Spring 5-24-2021

The Fruits of Labor: Home Food Procurement Impacts Food Security, Diet Quality and Mental Health During COVID-19

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Food Systems Master's: Final Project

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Introduction

COVID-19 has highlighted the uncertainty and fragility of food security and food access globally. In the United States, unemployment rates reached unprecedented levels at their height in April 2020 (Congressional Research Service, 2020), causing concerns among many Americans about how to access affordable and high-quality food (Callen, 2020). In a rural state such as Vermont, these concerns are especially pressing, as rural areas are estimated to have 50% higher rates of food insecurity than urban areas (Piontak et al., 2014). The stress of this unprecedented period has also had an effect on the mental well-being of many Americans. In a survey from the United States Census Bureau from May 2020, early in the pandemic, respondents reported feeling anxious 30% of the time, and more than 18% reported feeling depressed (Callen, 2020). Opportunities to both improve mental health and food security are thus vital during this pandemic period. Existing evidence suggests that home food procurement (i.e. backyard livestock, fishing, foraging, gardening, hunting, and canning, and backyard livestock production, hereafter referred to as HFP) may offer opportunities to improve diet quality, food security, and mental health via multiple mechanisms. This project explored whether interest and engagement in these activities has increased during the COVID-19 pandemic and if such strategies are providing these health and mental health outcomes.

Justification and Relevant Background

The potential for HFP to improve mental health and dietary outcomes is documented in the literature, including in historical moments such as World War 2. At that time, "victory gardens" were planted as patriotic acts to grow local food amidst disrupted supply chains (Lingeman, 1970). It is estimated that 40% of the nation's fruits and vegetables were produced via victory gardens during the war, demonstrating the potential for HFP to address food security challenges. Since the COVID-19 pandemic began, there have been a number of stories from popular media outlets in the United States discussing a comeback of these victory gardens in response to the pandemic (D'Amelio 2020; Rap 2020). Previous research has found that depictions of wild food foraging in the media change in times of economic hardship from being discussed as more of a luxury to being conceptualized as a way to provide for basic needs (Sachdeva et al., 2018). Public discussion and interest around HFP practices seem to shift in response to economic circumstances, but does participation in these endeavors actually make people more food secure and improve health outcomes? The existing evidence on the

relationship of HFP to food security outcomes is limited, especially in the context of a global pandemic, but it is generally positive through multiple pathways.

First, evidence suggests that growing your own food contributes directly toward food availability and access. Taylor & Lovell (2015) found that, while gardeners did not grow enough to sustain their families, ⅓ grew a substantial quantity and were self-sufficient in providing some items for a certain period of time during the growing season and almost all of these households said they always had enough to eat. Corrigan (2011)'s interviews of five gardeners in Baltimore found that most felt that they saved money from their gardens and that it allowed them to grow quality, fresh produce that they otherwise may not have had access to. They also found that many gardeners canned or froze their excess produce, allowing them access to healthy foods into the winter time. These results may also translate beyond gardening to other food procurement practices, although research is even more limited in these areas. Smith et al. (2019) found that participants from one reservation who participated in the Food Distribution Program on Indian Reservations who also participated in hunting, foraging, and fishing were more food secure than those who did not. Additionally, those who engaged in more than one practice were more secure than those who did only one. Cooke et al. (2018) found that most people who fish consume what they catch, even if their original motivation for fishing is recreation. This direct food procurement may also lead to cost savings realized by not purchasing food, which enables money to be available for the purchase of other foods, or for other financial priorities.

Perceived cost savings does appear to be a common motivation for those producing their own food (Darby et al., 2020; Smith et al., 2019) and there have been a number of studies suggesting that this may in fact be the case (Algert et al., 2014; Gray et al., 2014; Nova et al., 2020; Taylor & Lovell, 2015). Home gardeners in San Jose reported that cost savings of gardening allowed them to eat produce to which they otherwise would not have had access (Algert et al., 2016). However, many studies looking at cost savings were analyzing the results of nonprofit programs in which gardeners were supported with resources to help set up their gardens, and therefore had a smaller up front investment, which could have impacts on food security outcomes. Csortan et al. (2020) found that 65% of gardeners would break even on garden investments in five years or less and then start saving money. In such a case, gardening would not be a sufficient means for achieving food security in the short-term in response to an economic crisis. They also found that the number of years of gardening experience appeared to have a positive impact on productivity and resource efficiency, leading to additional concerns for new gardeners.

In addition to the potential for cost savings and increased food security, HFP may lead to a higher quality, more diverse diet. Growing one's own produce is linked to increased fruit and vegetable intake (Alaimo et al., 2008; Algert et al., 2016; Barnidge et al., 2013; Litt et al., 2011; Nova et al., 2020). Hunting, fishing, and foraging may also lead to a more nutritious and diverse diet; for example, 80% of people surveyed on a native reservation said that hunting, fishing, and foraging made their diets more diverse and 72% said these practices improved the quality of their diet (Smith et al., 2019). Stark et al. (2019) found that wild edible greens were abundant in three low-income neighborhoods in California, and offered the potential nutrient density comparable to some common nutritious vegetables, such as kale. Some research suggests that growing one's own food may also lead to improved nutritional knowledge (Machida and Kushida, 2020; Palar et al., 2019) and changes in eating habits for the long-term (Gray et al. 2014; Kortright and Wakefield, 2011; Palar et al., 2019).

Existing research suggests that HFP may also offer the potential to improve mental well-being. One mechanism for this potential outcome is that HFP are usually done outside, and research has demonstrated many mental health benefits associated with spending time in nature (Chavaly and Naachimuthu, 2020; Korpela et al., 2017; Maller et al., 2006; Russell et al. 2013). A growing body of research in ecopsychology makes the case that this is due to the inextricable link between humans and nature, that our continued industrialization and perceived separation from nature has not only led to the degradation of the planet, but also to the degradation of our own mental well-being (Chavaly and Naachimuthu, 2020; Fisher 1996; Maller et al., 2006). Gardening, in particular, has received a lot of attention in recent decades for its potential to improve mental health outcomes in clinical settings (De sexias et al., 2017; Clatworthy et al., 2013; Parr, 2007; Sempik, 2010). As well, Bennet et al.'s 2017 study of a 4 day fly-fishing trip for veterans showed a short-term impact on the symptoms of PTSD, depression, perceived stress, functional impairment, and leisure satisfaction.

The mental health benefits of HFP strategies are also found outside of clinical settings. A survey of students in New Zealand showed that those who gardened at home demonstrated higher family connection, better mental well-being, significantly lower levels of depressive symptoms, and better neighborhood connections (Van Lier et al., 2017). Machida and Kushida (2020) found that gardening and on-farm experience among people in Japan had a positive influence on mental health. Prior research has found that many gardeners find gardening relaxing and helpful in stress reduction (Ambrose et al., 2020; Calvet-Mir et al., 2012; Camps-Calvet et al., 2016; Darby et al., 2020; Dunnett and Qasim, 2000; Kortright and Wakefield, 2011; Palar et al. 2019), even when mental health benefits were not the gardener's original motivation (Pollard et al., 2018).

Fewer studies have specifically examined the mental health benefits of hunting, fishing, and foraging, though since these activities tend to take place in natural settings, there is potential for similar outcomes to other HFP activities like gardening. In their 2007 study on the impact of "green exercise" on physical and mental health, Pretty et al. found a statistically significant change in self-esteem and in the mood factors of anger-hostility, confusion-bewilderment, depression-dejection, and tension-anxiety in people who engaged in fishing. Norman et al.'s 2010 survey of hunters in Sweden found a 19% decrease in self-rated health under the hypothetical situation that hunting was no longer a possibility. In Boulanger-Lapointe et al.'s 2019 study of the importance of berry foraging practices in Inuit Nunangat, interviewees mentioned the foraging experience as "calming," an opportunity to "leave the stresses of the community," and "good therapy." Rural communities, with their close proximity to natural areas, have an increased opportunity to engage in these activities and spend time connecting with nature, while simultaneously improving their food security and diet quality.

Although, the mental health benefits of engaging in HFP strategies may extend beyond those of just spending time in nature. Swan (2003) makes the case that the use of tools and weapons is one of the defining, instinctual characteristics of humans, that their use is innate to our psyches, and that using weapons responsibly can be a way to reduce natural aggression. de Bell et al. (2020) found that access to a private garden is associated with better well-being overall, but that greater impacts on well-being were correlated with actual garden use, they were not consistent with just spending time in the garden to relax. These results suggest that there may be other factors influencing these mental health benefits, perhaps relating to increased physical

activity as noted in Pretty et al.'s 2007 study of outdoor exercise, reduced financial stress, or the ability to afford other necessities, such as needed medications.

Prior research suggests that partaking in HFP strategies may lead to an increase in food security, diet quality, and mental health, but the research is limited, especially as it pertains to the impact of hunting, fishing, and foraging practices in the Global North. Additionally, many of these studies have very small sample sizes and rely on participant perceptions and recall. Further, COVID-19 has changed the way many people, especially in the Global North, work, live, and shop, potentially providing opportunities or new barriers to HFP. In Vermont, a survey intended to assess food security and access at the start of the governor's Stay Home, Stay Safe order in March 2020 found that about half of respondents reported producing, foraging, hunting, or canning last year and nearly one third were engaging in those activities at the time of the survey (Belarmino et al., 2020). This is significant, considering that the survey was completed before the start of the traditional growing season in Vermont. Respondents who participated in HFP practices in the year prior to the pandemic had higher rates of food security. Many respondents expressed a heightened interest in supplying their own food due to many factors related to the pandemic. In addition to concerns about affordability in accessing food, Vermonters were concerned about food supply shortages and the handling of items in a global supply chain.

Early evidence during the pandemic suggested an increased interest in HFP since COVID-19, at least among those who were already partaking in production practices in the year prior (Belarmino et al., 2020), but large-scale and more detailed assessment of this understanding is limited, both within the context of the current COVID-19 pandemic and more generally across high-income countries. This project aims to fill this gap by surveying a representative sample of people in Vermont, a rural US state, to understand their HFP strategies, change in activity since COVID-19, and the relationship of HFP to food security, diet quality, and mental health.

Methods and Results

We examined HFP activities since the COVID-19 pandemic began, and their relationship to food security, dietary quality, and mental health using multivariable logit models and matching analysis. The data we used for this study were collected from a survey administered online in August and September of 2020 through Qualtrics (Provo, UT) market research panels and received responses from 600 people ages 18 and over. A general population sample characteristic of Vermont statistics on income, race, and ethnicity was achieved by matching sample recruitment quotas to the income, race (White, Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, and Two or more races), and ethnicity (Hispanic, non-Hispanic) population profile of Vermont in the American Community Survey (ACS 2019). We utilized analysis of variance, chi-square tests, and matching techniques with demographic controls for the analysis.

We found 29% of respondent households classified as food insecure since COVID-19, with higher prevalence of food insecurity among those experiencing a negative job change since COVID-19, households earning less than $50,000 annually, and Hispanic and multi-race respondents. Nearly 35% of respondents engaged in HFP activities since the COVID-19 pandemic began; the majority of those gardened, and more than half pursued HFP activities more intensely than before the pandemic or for the first time. Food insecure households were more likely to pursue HFP more intensely, including more gardening, fishing, foraging, and hunting.

Respondents who were food insecure, Black, Indigenous, People of Color, those with a negative job disruption, and larger households all had greater odds of increased intensity of HFP during the COVID-19 pandemic. HFP was significantly associated with eating greater amounts of fruits and vegetables; however, this effect was only significant for food secure households.

We found that certain demographics, especially women and people with a negative job change since COVID-19, were more likely to experience higher levels of perceived stress and emotional eating. Engaging in HFP activities is associated with lower levels of emotional eating overall. Specifically, this is true especially for individuals gardening and canning. However, we also find that those who engaged in fishing and canning more since the COVID-19 pandemic began were more likely to eat for emotional reasons. Similarly, those who gardened during the pandemic had lower perceived stress levels, while those who fished, hunted, or canned more than they did before the pandemic had higher perceived stress levels.

