Fruit and Vegetable Consumption, Food Acquisition Behavior, and Food Insecurity Before and After the COVID-19 Vaccine Rollout

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ABSTRACT

Objectives: To assess changes in food acquisition behavior, food insecurity, and dietary behavior and identify factors associated with fruit and vegetable (FV) consumption during the transitional period (before and after the initial vaccine rollout for all adults) of the COVID-19 pandemic.

Design: Successive independent samples design. Online surveys were conducted from October 2020 to February 2021 (time 1, before the vaccine rollout) and from October 2021 to December 2021 (time 2, after the vaccine rollout). Descriptive analysis examined changes in food sources, food security, and daily FV consumption in cup equivalents (CEs) from time 1 to time 2. A multivariable logistic regression analysis examined factors associated with FV consumption.

Setting: The Capital Region of New York State.

Participants: 1553 adults 18 years of age and older.

Main Outcome Measure: Meeting the 2020-2025 MyPlate daily FV consumption recommendations.

Results: There were statistically significant ($P < .05$) increases in the use of supermarkets, eat-in restaurants, farmers' markets, and convenience stores from time 1 to time 2. Food insecurity (40.1% vs 39.4%) and FV consumption (2.6 CE vs 2.4 CE) slightly declined but not significantly. Home food procurement such as gardening and foraging (OR, 1.61; 95% CI, 1.08-2.37) and shopping at food co-op/health food stores (OR, 1.64; 95% CI, 1.07-2.49) were significantly associated with the FV outcome, and these relationships were not modified by food security status.

Conclusions: The present study highlights the importance of food sources in understanding adult dietary behavior during the transitional period of the pandemic. Continuing efforts to monitor access to food sources, food insecurity, and dietary behavior are warranted as various COVID-related emergency food assistance measures have expired.

KEY WORDS: COVID-19, food insecurity, food sources, fruit and vegetable consumption

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The COVID-19 pandemic has created a major health crisis worldwide. Food shortages emerged largely due to disturbances in food production and the supply chain.[1] Furthermore, many governments enacted emergency legislation to restrict the operations of food retailers and restaurants to reduce community transmission of COVID-19. Accessing food became a daily challenge early on, and job losses and decreased income added a burden to purchasing food.[2]

Americans across the nation reacted to the disrupted food access by quickly changing their food acquisition and food preparation behaviors, with increased reliance on online shopping, grocery delivery/pickup services, restaurant takeouts, stockpiling, and home cooking.[1,3,4] Furthermore, the COVID-19 pandemic significantly decreased food security in the United States, in particular among low-income racial/ethnic

minority households, food assistance program participants, and individuals who experienced job disruption.[5,6] Some studies reported that food security status modified food shopping behavior: Food insecure individuals were more likely to purchase large quantities of foods due to sudden fears of a forthcoming shortage[3] and rely on restaurant food and groceries from food pantries compared with food secure individuals.[7]

The pandemic also influenced adults' dietary behaviors in the United States and abroad. Reported dietary behavioral changes include increased frequencies of snacking,[1] increased consumption of sweets and starchy foods,[8] decreased fast food consumption,[1] and increased intake of fruits, vegetables, and dairy.[9] It is likely that pandemic-period dietary behaviors were influenced or modified by changes in food access and/or food security status, but very few studies have investigated this topic.

The present study is rooted in the need to understand how food-related behaviors changed as the pandemic proceeded beyond that early phase, particularly the shifts that occurred as society began to reopen following the initial vaccine rollout. To our knowledge, no COVID-related nutrition behavior or food security study has incorporated the contextual changes before and after the vaccine rollout. Understanding the shifts provides insights that can be useful in broader efforts to understand food security and behavioral responses and recovery that occur as food availability, emergency food assistance policy, and other factors shift following emergencies.

