behavior: will the old habits return or die? *J Bus Res* 2020;**117**:280–3.
6. *Hunter food study special report*. 2020. https://www.hunterpr.com/foodstudy_coronavirus/. [Accessed 12 April 2021].
7. Redman R. *U.S. consumers ready to stockpile groceries again*. 2020. <https://www.supermarketnews.com/consumer-trends/us-consumers-ready-stockpile-groceries-again>. [Accessed 12 April 2021].
8. Lim N. Consumers' perceived risk: sources versus consequences. *Electron Commer Res Appl* 2003;**2**(3):216–28.
9. Devereux S, Béné C, Hoddinott J. Conceptualising COVID-19's impacts on household food security. *Food Security* 2020;**12**(4):769–72.
10. Fan S. *Preventing global food security crisis under COVID-19 emergency*. International Food Policy Research Institute; March 6, 2020, 2020.
11. FNS. *FNS responds to COVID-19*. 2020. <https://www.fns.usda.gov/coronavirus>. [Accessed 12 April 2021].
12. Blach B. *54 million people in America face food insecurity during the pandemic. It could have dire consequences for their health*. 2020. <https://www.aamc.org/news-insights/54-million-people-america-face-food-insecurity-during-pandemic-it-could-have-dire-consequences-their>. [Accessed 12 April 2021].
13. Fronstin PW, SA. *How many Americans have lost jobs with employer health coverage during the pandemic?*. 2020. <https://www.commonwealthfund.org/publications/issue-briefs/2020/oct/how-many-lost-jobs-employer-coverage-pandemic>. [Accessed 12 April 2021].
14. Gundersen C, Ziliak JP. Food insecurity and health outcomes. *Health Aff* 2015;**34**(11):1830–9.
15. Heath C, Soll JB. Mental budgeting and consumer decisions. *J Consum Res* 1996;**23**(1):40–52.
16. Sheehan D, Van Ittersum K. In-store spending dynamics: how budgets invert relative-spending patterns. *J Consum Res* 2018;**45**(1):49–67.
17. Thaler R. Mental accounting and consumer choice. *Market Sci* 1985;**4**(3):199–214.
18. Hager ER, Quigg AM, Black MM, et al. Development and validity of a 2-item screen to identify families at risk for food insecurity. *Pediatrics* 2010;**126**(1):e26–32.
19. Kamran-Disfani O, Mantrala MK, Izquierdo-Yusta A, Martínez-Ruiz MP. The impact of retail store format on the satisfaction-loyalty link: an empirical investigation. *J Bus Res* 2017;**77**:14–22.
20. Hayes AF. *Introduction to mediation, moderation, and conditional process analysis: a regression-based approach*. Guilford publications; 2017.
21. Eastman J. *What did the pandemic teach about stocking up for an emergency? Plenty*. The Oregonian; June 1, 2020, 2020.
22. Adams A, Li W, Zhang C, Chen X. The disguised pandemic: the importance of data normalization in COVID-19 web mapping. *Publ Health* 2020;**183**:36.
23. Chen X, Zhang A, Wang H, Gallaher A, Zhu X. Compliance and containment in social distancing: mathematical modeling of COVID-19 across townships. *Int J Geogr Inf Sci* 2021;**35**(3):446–65.
24. Chen X, Kwan M-P. Contextual uncertainties, human mobility, and perceived food environment: the uncertain geographic context problem in food access research. *Am J Publ Health* 2015;**105**(9):1734–7.