Processes and Outcomes

I began this project in August 2020 by conducting a literature review of previous research on the connection between HFP activities (specifically gardening, hunting, fishing, and foraging) and food security, diet quality, and mental health. When the survey was completed in the fall, we ran the statistical analysis and decided the research was worthy of two manuscripts. At that point, Meredith took the lead on Chapter 1 and I took the lead on Chapter 2. Chapter one of the manuscript looked at changing trends in HFP during the first five months of the pandemic, as well as its relationship with food security and diet quality. The second manuscript built off of the first and examined the relationship between HFP and mental health outcomes. Chapter one was completed in January and chapter two was completed in March. The first has been accepted to BMC: Journal of Public Health. The second has been submitted and is awaiting peer review at the Journal of Hunger and Environmental Nutrition. Additionally, I plan to present our findings at the Vermont Victory Garden group this summer.

Conclusion

This project documented the extent of a range of HFP activities among a statewide sample in the US and assessed associations between HFP and food security, diet quality, and mental health outcomes. The results demonstrate that HFP activities significantly increased during the first five months of the COVID-19 pandemic, and were especially prominent among food insecure households. The results also document clear relationships between HFP activities and dietary outcomes, including higher fruit and vegetable intake, which may have important health benefits long-term. Our results on the mental health outcomes of engaging in HFP are mixed but build on the existing body of research demonstrating the mental health benefits of gardening and adds the unique component of how these outcomes played out during a global pandemic. The project culminated in two completed manuscripts. Chapter 1 has been accepted to BMC: Journal of Public Health and chapter 2 is awaiting peer review at the Journal of Hunger and Environmental Nutrition.

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Appendix 1: Chapter 1

Home Food Procurement Impacts Food Security and Diet Quality During COVID-19

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Abstract

Background: Home food procurement (HFP) (i.e. gardening, fishing, foraging, hunting, backyard livestock and canning) have historically been important ways that people obtain food. Recently, some HFP activities have grown (e.g. gardening), while other activities (e.g. hunting) have become less common in the United States. Anecdotally, COVID-19 has sparked an increase in HFP evidenced by increased hunting licenses and shortages in seeds and canning supplies. HFP may have positive benefits for food security and diet quality, though research beyond gardening is especially limited in high-income countries.
Methods: We examine HFP activities since the COVID-19 pandemic began, and their relationship to food security and dietary quality using multivariable logit models and matching analysis with a statewide representative survey (n=600) of residents of Vermont, United States.
Results: We find 29% of respondent households classified as food insecure since COVID-19, and higher prevalence of food insecurity among those experiencing a negative job change since COVID-19, households earning less than $50,000 annually, Hispanic and multi-race respondents. Nearly 35% of respondents engaged in HFP activities since the COVID-19 pandemic began; the majority of those gardened, and more than half pursued HFP activities more intensely than before the pandemic or for the first time. Food insecure households were more likely to pursue HFP more intensely, including more gardening, fishing, foraging, and hunting. Respondents who were food insecure, Black, Indigenous, People of Color, those with a negative job disruption, and

larger households all had greater odds of increased intensity of HFP during the COVID-19 pandemic. HFP was significantly associated with eating greater amounts of fruits and vegetables; however, this effect was only significant for food secure households.

Conclusion: Overall, these results suggest that HFP activities have increased since the start of the COVID-19 pandemic, and may be an important safety net for food insecure households. However, HFP for food insecure households does not translate into the same higher fruit and vegetable intake as found among food secure HFP households, suggesting this population may be trying to maintain intake, or that they may have potential important resource or technical assistance needs. Long-term, HFP activities may have important food security and diet quality impacts, as well as conservation implications, which should be more thoroughly explored. Regardless, the increased interest and intensity of HFP demonstrates opportunities for educational and outreach efforts.

Keywords: gardening, hunting, fishing, foraging, fruit and vegetable intake, food insecurity, COVID-19, diet quality, red meat intake

Background

The COVID-19 pandemic has highlighted the uncertainty and fragility of food security and food access globally. In the United States, unemployment rates reached unprecedented levels at their height in April 2020, causing concerns among many Americans about how to access affordable and high-quality food [1]. Existing evidence suggests that home food procurement (i.e. backyard livestock, fishing, foraging, gardening, hunting, and canning, hereafter referred to as HFP) may offer opportunities to improve food security and diet quality (e.g. [2, 3]). HFP activities have varying levels of participation in recent decades. While homesteading [4] and backyard livestock, especially chickens, have become more fashionable in recent years [5], hunting has been declining for decades [6, 7]. However, since the COVID-19 pandemic began, there have been a number of stories from popular media outlets in the United States discussing a comeback of "victory gardens" in response to the pandemic [8, 9], increased interest and demand for hunting and fishing [10], and a shortage of canning supplies [11]. As well, previous research has found that depictions of wild food foraging in the media change in times of economic hardship from being discussed as more of a luxury to being conceptualized as a way to provide for basic needs [12]. Public discussion and interest around HFP practices seem to be shifting with COVID-19, but who is participating and what relationship do these activities have to food security and dietary outcomes? This study explores changes in HFP since the onset of the COVID-19 pandemic, and its relationship to food security and diet quality outcomes during the pandemic in a high-income country context.

The potential for HFP to improve food security and dietary outcomes has links to other challenging times, including in historical moments such as World War 2. At that time, planting "victory gardens" were patriotic acts to grow local food amidst disrupted supply chains [13]. It is estimated that 40% of the nation's fruits and vegetables were produced via victory gardens during the war, demonstrating the potential for HFP to address food security challenges. But the current COVID-19 context has created new difficulties and significant increases in food insecurity in many countries, including the United States (e.g.[14, 15]). Nevertheless, existing evidence suggests that HFP may positively affect both food security and dietary quality outcomes in high-income countries through multiple pathways.

Evidence suggests that growing your own food contributes directly toward food availability and access. Taylor & Lovell (2015) found that, while gardeners did not grow enough to sustain their families, ⅓ grew a substantial quantity and were self-sufficient in providing some items for a certain period of time during the growing season and almost all of these households said they always had enough to eat. Corrigan's (2011)[16] interviews of five gardeners in Baltimore found that most perceived that they saved money from their gardens and that it allowed them to grow quality, fresh produce that otherwise may not have been accessible. They also found that many gardeners canned or froze their excess produce, allowing them access to these foods into the winter.

These results may also translate beyond gardening to other food procurement practices, although research is even more limited in these areas. Smith et al. (2019) [17] found that participants from one reservation who participated in the Food Distribution Program on Indian Reservations who also hunted, fished, or foraged were more food secure than those who did not. Additionally, those who engaged in more than one practice were more secure than those who did only one. A survey of Canadian Inuit also found that households with an active hunter were more food secure than those without an active hunter [18]. Cooke et al. (2018) [19] found that many anglers in the United States often consume what they catch, with an average of 4,700 grams of edible fish provided through fishing annually, even if their original motivation for fishing is recreation. As well, African American anglers are more likely to consider fishing important for providing food, compared to non-African American anglers [20] and more likely to keep fish that they have caught [21], though these studies did not examine food security outcomes. This direct food procurement may also lead to cost savings realized by not purchasing food, which enable money to be available for the purchase of other foods, or for other financial priorities.

Realized cost savings from HFP may be another factor linking HFP to better food security outcomes. Perceived cost savings does appear to be a common motivation for those producing their own food [17, 22] and there have been a number of studies suggesting that this may in fact be the case [2, 3, 23, 24]. Home gardeners in San Jose, California reported that cost savings of gardening allowed them to eat produce they otherwise would not have had access to [25]. However, many studies looking at cost savings were analyzing the results of nonprofit programs in which gardeners were supported with resources to help set up their gardens, and

therefore had a smaller up-front investment, which could have impacts on food security outcomes. Csortan et al. (2020) [26] found that 65% of South Australian home food gardeners surveyed would break even on garden investments in five years or less and then start saving money. In such a case, gardening would not be a sufficient means for achieving food security in the short-term in response to an economic crisis. They also found that the number of years of gardening experience appeared to have a positive impact on productivity and resource efficiency, leading to additional concerns for new gardeners [26].

In addition to the potential for cost savings and increased food security, HFP may lead to a higher quality, more diverse diet, including one that may be more culturally appropriate [27, 28]. Growing one's own produce is linked to increased fruit and vegetable intake [3, 25, 29–31]. Hunting, fishing, and foraging may also lead to a more nutritious and diverse diet; for example, 80% of people surveyed on a native reservation said that hunting, fishing, and foraging made their diets more diverse and 72% said these practices improved the quality of their diet [17]. Stark et al. (2019) [32] found that wild edible greens were abundant in three low-income neighborhoods in California, and offered potential nutrient density comparable to some common nutritious vegetables, such as kale. Some research suggests that growing one's own food may also lead to improved nutritional knowledge [33, 34] and changes in eating habits for the long-term [24, 34, 35]. This may also be true of children, who are more likely to try vegetables when they garden [36].

Prior research suggests that partaking in HFP strategies may lead to an increase in food security and diet quality outcomes, but the current research is limited, especially as it pertains to the impact of hunting, fishing, and foraging practices in high-income countries. Further, COVID-19 has changed the way many people work, live, and shop, potentially providing opportunities or new barriers to HFP and new challenges for food security and high-quality diets. Emerging evidence indicates that dietary quality has decreased during the COVID-19 pandemic in many places (e.g. [37, 38], offering potential opportunities for HFP to counter such trends. Existing evidence of HFP activities since the start of the COVID-19 pandemic is limited, though our previous work found about half of respondents reported producing, foraging, hunting, or canning last year and nearly one third were engaging in those activities at the time of the survey [39]. Chenarides et al. (2020) [40] examined urban gardening before and during the COVID-19 pandemic, finding lower participation in community gardens as compared to at-home gardens. Constant et al. (2020) found having a garden/terrace positively associated with unhealthy behaviors including eating fewer fruits and vegetables during the COVID-19 lockdown in France. Finally, though a few commentaries have discussed the potential benefits of home gardens during COVID-19 (e.g.[41, 42]), to our knowledge, no population-based studies have comprehensively assessed HFP activities during the pandemic and its relationship to food security and diet quality outcomes. This study aims to fill this gap by surveying a representative sample of people in Vermont, a rural US state, to understand their HFP strategies, change in activity during the first five months of the COVID-19 pandemic, and the relationship of HFP to

food security and diet quality. In a predominantly rural state such as Vermont, these concerns are especially pressing, as rural areas are estimated to have 50% higher rates of food insecurity than urban areas [43].

Methods

Survey development and sampling strategy

The data were collected using a survey instrument developed initially in March 2020 [44], in collaboration with other researchers as part of the National Food Access and COVID research Team (NFACT) [45]. The survey was further refined [46], with the latter forming the basis for this data collection. The survey measures multiple components of food access, food security, dietary intake, home food procurement, COVID-19 experiences and food assistance program participation, as well as individual and household sociodemographics. Institutional Review Board approval was obtained from The University of Vermont (IRB protocol 00000873) prior to any data collection. The survey utilizes validated measurements when possible (Table 1), and was also validated prior to release of Version 1 in Vermont with 25 eligible (18 and over) respondents using Cronbach alpha and factor analysis [14]. All question sets obtained an internal validity of alpha > 0.70 [47, 48].

Participants were recruited through an online survey administered by Qualitrics (Provo, UT), using a general population sample representative to the state of Vermont with respect to income, race and ethnicity. This sample was achieved by matching sample recruitment quotas to the income, race (White, Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, and Two or more races), and ethnicity (Hispanic, non-Hispanic) population profile of Vermont in the American Community Survey [49]. A total of 600 people ages 18 and over responded to the survey, representing a margin of error (95% confidence level) for this segment of the Vermont population of +/- 4% [50]. The survey was administered in August and September 2020 and received a response rate of 35%.

Variables of Interest

We explore three self-reported dependent variables in this analysis (Table 1). First, food security status, as measured through the US Department of Agriculture 6-item short-form food security module [51] where food insecurity is classified as answering affirmatively to two or more out of six questions. This was modified to ask respondents about food security since the start of the COVID-19 pandemic (approximately five months at the time of the survey) rather than the traditional 12-month period. Second, current fruit and vegetable intake was measured through the National Cancer Institute's 2-item screener [52], which was modified to apply to the last month and some example foods were removed to shorten it. Current red and processed meat intake was measured using two questions from the Dietary Screener Questionnaire in the National Health and Nutrition Examination Survey (NHANES) 2009-10. Finally, we developed

new questions to measure perceived change in fruit/vegetable and red meat/processed meat consumption since the onset of the COVID-19 pandemic. Independent variables included multiple questions related to previous and current HFP, specific HFP activities, and changes in HFP activities during the COVID-19 pandemic, as well as several household and individual-level demographics (Table 1).