Bearing these research gaps and societal implications in mind, our team conducted surveys directed at samples of adults of all income levels and diverse racial/ethnic backgrounds in 2020 and 2021. The purpose of this study is 2-fold. The first purpose is to describe changes in food acquisition behavior, food security status, and fruit and vegetable (FV) consumption during the transitional period before and after the COVID-19 initial vaccine rollout. The second purpose is to investigate the factors associated with FV consumption through a multivariable statistical model that includes food acquisition sources, food insecurity, food assistance program participation, and pandemic period as potential associative or effect-modifying variables.

Methods

Study setting and background

The setting of this study was the Capital Region of New York State, which encompasses 11 counties with a population of approximately 1.24 million. The Albany-Schenectady-Troy Metropolitan Statistical Area (MSA) is the population center of this region.

Data collection

This study used a successive-independent-samples design, where independent samples were taken from the same source population at different time periods. We conducted 3 online Food Access Surveys (FAS). The first survey (FAS1) was from October 10, 2020, to January 31, 2021. The second survey (FAS2), which was added to augment representations of low-income and racial/ethnic minority individuals while FAS1 was still running, was from January 5 to February 7, 2021. The third survey (FAS3) was from October 20 to December 13, 2021. We adapted the survey questionnaire developed by the National Food Access and COVID research Team, a consortium to assess COVID-related food security at different United States study sites. The questionnaire, which included questions on sociodemographic characteristics, food acquisition behavior, food security, food assistance program participation, and dietary intake, among others, had previously been pilot-tested and validated.[10]

The eligibility criteria for the surveys were adults aged 18 or older, living in one of the 11 study counties, and being able to consent and take a self-administered online survey in English or Spanish. Participants in FAS1 and FAS3 were drawn from the Qualtrics survey company's online panel. Participants in FAS2 were recruited via emails and flyers sent by local partner organizations and targeted advertising through Facebook. There were incentives for survey participation. Participants in FAS1 and FAS3 received "points" appropriate for the length and complexity of the survey by Qualtrics, which would be exchanged for monetary rewards later. FAS2 participants received a $15 e-commerce gift card.

Measurements

We measured food acquisition by a series of questions that asked about places and programs the participant's household used to acquire food. Food security status was measured by the US Department of Agriculture (USDA) 6-item Short Form Food Security Survey Module. We asked daily FV consumption by cup equivalent (CE) using 2 questions: "About how many cups of fruit, including 100% pure fruit juice, do you eat or drink each day?" and "About how many cups of vegetables, including 100% vegetable juice, do you eat or drink each day?" We provided several examples of CE for popular fruits, vegetables, and juices to assist in cup conversion.

Data analysis

Because FAS1 and FAS2 had an overlap of survey periods and were administered before the COVID-19 vaccine rollout for all adults, we merged these 2 surveys to form data for "time 1" of the pandemic (ie, from October 10, 2020, to February 7, 2021, or the 7th to the 11th months of the pandemic). FAS3 was used alone to form data for "time 2" (ie, from October 20, 2021, to December 13, 2021, or the 19th to the 21st months of the pandemic) after the vaccine rollout. Using chi-square tests (for categorical variables) and *t* tests (for continuous variables), we confirmed that FAS1 and FAS2 respondents were not significantly different from each other in key demographics, food acquisition behavior, food security status, and FV consumption ($P < .05$).

For descriptive analysis, we computed sampling weights based on household income. By applying the sampling weights, the distribution of household income in each dataset would become identical to that for the 11 study counties by the 2020 US population census. The results generated from the weighted analysis were thus income standardized. We ran analyses for food sources, food security, and FV consumption for time 1 and time 2, with chi-square tests and *t* tests to evaluate the changes over time.