Table 1. Complete list of variables, questions and measurement utilized in this analysis.

Variable Name	**Question/Scale**	**Measurement**
Food Secure	6 item food security module from USDA	1= Food Secure (0 or 1 affirmatives in module), 0= Food Insecure (Affirmative to 2 or more questions in module)
Dietary Quality Variables:		
Fruit Intake	About how many cups of fruit (including 100% pure fruit juice) do you eat or drink each day? Examples of 1 cup for fruit include 1 small apple, 1 large banana, 1 cup (8 oz.) of 100% juice or canned fruit, or ½ cup of dried fruit.	0=None, 1=½ cup or less, 2=½ to 1 cup, 3=1–2 cups, 4=2–3 cups, 5=3–4 cups, 6=4 cups or more
Vegetable Intake	About how many cups of vegetables (including 100% vegetable juice) do you eat or drink each day? Examples of 1 cup of vegetables include 1 cup of cooked leafy greens, 2 cups of lettuce or raw greens, 12 baby carrots, 1 medium potato, or 1 large raw tomato.	
Red Meat Intake	How often did you eat red meat (such as beef, pork, ham, sausage, veal lamb)? Do not include chicken, turkey or seafood. Include red meat you had in sandwiches, lasagna, stew, and other mixtures.	0=Never, 1=1 time last month, 2=2-3 times last month, 3=1 time per week, 4=2 times per week, 5=3-4 times per week, 6=5-6 times per week, 7=1 time per day, 8=2 or more times per day
Processed Meat Intake	How often did you eat any processed meat, such as bacon, lunch meats, or hot dogs? Include processed meats you had in sandwiches, soups, pizza, casseroles, and other mixtures. Processed meats are those preserved by smoking, curing, or salting, or by the addition of preservatives.	
Fruit/Vegetable Change	I have been eating more, less, or about the same amount of fruits and vegetables per day.	1=Less, 2=Same, 3=More
Red/Processed Meat Change	I have been eating more, less, or about the same amount of processed meat, lunch meats, and red meats.	
Home Food Procurement Variables:		

COVID-19 HFP (HFP)	Indicated that the household accessed local food through gardening, fishing, foraging, hunting, backyard livestock or using your own canned good at any points since the COVID-19 pandemic began	Binary variable (1=home food procurement activity, 0=no activity)
Garden Since	Respondent that has gardened since COVID-19	1=Had a garden since COVID-19, 0=No garden since COVID-19
Fishing Since	Respondent that has fished since COVID-19	1=Fished since COVID-19, 0=No fishing since COVID-19
Foraging Since	Respondent that has foraged since COVID-19	1=Foraged since COVID-19, 0=No foraging since COVID-19
Hunting Since	Respondent that has hunted since COVID-19	1=Hunted since COVID-19, 0=No hunting since COVID-19
Livestock Since	Respondent that has backyard livestock since COVID-19	1=Had backyard livestock since COVID-19, 0=No backyard livestock since COVID-19
Canning Since	Respondent that has used own canned goods since COVID-19	1=Used own canned goods since COVID-19, 0=No canning since COVID-19
HFP More	Subset of respondents that pursued HFP- Any respondent that indicated they pursued a HFP activity "for the first time this year", or "I have previously done this, but did it more this year"	Binary variable (1=more intense HFP, 0=no change in activity, or pursued less this year)
Gardens More	Any respondent that indicated they pursued gardening "for the first time this year", or "I have previously done this, but did it more this year"	1=More intense or new, 0=same or less than before
Fishing More	Any respondent that indicated they pursued fishing "for the first time this year", or "I have previously done this, but did it more this year"	
Foraging More	Any respondent that indicated they pursued foraging "for the first time this year", or "I have previously done this, but did it more this year"	
Hunting More	Any respondent that indicated they pursued hunting "for the first time this year", or "I have previously done this, but did it more this year"	

Livestock More	Any respondent that indicated they pursued backyard livestock "for the first time this year", or "I have previously done this, but did it more this year"	
Canning More	Any respondent that indicated they pursued canning "for the first time this year", or "I have previously done this, but did it more this year"	
Demographic Variables:		
Female	Which of the following best describes your gender identity?	1=Female, 0=Male
Children in HH	How many people in the following age groups currently live in your household (including you)? Household includes people currently living within your home, including family and non-family members.	1=Any children in household, 0=No children in household
Over 55	Please select your age group	1=Respondent 55 or older, 0=Respondent 55 or younger
Race/Ethnicity (BIPOC/and or/Hispanic)*	What is your race? Are you of Hispanic, Latino, or Spanish origin?	1=Respondent identify as Asian, Black or African America, Native America, White, Mixed Race, and/or Hispanic, Latino or Spanish origin, 0=Respondent identifies as white and non-Hispanic, Latino or Spanish origin
Negative Job Change	Have you or anyone in your household experienced a loss of income or job since the COVID-19 outbreak (March 11th)?	1=Any job change (job loss, reduced hours or income at job, furloughed), 0=No job change
Less $50K	Which of the following best describes your household income range in 2019 before taxes?	1=Household income below $50,000 a year, 0=Household income above $50,000 a year
HH Size	How many people in the following age groups currently live in your household (including you)? Household includes people currently living within your home, including family and non-family members.	1=1 person, 2=2 people, 3=3 people, 4=4 people, 5=5 people, 6=6 people, 7=7 people or more

* We would like to acknowledge we aggregate this data because of the low number of respondents identifying as BIPOC and/or Hispanic. While this survey is representative of Vermont state characteristics on race and ethnicity, the sample size is too low to analyze racial and ethnic groups in a disaggregated format in models. We have disaggregated race and ethnicity in reporting food security statistics in the results, but aggregate race and ethnicity together for modeling and matching.

Statistical analysis

We utilize a series of logistical regression models, reporting with odds ratios to examine how demographic factors correlate with home food procurement since the COVID-19 pandemic began (HFP), and the different HFP strategies. We use chi-square tests to examine food security and diet quality changes since the start of the COVID-19 pandemic as it relates to HFP, specific HFP activities, and intensity of HFP. We use one-way analysis of variance (ANOVA) to examine diet quality intake at the time of the survey as it relates to HFP, specific HFP activities, and intensity of HFP. Then, to examine how HFP, intensity of HFP, and specific HFP activities relate to both food security outcomes and dietary quality, we use nearest neighbors matching techniques. We report statistical significance as anything $p<0.05$.

Matching techniques are useful with observational data to estimate causal effects of treated and control groups, aiming to balance the distribution of covariates across treated and control groups [53]. Here we explore how HFP, intensity of HFP, or specific HFP activities are "treatments" on food security and diet quality, using demographic factors as matching covariates across groups. We use six demographic covariates in our matching analysis: female, children in household (HH), race/ethnicity (Black, Indigenous, People of Color (BIPOC)/and or Hispanic), negative job change, household income less than $50,000 (less $50k), and HH size (Table 1), which are likely to be associated with the treatment and outcome [54, 55]. Matching techniques also require defining a distance (measure of similarity between the individuals). We use a nearest neighbor matching approach with a Mahalanobis distance, which accounts for covariance among variables, and is documented to work well with fewer than eight covariates [56, 57]. For each treated individual, nearest neighbor matching selects a control individual with the smallest distance from that individual.

For example, if we are exploring HFP, the technique would have people who did and did not engage in HFP as "treatment" and control groups, and then match a treatment and control respondent together based on similar demographic covariates included in the analysis (e.g. household size and job change status). In all our models we use nearest neighbor matching with between three and five matches per observation, meaning each observation was matched with at least three closest other observations within the control and treatment groups. Since we are interested in the difference between expected outcomes among those with and without "treatment" (HFP), we report average treatment effect on the treated, and ensure the existence of potential matches in the control group to satisfy the common support condition [58]. We report the total number of matched individuals for each matching outcome in results tables to confirm the existence of matches for all treatments. Furthermore, we implement a maximum caliper of 0.1 for all matching analyses with the exception of matching involving "more" HFP since COVID-19, where we implement a caliper of 0.3 because of a smaller sample size. The implementation of these calipers satisfies the overlap and common support requirements, and ensures high quality matching [58].

Results

Respondent Characteristics

Table 2 details the specific respondent characteristics, which reflect the demographic composition of the Vermont population for the gender, race, and income distribution. Overall, 67.3% of the respondents were female (std. dev= 0.47), and 30.2% of respondents had children in the household (std. dev= 0.46). Forty-four percent of respondents were age 55 years or older. Reflecting the racial/ethnic profile of Vermont, 8.3% of respondents identified as BIPOC and/or Hispanic ethnicity (std. dev= 0.28). More than 46% of respondents lived in a household that had experienced a negative job change during the first five months of the COVID-19 pandemic (job loss, loss of income or hours from job, or furlough) (std. dev=0.50). Household size was on average 2.57 (std. dev= 1.34), with 60.2% of households with 2 or fewer people.

Table 2.

Characteristic		**Respondents (N=600)**
Age - no. (%)		
	18-34	153 (25.5)
	35-54	182 (30.3)
	55+	263 (43.8)
Children in household - no. (%)		
	Yes	178 (30.2)
	No	415 (70.0)
Gender - no. (%)		
	Female	404 (67.3)
	Male	190 (31.7)
	Transgender/Non-binary/Self-Described	6 (1.0)
BIPOC -Race - no. (%)		
	White	559 (93.2)

	Two or more races	22 (3.7)
	American Indian or Alaska Native	5 (0.8)
	Asian	4 (0.7)
	Black or African American	9 (1.5)
BIPOC - Ethnicity - no. (%)		
	Not Hispanic or Latino	583 (97.2)
	Hispanic or Latino	17 (2.8)
2019 Household Income - no. (%)		
	Less than $10,000 per year	39 (6.5)
	$10.000-$24,999	81(13.5)
	$25,000-$49,999	141 (23.5)
	$50,000-$74,999	110 (18.3)
	$75,000 - $99,999	77 (12.8)
	$100,000 or more	145 (24.1)
Job change during the COVID-19 pandemic - no. (%)		
	Lost job	149 (24.8)
	Reduced hours or income	208 (34.7)
	Furloughed	122 (20.3)
	Any change	270 (46.2)
	No changes	314 (53.8)
Household Size - no. (%)		
	1 to 2	357 (60.2)
	3 to 5	211 (35.6)
	6 or more	25 (4.2)

Descriptive Statistics of Key Variables

Among all respondents, 34.5% (n=205) engaged in HFP activity during the first six months of the COVID-19 pandemic, with the greatest number of respondents gardening (34.7%), followed by canning (23.5%) and fishing (10.2%) (Figure 1). Among respondents who engaged in HFP, 51.8% (n=128) did at least one HFP activity more intensely since the COVID-19 pandemic began or for the first time during the COVID-19 pandemic, with the greatest increase in intensity of activity among backyard livestock (52%, n=26), gardening (45.3%, n=106), and foraging (44.9%, n=31).