Next, we created multivariable logistic regression models of FV consumption using the combined dataset. The outcome was a dichotomous variable indicating whether the daily consumption of FV was meeting or not meeting the 2020-2025 MyPlate FV recommendations. MyPlate is a consumer-translated version of the Dietary Guidelines for Americans by the USDA. The 2020-2025 MyPlate recommends daily consumption of at least 1.5 to 2.0 CE of fruits and 2.0 to 3.0 CE of vegetables for adults, depending on age and sex. The independent variables were food sources, food insecurity, participation in the Supplemental Nutrition Assistance Program (SNAP), and pandemic period (time 1 vs time 2). The covariates included age, gender identity, race/ethnicity, household income, and county of residence. We employed a backward elimination process for model building and used the Akaike Information Criterion for evaluating model fit. Sampling weights were not applied to this analysis because we included household income as a covariate. We tested whether food security status would act as an effect modifier.

Results

A total of 1553 respondents, consisting of 1049 respondents from the pre-vaccine rollout time 1 sample (595 from FAS1 and 454 from FAS2) and 504 respondents from the post-vaccine rollout time 2 sample, were in this study. The weighted sociodemographic profile of respondents is presented in Table 1. Briefly, 38% of all respondents had a household income of less than $50 000 a year, which reflected the income distribution of the Capital Region of New York State. A majority of respondents were non-Hispanic whites, women, and those living in the Albany-Troy MSA, and there were no significant ($P < .05$) differences between time 1 and time 2 samples in those variables.

Descriptive analysis

Table 2 summarizes food acquisition behavior. The most used source was supermarkets, with a significant increase (77.9% vs 87.5%) from time 1 to time 2 of the pandemic. That was followed by restaurant delivery/takeout, which also increased, but not significantly (64.3% vs 67.9%). Besides supermarkets, usage of eat-in restaurants (24.3% vs 45.4%), farmers' markets (25.7% vs 32.9%), and convenience stores (40.2% vs 45.8%) significantly increased ($P < .05$) from time 1 to time 2, while reported use of Meals on Wheels, a home meal delivery service for the elderly decreased (13.1% vs 8.7%). About a quarter of respondents used gardening/foraging/fishing/hunting (25.2% vs 24.4%) and food co-op/health food stores (22.9% vs 22.0%) during time 1 and time 2.

Food insecurity decreased (40.1% vs 39.4%), and SNAP participation increased (19.8% vs 24.0%), but these changes were not statistically significant. The mean daily fruit consumption (1.2 CE vs 1.1 CE) and the mean daily vegetable consumption (1.4 CE vs 1.3 CE) also had no significant change over time, though the trend was toward fewer cups per day. Reflecting this trend, individuals meeting the MyPlate daily FV consumption recommendations declined from 13.8% to 11.4%, but not significantly.

Multivariable logistic regression analysis

Table 3 presents the result of multivariable logistic regression analysis for meeting the MyPlate combined daily FV consumption recommendations. The analysis, which controlled for age, gender identity, race/ethnicity, household income, and county of residence, indicated that obtaining food from gardening/foraging/fishing/hunting (OR, 1.61; 95% CI, 1.08-2.37) and food co-op/health food stores (OR, 1.64; 95% CI, 1.07-2.49) was positively and significantly associated with meeting the MyPlate FV recommendations. Food security status, SNAP participation, and

TABLE 1
Sociodemographic Characteristics of the Samples (Weighted)

	Time 1		Time 2		
	n	%	n	%	*P*-value
Household income					1.0
<$10 000	49	4.7	23	4.6	
$10 000-$24 999	134	12.8	64	12.7	
$25 000-$49 999	216	20.6	104	20.7	
$50 000-$74 999	182	17.3	87	17.3	
$75 000-$99 999	143	13.6	69	13.7	
≥$100 000	326	31.0	156	31.0	
Race and ethnicity					.08
Asian and Pacific Islander	55	5.2	13	2.6	
Black, non-Hispanic	105	10.0	42	8.3	
Hispanic	92	8.7	35	6.9	
Native American	6	0.6	2	0.4	
White, non-Hispanic	758	71.8	393	77.7	
Other	39	3.7	21	4.2	
County of residence					.63
Albany-Troy-Schenectady MSA	813	77.5	385	76.4	
Non-MSA	236	22.5	119	23.6	
Age, y					<.001
18-34	368	35.1	156	31.0	
35-54	386	36.8	153	30.4	
55 and older	295	28.1	195	38.7	
Gender identity					.22
Men	332	31.6	139	27.6	
Women	706	67.2	357	70.8	
Transgender/nonbinary	12	1.1	8	1.6	
Education					.001
High school or less	154	14.7	121	24.0	
Some college or associate degree	360	34.4	182	36.1	
College or advanced degree	534	51.0	201	39.9	
In the labor force					
Yes	678	64.6	267	52.9	<.001
No	366	34.9	236	46.8	
SNAP participation					
Yes	208	19.8	121	24.0	.06
No	841	80.2	383	76.0	

Abbreviations: MSA, Metropolitan Statistical Area. Other race/ethnicity category includes multiple races and write-in categories. Chi-square tests were used to generate P values.

pandemic period (time 2 vs time 1) did not have significant independent associations with the outcome. Furthermore, food security status did not significantly modify the association between food sources and FV consumption.

Discussion

This study reported changes in food acquisition behavior, food security, and FV consumption from the pre-vaccine rollout (time 1) to the post-vaccine rollout

TABLE 2

Food Acquisition Behavior, Food Security, and FV Consumption Measured by MyPlate Recommendations for Time 1 and Time 2 (Weighted)

	Time 1		Time 2		*P*-value
Food source (n, %)					
Supermarket	817	77.9	441	87.5	<.001
Restaurant delivery or takeout	674	64.3	342	67.9	.16
Convenience store	422	40.2	231	45.8	.04
Grocery delivery	376	35.8	199	39.5	.16
Farmers' market	270	25.7	166	32.9	.003
Gardening, fishing, foraging, and hunting	264	25.2	123	24.4	.75
Eat-in restaurant	255	24.3	229	45.4	<.001
Food co-op, health food store	240	22.9	111	22.0	.71
Food pantry	234	22.3	97	19.2	.17
Direct from farm	190	18.1	80	15.9	.28
International/cultural food store	168	16.0	85	16.9	.67
Meal-kit delivery	165	15.7	83	16.5	.71
Meals on Wheels	137	13.1	44	8.7	.01
Congregate meal program	87	8.3	50	9.9	.29
Food security (n, %)					
Food insecure	399	40.1	154	39.4	.82
FV consumption (mean, SD)					
Fruit per day (CE)	1.2	1.0	1.1	1.0	.51
Vegetable per day (CE)	1.4	1.0	1.3	0.9	.52
MyPlate recommendations (n, %)					
Meeting the combined FV recommendations	143	13.8	57	11.4	.18

Abbreviations: CE, cup equivalent; FV, fruit and vegetable; SNAP, Supplemental Nutrition Assistance Program. Chi-square tests (for nominal variables) and t tests (for continuous variables) were used to generate P values.

(time 2) of the COVID-19 pandemic and identified factors associated with meeting the MyPlate daily FV consumption recommendations.

Our descriptive analysis indicated that supermarkets and restaurant delivery/takeout continued to be the dominant food acquisition sources in the Capital Region of New York in both time periods. This finding is similar to a finding regarding the shopping behavior of US consumers assessed from September 2020 to March 2021 before the vaccine rollout.[11] In addition, the use of farmers' markets, eat-in restaurants, and convenience stores significantly increased from before and after the vaccine rollout. The increased in-person food shopping and restaurant dining during this period was likely a direct consequence of the lifting of COVID-related restrictions for these businesses by the end of June 2021. The decline in reported use of Meals on Wheels can be attributed to the onetime surge of their home delivery services during time 1. The Meals on Wheels America reported that the COVID-19 Response Fund enabled them to increase the number of seniors served by 47% by July 2020.[12] It is also likely that the reopening of senior congregate meal program sites reduced the need for home delivery services in time 2, and our data supported the increased congregate meal program use during time 2. We note that some respondents may have perceived Meals on Wheels as a generic descriptor for similar services.