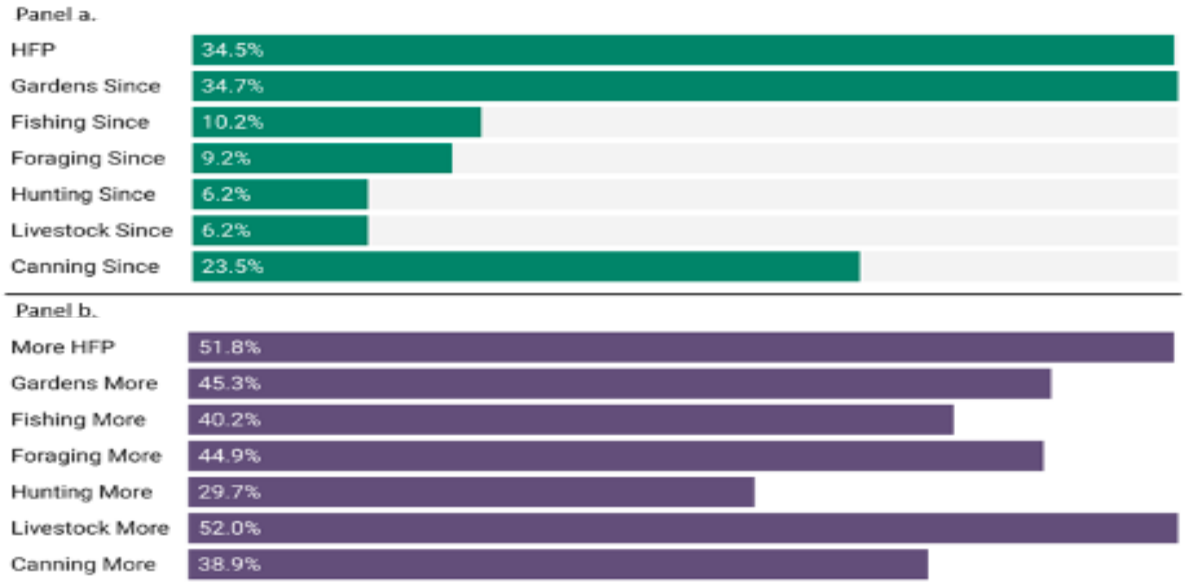

Figure 1. a) Percent of respondents engaging in any HFP, and specific HFP activities since COVID-19. Percentages include all respondents (n=600). b) Among respondents who engaged in any HFP (n=205), percent of those that increased intensity or did a new HFP activity since COVID-19.

On average, respondents self-reported they ate between 1-2 cups cumulatively of fruit (mean=2.20) and vegetables (mean=2.74) per day, though 11% and 5% of respondents ate no fruit or vegetables respectively daily. Respondents self-reported they ate red meat (mean=3.34) and processed meat (mean=3.15) about one time per week, with 10% each indicating they never eat red or processed meat. Nearly one in four (23.3%) respondents indicated eating less fruits and vegetables during the pandemic as compared to before, 65.5% reported eating the same as before COVID-19, and 11.2% reported eating more. Changes in red and/or processed meat consumption were also indicated by about one-third of respondents, with 25.9% eating less red and/or processed meat since the start of the COVID-19 pandemic, and 7.9% eating more.

Demographics of Food Security

Among our dependent variables, 71% (n=414) of respondent households were classified as food secure since COVID-19 (29% food insecure, n=169). To assess the relationship of our demographic controls on food security, we ran a multivariable logit model (Supplementary Table 1). Respondents 55 and over were at higher odds of food security (OR=2.52, p=0.001), while households experiencing a negative job disruption (OR=0.47, p=0.001), and those earning less than $50K annually (OR=0.134, p<0.001), were at reduced odds of food security. Disaggregating race and ethnicity demonstrates lower rates of food security among Black (50%), Hispanic (50%), and multiple race respondents (66.6%); however, these results are not statistically significant (p<0.05) with a chi-square test, likely because of our low sample size (Supplementary Table 2).

Demographics of Home Food Procurement

Using a multivariate logit model, we examine how demographics correlate with different aspects of HFP. We find that households experiencing a negative job change have 1.53 greater odds (p=0.022) of HFP since the COVID-19 pandemic (Table 3). Among those that did HFP since COVID-19, we find that multiple demographic factors are correlated with increased intensity of HFP during the pandemic. Specially, BIPOC /Hispanic respondents (OR=3.58, p=0.026), households experiencing a negative job change (OR=1.89, p=0.026), and larger households (OR=1.48, p=0.021) were at significantly greater odds of increased intensity of HFP while respondents over 55 were at significantly reduced odds of increasing intensity during the pandemic (OR= 0.49, p= 0.029) (Table 4).

Table 3. Multivariate logit model predicting COVID-19 home food procurement (HFP) activities with demographics.

Variable	Odds Ratio	Std. Error	P=	95% Confidence Interval	
Female	0.929	0.181	0.704	0.634	1.360
Children in HH	1.074	0.288	0.789	0.636	1.816
Over 55	1.299	0.279	0.223	0.853	1.979
BIPOC/Hispanic	1.082	0.351	0.807	0.573	2.043
Negative Job Change	1.525	0.282	0.022	1.062	2.191
Less $50K	0.756	0.141	0.133	0.525	1.089
HH Size	0.918	0.084	0.351	0.767	1.099

Table 4. Multivariate logit model predicting increased intensity of HFP since COVID-19 with demographics.

Variable	Odds Ratio	Std. Error	P=	95% Confidence Interval	
Female	1.436	0.450	0.249	0.777	2.655
Children in HH	0.758	0.322	0.514	0.329	1.745
Over 55	0.486	0.160	0.029	0.255	0.927
BIPOC	3.585	2.051	0.026	1.169	11.000
Negative Job Change	1.894	0.543	0.026	1.080	3.320
Less $50K	0.855	0.254	0.599	0.478	1.532
HH Size	1.477	0.249	0.021	1.062	2.054

Multivariate logistical regression models predicting the specific types of all six HFP activities since the COVID-19 pandemic by demographics found multiple significant factors. Respondents with a negative job change were at increased odds of gardening (OR=1.43, p=0.055), while households making less than $50,000 annually were at reduced odds (0.63, p=0.014). Respondents over 55 were at reduced odds of fishing since the start of the COVID-19 pandemic (OR=0.50, p=0.051), while respondents with a negative job change (OR=2.13, p=0.014) were at increased odds. Women were at reduced odds of hunting during the pandemic (OR=0.46, p=0.034. Respondents over 55 were at reduced odds of having backyard livestock during the pandemic (OR=0.16, p=0.001) (Supplementary Tables 3-8).

Home Food Procurement and Food Security

At the aggregate, we do not find statistically significant differences in engagement in HFP between food secure and insecure households. However, we do find that food insecure households are significantly more likely to engage in certain types of HFP activities. Overall, food insecure respondents were significantly more likely to be fishing (p=0.005), foraging (p=0.003), hunting (p<0.001), canning (p=0.019), and have backyard livestock (p=0.008) during the COVID-19 pandemic (Figure 2).

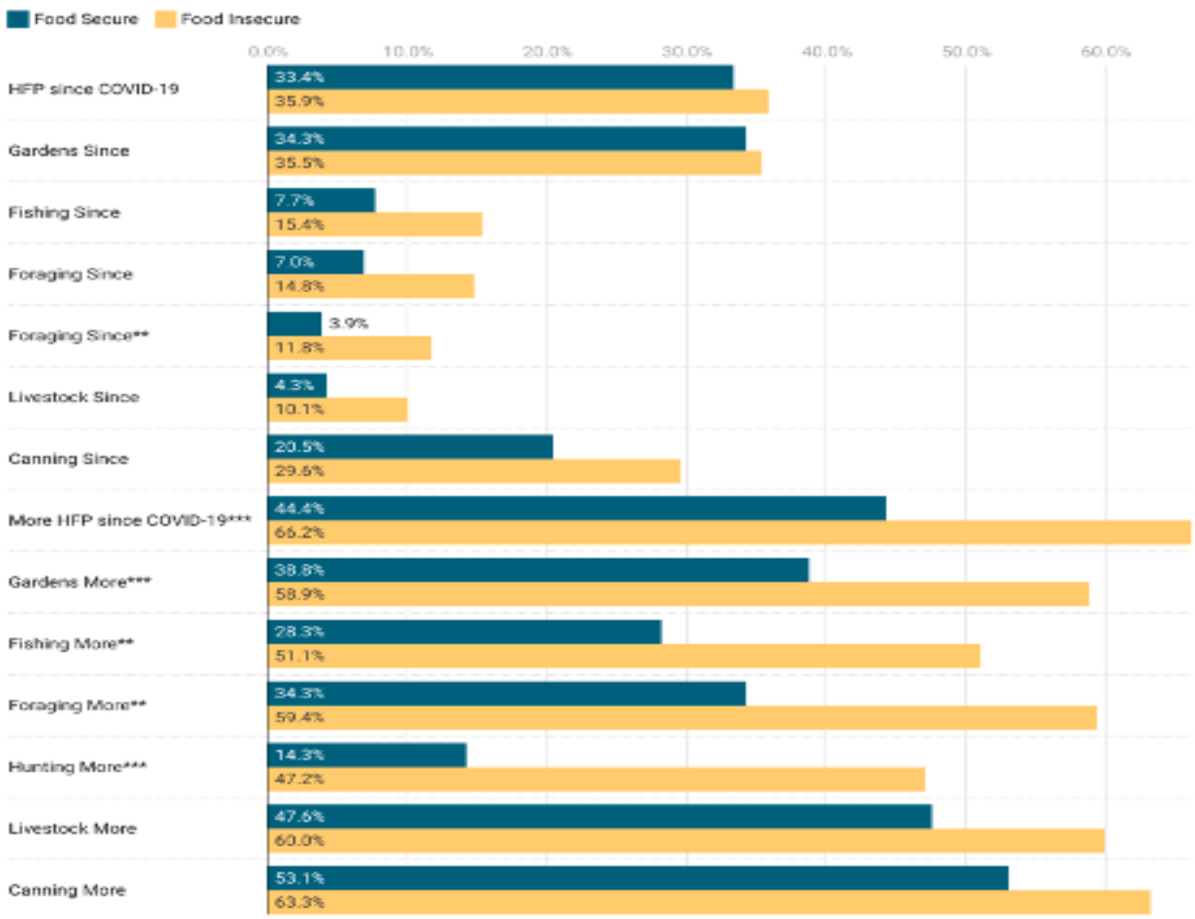

Figure 2. Percent of food secure and food insecure households engaging in various types of HFP activities and intensity since COVID-19. (**=$p<0.05$, ***=$p<0.01$, Supplementary Table 9). Questions about any HFP, and specific HFP since COVID-19 include all respondents. Questions about increased HFP activity are asked only of respondents engaging in HFP (n=250).

We use matching approaches to examine the effect of HFP since the COVID-19 pandemic on household food security. We find no association between HFP since COVID-19 and food security while controlling for multiple demographic factors. However, exploring the effect of specific HFP activities during the pandemic on food security outcomes, we find that fishing ($b=-0.174$, $p=0.007$), hunting ($b=-0.297$, $p<0.001$), and canning ($b=-0.149$, $p=0.001$) are all negatively associated with food security (Table 5).

Table 5. Food security outcomes as related to HFP using nearest neighbors matching analysis. Each row indicates a separate matching analysis, where the HFP variable was used as a "treatment" while using six demographic controls (Female, Children in HH, BIPOC, Negative Job Change, Less $50k, HH size) to conduct the matching. Negative coefficients indicate an association with reduced food security.

	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Treated n= (Matched n=)	Control n= (Matched n)
HFP Since COVID	-0.02	0.041	0.627	-0.102	0.061	193 (193)	355 (193)
Garden Since	-0.055	0.038	0.146	-0.130	0.193	197 (197)	357 (197)
Fishing Since	-0.174	0.064	0.007	-0.301	-0.048	56 (56)	498 (56)
Foraging Since	-0.112	0.078	0.151	-0.265	0.041	53 (53)	501 (53)
Hunting Since	-0.297	0.082	0.000	-0.458	-0.137	34 (34)	520 (34)
Livestock Since	-0.144	0.086	0.093	-0.311	0.024	35 (35)	519 (35)
Canning Since	-0.149	0.045	0.001	-0.237	-0.062	133 (133)	421 (133)
HFP More	-0.206	0.055	0.000	-0.314	-0.098	117 (117)	113 (117)
Gardens More	-0.202	0.057	0.000	-0.315	-0.089	98 (98)	120 (98)
Fishing More	-0.241	0.109	0.027	-0.455	-0.027	36 (36)	53 (36)
Foraging More	-0.130	0.133	0.327	-0.390	0.130	30 (30)	35 (30)
Hunting More	-0.225	0.176	0.201	-0.570	0.120	20 (20)	48 (20)
Livestock More	-0.202	0.750	0.007	-0.350	-0.055	25 (25)	20 (25)
Canning More	-0.318	0.073	0.000	-0.462	-0.175	58 (58)	89 (58)

We also find through chi-square analysis, significant associations between food security and intensity of HFP since the COVID-19 pandemic began, with 66.2% of food insecure households increasing intensity of HFP since the COVID-19 pandemic began, compared to 44.4% of food secure households ($p=0.002$). Food insecure households were also more likely to engage in HFP more intensely since COVID-19, and do certain activities more ($p<0.050$) (Figure 2). Matching results with demographic controls confirm that engaging in HFP more overall as

well as more intensely gardening, fishing, and canning since the COVID-19 pandemic were associated with reduced food security ($p<0.050$, Table 5).