The number of respondents who met the criteria for food insecurity declined slightly from time 1 to time 2, though food insecurity was still considerably higher compared to the pre-pandemic level of 28% measured by recalls in the same study community.[13] While many households continued to experience food insecurity, our study indicated that food security status at least did not worsen during time 2. Government interventions to increase food security, in particular various emergency measures to expand SNAP, have been suggested as a major protective factor.[14] The suspension of the 3-month time limit on low-income adults without children to receive SNAP benefits, the

TABLE 3
Multivariable Logistic Regression Model for Meeting the MyPlate FV Consumption Recommendations

Factor		OR	95% CI	*P*-value
Food source	Supermarket	1.27	0.76-2.18	.37
	Restaurant delivery or takeout	1.01	0.68-1.52	.96
	Convenience store	0.72	0.49-1.06	.10
	Grocery delivery	1.11	0.75-1.61	.60
	Farmers' market	1.11	0.73-1.66	.63
	Gardening, foraging, fishing, hunting	1.61	1.08-2.37	.02
	Eat-in restaurant	0.87	0.56-1.31	.50
	Food co-op, health food store	1.64	1.07-2.49	.02
	Food pantry	1.44	0.89-2.33	.13
	Direct from farm	1.27	0.78-2.04	.32
	International/cultural food store	1.13	0.67-1.85	.65
	Meal-kit delivery	1.04	0.61-1.71	.89
	Meals on Wheels	0.9	0.45-1.77	.77
	Congregate meal program	0.55	0.25-1.15	.13
Food security	Secure	1.24	0.79-1.96	.35
	Insecure	1	*Ref*	
SNAP	Yes	1.11	0.67-1.81	.69
	No	1	*Ref*	
Pandemic period	Time 2 (after the vaccine rollout)	0.78	0.50-1.17	.24
	Time 1 (before the vaccine rollout)	1	*Ref*	

Abbreviations: CI, confidence interval; OR, odds ratio; SNAP, Supplemental Nutrition Assistance Program. The presented model is the full model to predict meeting the MyPlate fruit and vegetable consumption recommendations. The model building involved a backward deletion process with the Akaike Information Criterion. The model is adjusted for age, gender identity, race/ethnicity, household income, education, and county of residence.

introduction of Pandemic Electronic Benefits Transfer under the Families First Coronavirus Act, and state-based expansions of SNAP maximum benefits were notable pandemic emergency SNAP measures. Our data also indicated increased SNAP participation during the same period. Furthermore, New York was 1 of the 5 states that allowed SNAP participants to purchase food online at selected stores before and after the pandemic.[15] Although our study did not have a statistically significant food insecurity reduction, a report on New York state households revealed a decline in food insufficiency (ie, sometimes or often not having enough to eat in the previous 7 days) from 10.2% in 2020 to 8.6% in 2021.[16]

FV consumption did not change significantly from time 1 to time 2, though the nonsignificant trend was toward consuming slightly fewer amounts. A pre-pandemic (2013-2016) study using the National Health and Nutrition Examination Survey data indicated that the average FV consumption among US adults was 2.5 CE, which was very similar to our findings even though there were methodological differences.[17] Furthermore, the US-based studies that examined changes in food consumption patterns between pre- and early-pandemic months found most participants self-reported no changes in FV consumption.[1,8,18]

The multivariable logistic regression analysis provided broader insights into FV consumption behavior during the transitional period of the pandemic. When age, gender identity, race/ethnicity, household income, education, and county of residency were controlled in the model, home food procurement (gardening, foraging, fishing, or hunting) and shopping at food co-op/health food stores emerged as significant associative factors of meeting the MyPlate daily FV consumption recommendations. In the literature, home gardening was associated with increased FV consumption in the pre-pandemic era,[19,20] as well as during the early part of the COVID pandemic.[21] Having more time to spend in the gardens was reportedly the most common reason to take up gardening during the pandemic.[22] Since gardening can reduce stress and anxiety and increase environmental awareness, for many, it is a positive behavioral response during the time of a health crisis.[23] Research from the pre-pandemic era also supports the positive association between shopping at food co-op/health food stores and increased FV consumption: adults

who shopped frequently at food co-ops consumed FV significantly more frequently[24] and also had a significantly lower BMI[25] than people who did not, and shopping at health specialty stores at least once a week was associated with higher FV consumption.[26]

In our study as well as in literature, adults who met the MyPlate FV recommendations were a small minority of about 1 in 8 adults.[27] It is argued that adults who had a "healthier diet" characterized by a balanced diet with lower amounts of sweets, salty snacks, and processed foods during the pandemic were more likely to be motivated by health (eg, to maintain a balanced diet and keep in shape) and natural concerns (eg, to consume food that are not genetically modified, organic, and free of harmful substances) and less likely to be influenced by social and emotional motivations.[9] Although our study cannot determine the direction of associations, patronizing food co-op/health food stores seems to be motivated by the respondents' determination to eat healthy amid the COVID pandemic. This is consistent with the assessment that the type of food sources individuals consciously choose is an important determinant of diet quality, regardless of socioeconomic differences.[28]

We identified that all food co-ops and most health food stores in our study area were SNAP retailers; however, these stores tended to operate in middle-income urban and suburban communities.[29] On the other hand, gardening can be practiced in most households and communities. The gardening experience is associated with a variety of positive health outcomes, including improvements in depression and anxiety symptoms, reductions in stress and BMI, and increases in quality of life, physical activity levels, and cognitive function.[30] Providing horticulture education, low-cost gardening equipment, seeds and seedlings, and other efforts to promote gardening as a nutrition intervention may help some households engage in these practices.

In our study, food security status did not modify the associations between food sources and FV consumption during the transitional period of the pandemic. Research conducted in the early-pandemic months showed significantly less FV consumption among food insecure individuals,[18] and that the positive association between home gardening and FV consumption was significant only among food secure individuals.[21] Although our data showed less FV consumption among food insecure individuals, the contribution of food security status was attenuated in the multivariable model. Caution should be taken when comparing the results of existing research and ours because definitions and methods to measure FV consumption differ from study to study.

Implications for Policy & Practice

- Most adults resumed in-person food shopping and restaurant dining following the COVID-vaccine rollout, but there was no significant improvement in food security or FV consumption.
- Home food procurement and shopping at food co-op/health food stores were associated with meeting the MyPlate FV consumption recommendations, and these associations existed regardless of food security status. The finding highlights the importance of food sources in understanding adult dietary behavior during the transitional period of the pandemic.
- Continuing efforts to monitor access to various food sources, food insecurity, and dietary behavior are warranted, as most COVID-related emergency food assistance measures expired by March 2023. Future public health emergency preparedness policy should also continue to focus on assuring access to a variety of food sources, including gardening, for promoting health during a crisis.

There are limitations to this study. Our surveys were administered online, limiting participants to those with information technology literacy and access to an Internet-connected computer or a smartphone. FV consumption was measured by self-reported consumed FV amounts converted into CE units. This may have introduced potential systematic misclassification errors from social desirability (ie, overstating FV consumption) and random error from incorrect CE conversion. The relatively large sample size of this study, however, attenuated the effect of random error. Finally, we did not collect street addresses from respondents because our surveys were anonymous. We were thus unable to incorporate potentially important contextual variables such as neighborhood-level food environment and deprivation in our analysis.

Despite its limitations, this study has several important strengths. It is one of a few studies focused on the critical transitional period of the COVID pandemic before and after the initial vaccine rollout. Our study design allowed us to measure various behaviors and food security status point in time, reducing recall bias. The use of the sampling weights removed the income variability of the samples and increased the generalizability of our descriptive analysis findings. The outcome variable in the logistic regression analysis was based on the USDA's FV consumption goals customized for various age-sex groups, making it easier to translate the results into public health practice.

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