Home Food Procurement and Diet Quality

We use ANOVA to examine the current dietary quality at the time of the survey as it relates to HFP, specific HFP activities and intensity of HFP. Overall, respondents engaging in HFP were significantly more likely to eat greater amounts of fruits (mean 2.40 cup equivalents compared to 2.11, $p=0.02$) and vegetables (mean 3.11 cup equivalents compared to 2.57, $p<0.001$) (Figure 3).

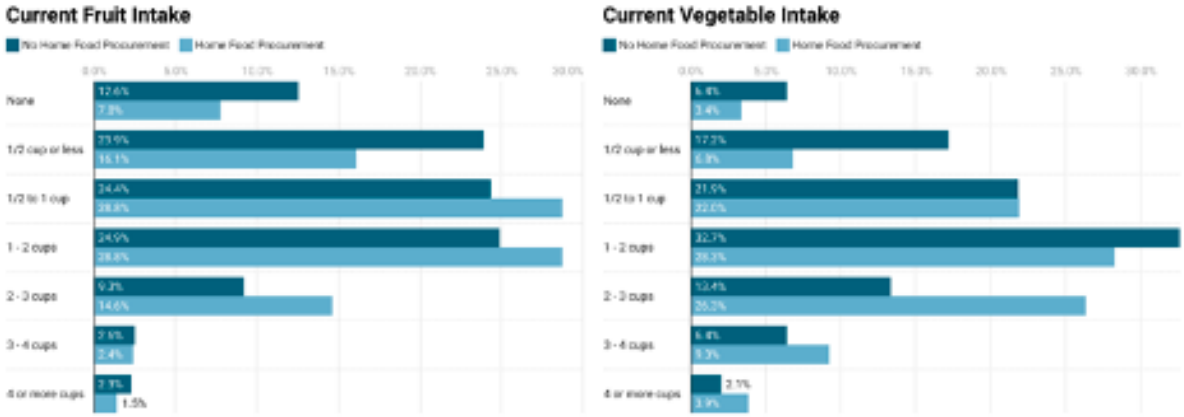

Figure 3. Current self-reported vegetable and fruit intake among respondents engaged or not in HFP since the COVID-19 pandemic. On average, respondents who engaged in HFP are significantly more likely to be eating more fruit ($p<0.05$) and vegetables ($p\leq 0.001$). However, these results differed by a household's food security status (Table 6).

We find no significant differences between HFP and intake of red meat (mean=3.43 compared to 3.329, $p=0.490$) or processed meat (mean=2.98 compared to 3.24, $p=0.100$). Using matching techniques, with demographic controls, we examine current fruit, vegetable, red meat and processed meat intake as it relates to HFP, increased HFP, and relevant specific HFP activities (i.e. gardening, foraging and canning for fruit and vegetable intake and fishing, hunting and backyard livestock for red and processed meat intake). We find the "treatment" of HFP to have a significant and positive relationship to higher fruit ($b=0.292$, $p=0.019$) and vegetable intake ($b=0.487$, $p<0.001$) (Supplementary Tables 10 and 11). We find no relationship between red meat intake and HFP (Supplementary Table 12), but we do find HFP since the COVID-19 pandemic to associated with reduced processed meat consumption ($b=-0.365$, $p=0.025$) (Supplementary Table 13). Further, we also assess the relationship of HFP engagement to dietary outcomes specifically among food secure and food insecure households, which yields different results (Table 6). Importantly, HFP among food secure households is associated with higher fruit ($b=0.309$, $p=0.022$) and vegetable intake ($b=0.669$, $p<0.001$); however, among food insecure

households, we see no significant effect of HFP on any dietary intake outcomes. This suggests that the "treatment" of HFP is significant for food secure households and fruit and vegetable intake, but not for food insecure households.

Table 6. Dietary intake outcomes as related to HFP among food secure and food insecure households using nearest neighbors matching analysis. Each row indicates a separate matching analysis, where the HFP variable was used as a "treatment" while using six demographic controls (Female, Children in HH, BIPOC, Negative Job Change, Less $50k, HH size) to conduct the matching. Negative coefficients indicate an association with lower intake.

	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Treated n= (Matched n=)	Control n= (Matched n)
Current Fruit Intake							
HFP- Food Secure	0.309	0.135	0.022	0.045	0.573	201 (201)	364 (201)
HFP- Food Insecure	0.159	0.292	0.586	-0.413	0.732		
Current Vegetable Intake							
HFP- Food Secure	0.669	0.145	0.000	0.385	0.953	201 (201)	364 (201)
HFP- Food Insecure	-0.064	0.29	0.825	-0.633	0.504		
Current Red Meat Intake							
HFP- Food Secure	-0.018	0.200	0.926	-0.41	0.373	201 (201)	364 (201)
HFP- Food Insecure	0.065	0.432	0.88	-0.781	0.912		
Current Processed Meat Intake							
HFP- Food Secure	-0.266	0.187	0.154	-0.632	0.098	201 (201)	364 (201)
HFP- Food Insecure	0.219	0.364	0.548	-0.494	0.932		

Examining the effect of increasing intensity of HFP and specific HFP activities, we find that gardening and canning since the COVID-19 pandemic began have significant effects on higher current intake of fruits (gardening b= 0.392, p=0.001, canning b=0.275, p= 0.044) and

vegetables (gardening b=0.551,p <0.001; canning b= 0.513, p<0.001) (Supplementary Tables 10 and 11). We find no significant effect of increased intensity of HFP on current red or processed meat intake. We also find having backyard livestock (b=1.020, p=0.001) since the start of the COVID-19 pandemic is associated with higher current red meat intake (Supplementary Tables 12 and 13.)

We use chi-square tests to examine the change in dietary quality outcomes since the COVID-19 pandemic began as it relates to HFP, specific HFP activities and intensity of HFP. We find households engaging in HFP have a higher proportion of respondents with increased fruit and vegetable intake (15.6% compared to 8.7%, p=0.021) which is confirmed through matching techniques with demographic controls (b=0.116, p=0.029) (Supplementary Table 14). However, we find no other significant effects of increased intensity of HFP, or specific HFP activities on change in fruit and vegetable intake (Supplementary Table 14) or meat intake (Supplementary Table 15) since the start of the COVID-19 pandemic.

Discussion

Overall, we find a significant increase in HFP since the beginning of the COVID-19 pandemic, evidence that has been documented in the popular media, but not yet widely shown through peer-reviewed literature. Those engaging in HFP were more likely to be in households with negative job changes, and increased intensity was more likely among those with negative job changes, BIPOC respondents, and larger households. While we do not find that food secure and insecure households engage in HFP at different levels overall, food insecure households are more likely to have increased intensity of HFP during the pandemic. Engagement in some types of HFP activities, as well as overall increasing intensity of some activities is also associated with reduced food security. Though we find that nearly 25% are eating less fruits and vegetables since before the onset of the COVID-19 pandemic, we also find that HFP is positively associated with higher fruit and vegetable intake; however, this effect is only statistically significant among food secure households engaging in HFP, not food insecure households engaging in HFP. These results were especially prevalent among gardening and canning households, while red meat intake was higher among households with backyard livestock.

These results have several important implications. First, they suggest that food insecure households engage in HFP as a potential coping mechanism for food insecurity, and this appears to have been especially true during the first US growing season during the COVID-19 pandemic. This is further corroborated by the results that those with negative job changes were also more likely to be engaging in HFP and increasing the intensity of their engagement. More than 2/3 of food insecure households engaged more intensely in HFP or for the first time during the first five months of the pandemic. It is also important to note that a higher percentage of food insecure households are engaging more in non-gardening HFP activities (e.g. hunting, fishing, foraging) during the pandemic. Coupled together, these results provide important evidence about the

reliance on HFP during a pandemic, and as a "safety net" for many potential households engaging in these activities for the first time or more intensely than before.

Our results are counter to some of the existing research that demonstrates that households using HFP are more food secure than those not using HFP [17], though the existing research on this topic is limited. There are several potential explanations for these different findings. First, the existing research in a Western context generally has had small sample sizes (e.g. [16]), and often focused on specific populations such as Native Americans [17]. This larger sample may provide additional insight into how food insecure households rely on HFP to minimize or lessen their food insecurity in new ways. Second, our analysis is specifically focused on the COVID-19 pandemic, an unprecedented time in recent history, in which unemployment and job loss, as well as food supply chain disruptions were widespread, triggering levels of food insecurity not seen in decades. Indeed, given that cost savings is often a motivation for HFP [3, 23, 24], such financial and lifestyle disruptions were likely an important component of HFP motivation and increased intensity. Finally, our study asked about a suite of HFP strategies, while other studies have typically focused on a single strategy such as gardening or fishing. This may be especially important when interpreting the results, since a larger percentage of food insecure households as compared to food secure households were engaging in non-gardening activities, which may have different potential impacts on food security. Hunting, fishing, and foraging for example, may not actually secure food in the same ways that gardening or backyard livestock could more reliably, at least during the time period in which our survey was conducted (e.g. summer before major hunting seasons).

Our results also demonstrate clear links between HFP and diet quality outcomes, especially for current fruit and vegetable intake among respondents using HFP, gardening and canning. These results confirm previous research findings that gardening is correlated with increased fruit and vegetable intake (e.g. [25, 29, 31]. However, this analysis goes further to demonstrate that these positive benefits are only found among food secure households, not food insecure households. This has important programmatic and policy implications, as it suggests that food insecure households may have less resources, time or capacity to engage in HFP in ways that may provide increased fruit and vegetable intake. Alternatively, these findings could suggest that food insecure households are using HFP as a strategy to maintain fruit and vegetable intake whereas food secure households are supplementing their usual intake with foods that they procure themselves. Since there was no significant difference in the percent of food secure versus food insecure households engaging in gardening or canning, the type of activity does not explain these differences. Further, food insecure households were engaging in gardening and foraging more intensely or for the first time as compared with food secure households since the start of the COVID-19 pandemic. This may signal that food insecure households are "new" to HFP, and may lack the necessary resources or capacity to engage in HFP activities. We suggest that this result should form the basis of further research, especially around the economic or other barriers that may exist for HFP engagement among food insecure households, and the use of

HFP to replace vs. augment intake of nutrient-dense foods during economically challenging times.

Our work also demonstrates that food insecure households were significantly more likely to increase intensity of hunting since the COVID-19 pandemic, though this was not associated with a change in red meat intake. Interpreting the implications of these results (i.e. whether this is a positive or negative health outcome) is challenging, since prior research among a Native American population found that hunting, fishing and foraging increased the diversity and quality of diets [17]. While red meat intake is linked to various adverse health outcomes (e.g.[59–62]), not all red meats have the same nutritional profile. Wild meat and game that could be acquired through hunting may provide higher levels of essential fatty acids and protein [63, 64], which could provide dietary quality benefits.

These findings may have important long-term health implications, especially the finding that nearly one in four respondents was eating less fruits and vegetables during the COVID-19 pandemic than before. Increased fruit and vegetable intake is associated with reduced risk of cardiovascular disease, certain cancers, and all-cause mortality [65], yet even pre-pandemic, most Americans did not meet the national recommendations for fruit and vegetable intake [66]. Our finding of reduced intake are similar to those from studies conducted recently in France (Constant et al. 2020) and the United Arab Emirates [37] finding lower fruit and vegetable intake during COVID-19 associated lockdowns. Respondents using HFP were on average eating ½ cup more of fruits and vegetables daily; higher fruit and vegetable intake is associated with reduced risk of cardiovascular disease, cancer and mortality [65]. Furthermore, since previous research suggests that gardening is also associated with improved nutritional knowledge [33, 34], and long-term beneficial changes in eating habits [24, 35], the significant uptick in gardening and other HFP strategies during the pandemic may have future impacts on diet quality and health not yet realized. Future research should continue to monitor these potential changes, including their link to health outcomes more specifically.

There are many opportunities to expand this work with future research and address potential limitations of the current study. One limitation of this study is a lack of understanding about the amount of food generated through HFP activities. Future research could more clearly explore how different quantities of HFP affect food security and diet quality outcomes by asking what percent of food intake is coming from HFP, or whether HFP activities, especially hunting, fishing and foraging, reliably result in food procurement. Second, future analyses would benefit from more nuanced and complete measurement of dietary intake, including measurement of white meat, fish, and seafood, as these are nutrient-dense foods that may be acquired through HFP. A limitation of the present study was the measurement of only fruit, vegetable, red meat, and processed meat intake (selected for their strong associations to diet-related disease outcomes), rather than a broader portfolio of foods and nutrients. Further, in some of our diet quality metrics, we combined red and processed meat, which may have different nutritional profiles, especially if wild meat is part of a diet. These should be more carefully separated in

future studies. Third, our work includes self-reports of dietary intake, which are known to have limitations in their accuracy (especially for energy intake, which we do not assess here), but are still the primary way in which dietary intake data is collected and continue to be recommended for use [67]. Indeed, while we utilized a sampling strategy that would be at least partially representative of characteristics of the state, response bias in questions may still be possible with our data. Fourth, this work demonstrates outcomes during a global pandemic, when many people's daily lives were significantly changed. People potentially had new motivations for pursuing HFP activities that could be related to food security, but also may be unrelated (e.g. hobbies, time in nature, cultural trends). Long-term potential diet and food security costs and benefits from HFP will likely accrue over many years. Therefore, it is critical to assess whether the new and increased intensity of HFP is sustained in the future. Such sustained efforts would also potentially have important impacts on conservation through increased demand in hunting, fishing and foraging that should be adequately considered. As well, long-term increased engagement in HFP activities may require increased resources for people pursuing these activities, which could happen through educational efforts, cost-share or grants for infrastructure (e.g. garden beds) and equipment (e.g. tools), especially since gardening can have significant up-front costs [26]. Fifth, our study population is from a predominantly rural state, which may influence the ability of people to access land for engaging in HFP. In more urban settings, access to land for gardening, or ability to engage in other HFP may be more limited [68, 69], especially if residents need to travel significant distances [70, 71]. Finally, given the social distanced nature of COVID-19, this research utilized an online survey to capture an understanding of this issue, but this research would certainly benefit from additional qualitative and quantitative data analysis. Interviews and focus groups could contextualize the results and better understand the motivations and challenges of HFP activities, which can provide important information for future education and resource allocation. Future studies would benefit from a longitudinal or interventional design that support the examination of causality.

Conclusion

This study documented the extent of a range of HFP activities among a statewide sample in the US and assessed associations between HFP and food security and dietary outcomes. The results demonstrate that HFP activities significantly increased during the first five months of the COVID-19 pandemic, and were especially prominent among food insecure households. The results also document clear relationships between HFP activities and dietary outcomes, including higher fruit and vegetable intake, which may have important health benefits long-term. Taken together, the results suggest that HFP activities are an important, and potentially increasingly important, way in which many people engage in the food system and the natural environment, with potential implications for both conservation and nutrition and health outcomes. As such, additional research should aim to more fully understand these relationships over time, and in

greater depth, especially in the continuation and aftermath of the COVID-19 pandemic. As well, additional collaborations within the conservation sector may be important to assess the long-term impact of increased levels of HFP that may affect forests, waterways, and species. Heightened engagement in HFP may necessitate expanded education and outreach efforts to provide resources for HFP that is productive and sustainable.

Declarations

Ethics approval and consent to participate: Institutional Review Board approval was obtained from the University of Vermont under protocol 00000873. All protocols were carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from all participants prior to data collection.

Consent for publication: Not Applicable

Availability of data and materials: The survey instrument materials used for this current study are available at Harvard Dataverse at: https://dataverse.harvard.edu/dataverse/foodaccessandcoronavirus . The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

Funding: This research was made possible through grants provided by The University of Vermont College of Agriculture and Life Sciences and the Office of the Vice President of Research, as well as a COVID-19 Rapid Research Fund grant from the Gund Institute for Environment. The funders had no role in the design of the study and collection, analysis, and interpretation of data.

Authors' contributions: MTN conceived and designed the work, analyzed the data, and wrote and revised the manuscript. KBW conceived and designed the work, wrote and revised the manuscript. EHB and FB conceived and designed the work, and revised the manuscript.

Acknowledgements: We thank Peter Callas for statistical advice for this analysis. This research is conducted as part of the National Food Access and COVID Research Team (NFACT). NFACT is a national collaboration of researchers committed to rigorous, comparative, and timely food access research during the time of COVID-19. We do this through collaborative, open access

research that prioritizes communication to key decision-makers while building our scientific understanding of food system behaviors and policies. To learn more visit www.nfactresearch.org.

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Supplementary Materials

Home Food Procurement Impacts Food Security and Diet Quality during COVID-19

Meredith T. Niles, Kristen Brassard Wirkkala, Emily H. Belarmino, Farryl Bertmann

Supplementary Table 1. Results of a logit model predicting food security with demographic controls.

Variable Name	Odds Ratio	Std. Err.	p=	95% Confidence Interval	
Female	1.052	0.261	0.840	0.646	1.710
Children in HH	0.842	0.253	0.567	0.467	1.518
Over 55	2.518	0.674	0.001	1.490	4.256
BIPOC/Hispanic	1.606	0.663	0.251	0.715	3.605
Negative Job Change	0.474	0.106	0.001	0.306	0.733
Less50k	0.134	0.031	0.000	0.085	0.211
HH Size	0.857	0.089	0.139	0.699	1.051

Supplementary Table 2. Food insecurity by disaggregated race and ethnicity.

	Food Security Rate			
	For Demographic Group	For Outside Demographic Group	Total in Demographic Group	p= (chi2 test)
Asian	75.0%	70.9%	4	0.858
Black	50.0%	71.3%	8	0.188
Native American	80.0%	70.9%	5	0.655
Multiple Race	66.6%	71.1%	21	0.066
White	71.3%	65.8%	544	0.467
BIPOC/Hispanic	63.8%	71.6%	47	0.261
Hispanic	50.0%	71.6%	16	0.061

Supplementary Table 3. Logit model predicting gardening activity since COVID-19 by demographic controls.

Variable	Odds Ratio	Std. Error	p=	95% Confidence Interval	
Female	0.905	0.176	0.606	0.618	1.324
Children in HH	1.341	0.360	0.274	0.793	2.269
Over 55	1.351	0.291	0.162	0.886	2.060
BIPOC/Hispanic	0.884	0.295	0.711	0.459	1.700
Negative Job Change	1.425	0.263	0.055	0.993	2.047
Less $50K	0.632	0.118	0.014	0.438	0.912
HH Size	0.867	0.080	0.124	0.723	1.040

Supplementary Table 4. Logit model predicting fishing activity since COVID-19 by demographic controls.

Variable	Odds Ratio	Std. Error	p=	95% Confidence Interval	
Female	0.732	0.220	0.299	0.407	1.318
Children in HH	1.265	0.484	0.539	0.598	2.677
Over 55	0.501	0.177	0.051	0.250	1.003
BIPOC/Hispanic	1.095	0.517	0.848	0.434	2.763
Negative Job Change	1.550	0.449	0.131	0.878	2.735
Less $50K	0.718	0.211	0.258	0.404	1.276
HH Size	0.939	0.125	0.634	0.723	1.218

Supplementary Table 5. Logit model predicting foraging activity since COVID-19 by demographic controls.

Variable	Odds Ratio	Std. Error	p=	95% Confidence Interval	
Female	1.207	0.397	0.567	0.633	2.302
Children in HH	1.260	0.535	0.586	0.549	2.895
Over 55	1.846	0.682	0.097	0.894	3.809
BIPOC/Hispanic	1.162	0.594	0.769	0.427	3.162
Negative Job Change	2.130	0.652	0.014	1.169	3.881
Less $50K	1.463	0.438	0.204	0.813	2.630
HH Size	1.119	0.158	0.427	0.848	1.477

Supplementary Table 6. Logit model predicting hunting activity since COVID-19 by demographic controls.

Variable	Odds Ratio	Std. Error	p=	95% Confidence Interval	
Female	0.458	0.169	0.034	0.222	0.942
Children in HH	2.263	1.105	0.094	0.870	5.890
Over 55	0.594	0.277	0.265	0.238	1.483
BIPOC/Hispanic	1.529	0.812	0.424	0.540	4.328
Negative Job Change	1.642	0.614	0.185	0.789	3.416
Less $50K	0.900	0.333	0.777	0.436	1.859
HH Size	0.836	0.144	0.299	0.597	1.172

Supplementary Table 7. Logit model predicting backyard livestock activity since COVID-19 by demographic controls.

Variable	Odds Ratio	Std. Error	p=	95% Confidence Interval	
Female	0.721	0.276	0.392	0.340	1.526
Children in HH	1.248	0.560	0.621	0.518	3.005
Over 55	0.157	0.091	0.001	0.050	0.491
BIPOC/Hispanic	1.404	0.740	0.519	0.500	3.944
Negative Job Change	1.487	0.551	0.285	0.719	3.075
Less $50K	0.741	0.271	0.412	0.362	1.518
HH Size	0.962	0.149	0.800	0.710	1.303

Supplementary Table 8. Logit model predicting canning activity since COVID-19 by demographic controls.

Variable	Odds Ratio	Std. Error	p=	95% Confidence Interval	
Female	0.920	0.198	0.698	0.604	1.402
Children in HH	1.342	0.395	0.318	0.754	2.388
Over 55	1.317	0.321	0.257	0.818	2.122
BIPOC/Hispanic	1.417	0.485	0.309	0.724	2.773
Negative Job Change	1.454	0.297	0.067	0.973	2.171
Less $50K	0.703	0.147	0.091	0.467	1.058
HH Size	0.963	0.097	0.704	0.790	1.172

Supplementary Table 9. Percent of Respondents by Food Security Status Engaging in HFP activities. P values determined through chi-square tests.

Activity	Food Secure	Food Insecure	p=
Home Food Procurement	33.4%	35.9%	0.564
More HFP since COVID	44.4%	66.2%	0.002
Gardens Since	34.3%	35.5%	0.782
Fishing Since	7.7%	15.4%	0.005
Foraging Since	7.0%	14.8%	0.003
Hunting Since	3.9%	11.8%	0.000
Livestock Since	4.3%	10.1%	0.008
Canning Since	20.5%	29.6%	0.019
Gardens More	38.8%	58.9%	0.005
Fishing More	28.3%	51.1%	0.025
Foraging More	34.3%	59.4%	0.040
Hunting More	14.3%	47.2%	0.003
Livestock More	47.6%	60.0%	0.401
Canning More	53.1%	63.3%	0.136

Supplementary Table 10. Matching results examining current fruit intake, with various treatment variables. Each row indicate a separate matching result.

Variable	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Treated n= (Matched n=)	Control n= (Matched n)
HFP	0.292	0.125	0.019	0.047	0.537	201 (201)	364 (201)
HFP More	-0.060	0.252	0.811	-0.554	0.433	123 (123)	117 (123)
Garden Since	0.392	0.120	0.001	0.157	0.627	203 (203	368 (203)
Foraging Since	0.154	0.225	0.493	-0.287	0.596	54 (54)	517 (54)
Canning Since	0.275	0.136	0.044	0.008	0.542	139 (139)	432 (139)
Gardens More	-0.048	0.210	0.821	-0.459	0.364	102 (102)	125 (102)
Foraging More	0.109	0.706	0.877	-1.274	1.493	30 (30)	37 (30)
Canning More	0.345	0.335	0.302	-0.311	1.001	61 (61)	94 (61)

Supplementary Table 11. Matching results examining current vegetable intake, with various treatment variables. Each row indicates a separate matching result.

Variable	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Treated n= (Matched n=)	Control n= (Matched n)
HFP	0.487	0.124	0.000	0.244	0.730	201 (201)	364 (201)
HFP More	-0.132	0.204	0.516	-0.531	0.267	123 (123)	117 (123)
Garden Since	0.551	0.122	0.000	0.313	0.790	203 (203)	368 (203)
Foraging Since	0.260	0.201	0.196	-0.134	0.653	54 (54)	517 (54)
Canning Since	0.513	0.142	0.000	0.234	0.791	139 (139)	432 (139)
Gardens More	-0.020	0.178	0.909	-0.368	0.327	102 (102)	125 (102)
Foraging More	0.048	0.665	0.942	-1.255	1.352	30 (30)	37 (30)
Canning More	-0.121	0.386	0.754	-0.877	0.635	61 (61)	94 (61)

Supplementary Table 12. Matching results examining current red meat intake, with various treatment variables. Each row indicates a separate matching result.

Variable	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Treated n= (Matched n=)	Control n= (Matched n)
HFP	0.038	0.174	0.828	-0.303	0.379	201 (201)	364 (201)
HFP More	-0.083	0.273	0.762	-0.618	0.452	123 (123)	117 (123)
Fishing Since	0.275	0.265	0.301	-0.246	0.795	59 (59)	512 (59)
Hunting Since	0.325	0.275	0.238	-0.215	0.865	35 (35)	536 (35)
Livestock Since	1.020	0.314	0.001	0.404	1.635	37 (37)	534 (37)
Fishing More	-0.204	0.746	0.784	-1.667	1.258	38 (38)	55 (38)
Hunting More	-0.662	0.499	0.184	-1.639	0.315	20 (20)	51 (20)
Livestock More	-0.148	0.509	0.772	-1.145	0.850	26 (26)	23 (26)

Supplementary Table 13. Matching results examining current processed meat intake, with various treatment variables. Each row indicates a separate matching result.

Variable	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Treated n= (Matched n=)	Control n= (Matched n)
HFP	-0.365	0.163	0.025	-0.685	-0.046	201 (201)	364 (201)
HFP More	0.180	0.274	0.512	-0.357	0.717	123 (123)	117 (123)
Fishing Since	0.218	0.268	0.416	-0.308	0.744	59 (59)	512 (59)
Hunting Since	-0.111	0.363	0.760	-0.821	0.600	35 (35)	536 (35)
Livestock Since	0.352	0.332	0.289	-0.298	1.002	37 (37)	534 (37)
Fishing More	0.761	0.499	0.217	-0.217	1.738	38 (38)	55 (38)
Hunting More	-0.065	0.555	0.906	-1.153	1.022	20 (20)	51 (20)
Livestock More	0.201	0.487	0.666	-0.745	1.165	26 (26)	23 (26)

Supplementary Table 14. Matching results examining change in fruit and vegetable intake since COVID-19, with various treatment variables. Each row indicates a separate matching result.

Variable	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Treated n= (Matched n=)	Control n= (Matched n)
HFP	0.116	0.053	0.029	0.012	0.220	201 (201)	364 (201)
HFP More	-0.047	0.119	0.696	-0.280	0.187	123 (123)	117 (123)
Garden Since	0.079	0.051	0.124	-0.022	0.179	203 (203)	368 (203)
Foraging Since	0.052	0.095	0.580	-0.134	0.239	54 (54)	517 (54)
Canning Since	0.119	0.061	0.051	-0.001	0.239	139 (139)	432 (139)
Gardens More	-0.030	0.101	0.765	-0.228	0.168	102 (102)	125 (102)
Foraging More	-0.157	0.217	0.470	-0.581	0.268	30 (30)	37 (30)
Canning More	-0.043	0.206	0.834	-0.447	0.361	61 (61)	94 (61)

Supplementary Table 15. Matching results examining change in red and processed meat intake since COVID-19, with various treatment variables. Each row indicates a separate matching result.

Meat Change	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Treated n= (Matched n=)	Control n= (Matched n)
HFP	-0.024	0.057	0.678	-0.135	0.088	200 (200)	364 (200)
HFP More	-0.120	0.110	0.276	-0.336	0.096	122 (122)	117 (122)
Fishing Since	0.051	0.091	0.576	-0.128	0.230	59 (59)	511 (59)
Hunting Since	0.077	0.110	0.485	-0.139	0.293	35 (35)	535 (35)
Livestock Since	0.042	0.112	0.707	-0.177	0.262	37 (37)	533 (37)
Fishing More	-0.152	0.233	0.515	-0.609	0.305	38 (38)	55 (38)
Hunting More	-0.104	0.188	0.581	-0.473	0.265	20 (20)	51 (20)
Livestock More	-0.056	0.154	0.717	-0.358	0.246	26 (26)	23 (26)

Appendix 2: Chapter 2

The Fruits of Labor: Home Food Procurement and Mental Health in the Time of COVID-19

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Abstract

The stress of COVID-19 has affected the mental well-being of many Americans. Simultaneously, stories from popular media during the first year of the pandemic suggested an increased interest in gardening and other home food procurement (HFP) activities (i.e. backyard livestock, fishing, foraging, hunting, and canning/preserving). Prior research suggests that HFP may improve mental health as a byproduct of producing one's own food. This study builds on our previous research, which explored changes in HFP during the COVID-19 pandemic and their relationship to food security and diet quality. Here we expand that analysis to examine the relationship of HFP to emotional eating patterns and perceived stress levels. We use a statewide representative survey (n=600) of residents in Vermont, US. We find that people who engaged in HFP overall were more likely to be eating for physical health, rather than for emotional reasons. Those who engaged in gardening and canning during the pandemic were more likely to eat for physical reasons, while those who engaged in fishing and canning more than before the pandemic were more likely to eat for emotional reasons, though motivations for eating before and during the pandemic varied by specific HFP activity. While the mental health impacts of HFP require further exploration, interest and engagement in these practices has increased overall and points to a need for education and outreach efforts to support those starting or expanding HFP.

Introduction

The stress of the uncertain period of COVID-19 has affected the mental well-being of many Americans. In a May 2020 survey conducted by the United States Census Bureau, respondents reported feeling anxious 30% of the time, and more than 18% reported feeling depressed (Callen 2020). COVID-19 has also highlighted the uncertainty and fragility of food security and food access. In the United States, unemployment rates reached unprecedented levels at their height in April 2020 (Congressional Research Service 2020), causing concerns among many Americans about how to access affordable and high-quality food (Callen 2020). Opportunities to improve both mental health and food security are thus vital during this pandemic period.

Simultaneously, since the COVID-19 pandemic began, there have been a number of stories from popular media outlets in the United States reporting a comeback of "victory gardens" in response to the pandemic (D'Amelio 2020; Rao 2020), increased interest and demand for hunting and fishing (Flesher & Nichols 2020), and a shortage of canning supplies (Rathke 2020). Existing evidence suggests that home food procurement (i.e. backyard livestock, fishing, foraging, gardening, hunting, and canning/preserving, hereafter referred to as HFP) might offer opportunities to improve mental health as a byproduct of producing one's own food (Van Lier et al. 2017; Machida and Kushida 2020; Ambrose et al. 2020; Calvet-Mir et al. 2012; Camps-Calvet et al. 2016; Darby et al. 2020; Dunnett and Qasim 2000; Kortright and Wakefield 2011; Palar et al. 2019).

One mechanism by which HFP might improve mental health and well-being is through increased time outdoors. Research has demonstrated many mental health benefits associated with spending time in nature (Chavaly & Naachimuthu 2020; Korpela et al. 2017; Maller et al. 2006; Russell et al. 2013). A growing body of research in ecopsychology makes the case that this is due to the inextricable link between humans and nature, that our continued industrialization and perceived separation from nature has not only led to the degradation of the planet, but also to the degradation of our own mental well-being (Chavaly & Naachimuthu 2020; Fisher 1996; Maller et al. 2006). Gardening, in particular, has received considerable attention in recent decades for its potential to improve mental health outcomes in clinical settings. Past research has found benefits of these interventions to include reduced depression (Clatworthy et al. 2013; Sempik 2010), reduced anxiety and a general sense of improved wellbeing (Clatworthy et al. 2013; de Sexias et al. 2017), developing new skills and finding meaning and purpose in the work (de Sexias et al. 2017; Parr 2017; Sempik 2010), and promoting social interaction and inclusion (Clatworthy et al. 2013; de Sexias et al 2017; Parr 2017; Sempik 2020). Research on other HFP activities in clinical settings is limited, but Bennet et al.'s 2017 study of a 4 day fly-fishing trip for veterans showed a short-term positive impact on symptoms of PTSD, depression, perceived stress, functional impairment, and leisure satisfaction.

The mental health benefits of HFP strategies are also documented outside of clinical settings. A survey of students in New Zealand showed that those who gardened at home demonstrated higher family connection, better mental well-being, significantly lower levels of depressive symptoms, and better neighborhood connections (Van Lier et al. 2017). Machida and Kushida (2020) found that gardening and on-farm experience among people in Japan had a positive influence on mental health. Prior research also has found that many gardeners find gardening relaxing and helpful in stress reduction (Ambrose et al. 2020; Calvet-Mir et al. 2012; Camps-Calvet et al. 2016; Darby et al. 2020; Dunnett and Qasim 2000; Kortright and Wakefield 2011; Palar et al. 2019), even when mental health benefits were not the gardener's original motivation (Pollard et al. 2018).

Fewer studies have specifically examined the mental health outcomes related to hunting, fishing, foraging, canning, and livestock production, though since these activities tend to take

place in natural settings, there is potential for similar outcomes to gardening. In their 2007 study on the impact of "green exercise" on physical and mental health, Pretty et al. found a significant increase in self-esteem and in the mood factors of anger-hostility, confusion-bewilderment, depression-dejection, and tension-anxiety among people who engaged in fishing. Norman et al. (2010)'s survey of hunters in Sweden found a 19% decrease in self-rated health under the hypothetical situation that hunting was no longer a possibility. In Boulanger-Lapointe et al.'s 2019 study of the importance of berry foraging practices in Inuit Nunangat, interviewees mentioned the foraging experience as "calming," an opportunity to "leave the stresses of the community," and "good therapy." Rural communities, with their close proximity to natural areas, may have increased opportunities to engage in these activities and spend time connecting with nature, while potentially improving their food security and diet quality (Niles et al., 2021; Smith 2019; Huet et al., 2012; Alaimo et al., 2008; Algert et al., 2016; Barnidge et al., 2013; Litt et al., 2011; Nova et al., 2020.)

Furthermore, some evidence suggests that mental health benefits from HFP extend beyond a natural connection. Swan (2003) makes the case that the use of tools in hunting and fishing is one of the defining, instinctual characteristics of humans, that their use is innate to our psyches, and that using these tools responsibly can be a way to reduce natural aggression. de Bell et al. (2020) found that access to a private garden is associated with better well-being overall, but that greater impacts on well-being were correlated with actual garden use, rather than just using a garden as a space to relax. These results suggest that there may be other factors influencing these mental health benefits, perhaps relating to increased physical activity as noted in Pretty et al.'s 2007 study of outdoor exercise, the reduced financial stress that may result from cost savings of home food procurement (Algert et al., 2014; Gray et al., 2014; Nova et al., 2020; Taylor & Lovell, 2015), or the ability to afford other necessities, such as medications.

Evidence on the relationship between hunting, fishing, foraging, and backyard livestock production practices and mental health is limited, especially in the Global North. Additionally, the COVID-19 pandemic has changed the way many people work, live, and shop, potentially providing new opportunities or barriers to HFP. Emerging research does seem to corroborate an increased interest in HFP, especially gardening, since the pandemic began (Chenarides et al. 2020). Research is also beginning to show that time spent outdoors during the initial lockdown period was associated with more positive psychological outcomes, including decreased feelings of loneliness (Stieger et al. 2020) and anxiety (Lesser and Nienhuis 2020). Morse et al. (2020) found that, of the respondents who participated in gardening and foraging, many were partaking in these activities more than in years prior. Additionally, they found that mental health benefits were ranked among the top values associated with spending time in nature for Vermonters during the pandemic period.

While a few studies have looked at the potential benefits of home gardens during the pandemic period, to our knowledge, there have been no population-level studies intended to assess potential changes in HFP activities during the COVID-19 pandemic and their relationship

to mental health. In previous research, we found that 35% of Vermonters were engaged in HFP during the first six months of the pandemic and that 52% did at least one HFP more intensely than they had in years prior (Niles et al. 2021). We also found that HFP was more common among food insecure households and that these households were more likely to have increased their HFP activities since the pandemic began. Here we expand that analysis to see how these activities relate to the mental health outcomes of emotional eating patterns and perceived stress. We survey a representative sample of people in Vermont, a rural US state, to understand their engagement in HFP and its relationship to mental health outcomes since the COVID-19 pandemic began.

Methods

Survey development and sampling strategy

The data we used for this survey were collected using an instrument created in March 2020 (Niles et al. 2020b), as a collaboration among researchers in the National Food Access and COVID research Team (NFACT) (Niles et al. 2020c). The survey continued to be refined in May (Niles et al. 2020d), and the latest version (Niles et al. 2020c), created in July, was used to collect data for this study. The survey examines experiences during the COVID-19 pandemic, mental health outcomes, food security and access, dietary quality, HFP practices, participation in food assistance programs, and individual and household sociodemographics. When possible, the survey utilizes validated measurements (Table 1), and also underwent previous validation in Vermont with 25 respondents aged 18 and over using Cronbach alpha and factor analysis (Niles et al. 2020a). All question sets obtained an internal validity of alpha > 0.70 (Nunnally 1978; Petersen 1994).We obtained Institutional Review Board approval from The University of Vermont (IRB protocol 00000873) before beginning data collection.

The survey was administered online in August and September of 2020 through Qualtrics (Provo, UT) market research panels and received responses from 600 people ages 18 and over. A general population sample characteristic of Vermont statistics on income, race, and ethnicity was achieved by matching sample recruitment quotas to the income, race (White, Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, and Two or more races), and ethnicity (Hispanic, non-Hispanic) population profile of Vermont in the American Community Survey (ACS 2019). This sample represents a margin of error (95% confidence level) for this segment of the Vermont population of +/- 4% (Vermont Department of Health).

Variables of Interest

This analysis explores two self-reported dependent variables from the survey mentioned above (Table 1). First, we examine emotional eating patterns using the scale developed by Arnow et al. (1995) to measure if a person is coping with negative feelings through food and

eating for emotional rather than physical health. Respondents were asked four questions on a five-point Likert scale, and scores were determined by averaging their answers. Among these averages (ranging from 1 to 5), a higher average indicates eating for physical health rather than emotion. Following established scoring methods for this scale, we reversed the score for one question: "I am able to cope with my negative emotions (such as anxiety, sadness) without turning to food for comfort," in order to make it consistent with the other questions. Second we explore perceived stress levels, measured using the perceived stress scale developed by Cohen et al. (1994). Scores for stress levels were evaluated with the sum of responses, ranging from 0 to 16. In this scale, a higher number is indicative of higher perceived stress. Following established scoring methods for this scale, we also reversed the scores of two questions in this data set: "In the last month, how often have you felt confident about your ability to handle your personal problems?" and "In the last month, how often have you felt that things were going your way?" in order to make them consistent with the other perceived stress scores. Our independent variables included a variety of questions related to previous and current HFP, specific HFP activities, and changes in HFP activities since the pandemic began, as well as demographics at the household and individual level (Table 1).

Table 1. Complete list of variables, questions and measurement utilized in this analysis.

Variable Name	**Question/Scale**	**Measurement**
Emotional Eating	1. I find myself eating when I'm feeling emotional (such as anxious, depressed, sad), even when I'm not physically hungry. 2. find myself eating when I am lonely, even when I'm not physically hungry. 3. I find myself eating when I am stressed out, even when I'm not physically hungry. 4. I am able to cope with my negative emotions (such as anxiety, sadness) without turning to food for comfort. (score reversed)	1=Strongly Agree, 2=Agree, 3=Neither agree nor disagree, 4=Disagree, 5=Strongly disagree
Perceived Stress (PSS)	1. In the last month, how often have you felt that you were unable to control the important things in your life? 2. In the last month, how often have you felt confident about your ability to handle your personal problems? (score reversed) 3. In the last month, how often have you felt that things were going your way? (score reversed) 4. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0=Never, 1= Almost Never, 2=Sometimes, 3=Fairly Often, 4= Very Often Summation of responses for scale ranging from 0-16.
Home Food Procurement Variables		

Any HFP (AHFP)	Indicated that the household accessed local food through gardening, fishing, foraging, hunting, backyard livestock or using your own canned goods at any point before or since COVID-19	Binary variable (1= home food procurement activity, 0= no activity)
Garden During Pandemic	Respondent that has gardened during the COVID-19 pandemic	1= Had a garden since COVID-19, 0= No garden since COVID-19
Fishing During Pandemic	Respondent that has fished during the COVID-19 pandemic	1= Fished since COVID-19, 0= No fishing since COVID-19
Foraging During Pandemic	Respondent that has foraged during the COVID-19 pandemic	1= Foraged since COVID-19, 0= No foraging since COVID-19
Hunting During Pandemic	Respondent that has hunted during the COVID-19 pandemic	1= Hunted since COVID-19, 0= No hunting since COVID-19
Livestock During Pandemic	Respondent that has backyard livestock during the COVID-19 pandemic	1= Had backyard livestock since COVID-19, 0= No backyard livestock since COVID-19
Canning During Pandemic	Respondent that has used own canned goods during the COVID-19 pandemic	1= Used own canned goods since COVID-19, 0= No canning since COVID-19
HFP More During Pandemic	Subset of respondents that pursued HFP- Any respondent that indicated they pursued a HFP activity "for the first time this year", or "I have previously done this, but did it more this year"	Binary variable (1= more intense HFP, 0= no change in activity, or pursued less this year)
Gardens More During Pandemic	Any respondent that indicated they pursued gardening "for the first time this year", or "I have previously done this, but did it more this year"	1= More intense or new, 0= same or less than before
Fishing More During Pandemic	Any respondent that indicated they pursued fishing "for the first time this year", or "I have previously done this, but did it more this year"	
Foraging More During Pandemic	Any respondent that indicated they pursued foraging "for the first time this year", or "I have previously done this, but did it more this year"	
Hunting More During Pandemic	Any respondent that indicated they pursued hunting "for the first time this year", or "I have previously done this, but did it more this year"	

Livestock More During Pandemic	Any respondent that indicated they pursued backyard livestock "for the first time this year", or "I have previously done this, but did it more this year"	
Canning More During Pandemic	Any respondent that indicated they pursued canning "for the first time this year", or "I have previously done this, but did it more this year"	
Demographic Variables:		
Female	Which of the following best describes your gender identity?	1= Female, 0=Male
Children in HH	How many people in the following age groups currently live in your household (including you)? Household includes people currently living within your home, including family and non-family members.	1= Any children in household, 0= No children in household
Over 55	Please select your age group	1= Respondent 55 or older, 0= Respondent 55 or younger
Race/Ethnicity (BIPOC/Hispanic)	What is your race? Are you of Hispanic, Latino, or Spanish origin?	1= Respondent identify as Asian, Black or African American, Native American, White, Mixed Race, and/or Hispanic, Latino or Spanish origin, 0= Respondent identifies as white and non-Hispanic, Latino or Spanish origin
Negative Job Change	Have you or anyone in your household experienced a loss of income or job since the COVID-19 outbreak (March 11th)?	1= Any job change (job loss, reduced hours or income at job, furloughed), 0= No job change
Less $50K	Which of the following best describes your household income range in 2019 before taxes?	1= Household income below $50,000 a year, 0= Household income above $50,000 a year
HH Size	How many people in the following age groups currently live in your household (including you)? Household includes people currently living within your home, including family and non-family members.	1= 1 person, 2= 2 people, 3= 3 people, 4= 4 people, 5= 5 people, 6= 6 people, 7=7 people or more

*We aggregate these data due to the low number of respondents identifying as BIPOC and/or Hispanic. The survey is representative of Vermont characteristics on race and ethnicity, but our sample size is too low to analyze racial and ethnic groups independently in models.

Statistical analysis

Since the distribution of the two dependent variables were normally distributed, we use multivariable regression models to examine changes in emotional eating and perceived stress outcomes as they relate to demographic factors. Then, we use nearest neighbors matching techniques to examine how engagement in any home food procurement activity (AHFP), intensity of HFP, and specific HFP activities relate to both emotional eating and perceived stress. We used matching techniques because they are a useful means by which to explore causal effects of treated and control groups among observational data. With this we aim to balance the distribution of covariates across treatment and control groups (Stuart et al. 2010). We used this method to explore how AHFP, intensity of HFP, or specific HFP activities may be "treatments" on emotional eating and perceived stress, using six demographic factors we consider likely to be associated with the treatment and outcome (Rubin and Thomas 1996; Hill et al. 2004). This technique also requires defining a distance (or measure of similarity between the individuals). We use a nearest neighbor matching approach with a Mahalanobis distance, which accounts for covariance among variables, and which previous research has documented to work well with eight covariates or fewer (Rubin 1979; Zhao 2004). Nearest neighbor matching selects a control individual with the smallest distance from each treated individual. For example, if we are exploring gardening with increased intensity since COVID-19, the technique would have people who did and did not increase their intensity as a "treatment" and control group, and then match a treatment and control respondent together based on similar demographic covariates included in the analysis (e.g. income level and age). In all our models, each observation was matched with five closest other observations within the control and treatment groups.

Results

Respondent Characteristics

Overall, 68% of the respondents to our survey were female and 30% had children in the household . A total of 44% of survey respondents were aged 55 years or older and 8.3% identified as BIPOC/Hispanic ethnicity. More than 46% of respondents lived in a household that had experienced either a job loss, loss of income or hours from job, or furlough during the first six months of the pandemic. The average household size was 2.57 people, with 19.6% single households, 40.6% two person households, 16.5% three person households, 14.3% four person households, and 9.1% five or more person households.

Table 2: Demographic characteristics of sample.

Characteristic		Respondents (n=600)	
Age	18-34	153	25.5

	35-54	182	30.3
	55+	263	43.8
Children in HH	Yes	178	30.2
	No	415	70.0
Gender	Female	404	67.3
	Male	190	31.7
	Transgender/Non-binary/Self-Described	6	1.0
BIPOC-Race	White	559	93.2
	Two or more races	22	3.7
	American Indian or Alaska Native	5	0.8
	Asian	4	0.7
	Black or African American	9	1.5
BIPOC-Ethnicity	Not Hispanic or Latino	583	97.2
	Hispanic or Latino	17	2.8
2019 Household Income	Less than $10,000 per year	39	6.5
	$10,000-$24,999	81	13.5
	$25,000-$49,999	141	23.5
	$50,000-$74,999	110	18.3
	$75,000-$99,999	77	12.8
	$100,000 or more	145	24.1
Negative Job Change	Lost Job	149	24.8
	Reduced Hours or Income	208	34.7
	Furloughed	122	20.3
	Any Change	270	46.2
	No Changes	314	53.8
Household Size	1 to 2	357	60.2

3 to 5	211	35.6
6 or more	25	4.2

Descriptive Statistics of Key Variables

Among our dependent variables we found many respondents demonstrating signs of emotional eating and perceived stress (Figures 1 and 2). When asked if they eat when they are feeling emotions such as anxiety or depression, even if they are not physically hungry, 42.14% of respondents agreed or strongly agreed. One third (33.62%) agreed or strongly agreed that they eat when they feel lonely, while 39.46% agreed or strongly agreed they eat when they feel stressed. Nearly half (44.65%) of respondents said they agree or strongly agree that they are able to cope with negative emotions (such as anxiety or sadness) without turning to food for comfort; while 37.13% said they disagree or strongly disagree. When asked about their stress levels over the last month, 61.20% of respondents said they sometimes, fairly, or very often felt as though they were unable to control the important things in their life and 17.26% of respondents indicated that they never or almost never felt confident about their ability to handle their personal problems. When asked how often they felt that things were going their way, 29.98% said never or almost never. When asked how often in the last month respondents felt difficulties were piling up so high that they could not overcome them, 50.59% said sometimes, fairly, or very often. A pearson's correlation found that the emotional eating and perceived stress scales were significantly correlated (-0.342, $p<0.001$), indicating that people with higher perceived stress were also more likely to eat for emotional reasons.

Figure 1. Emotional eating scale responses by percent.

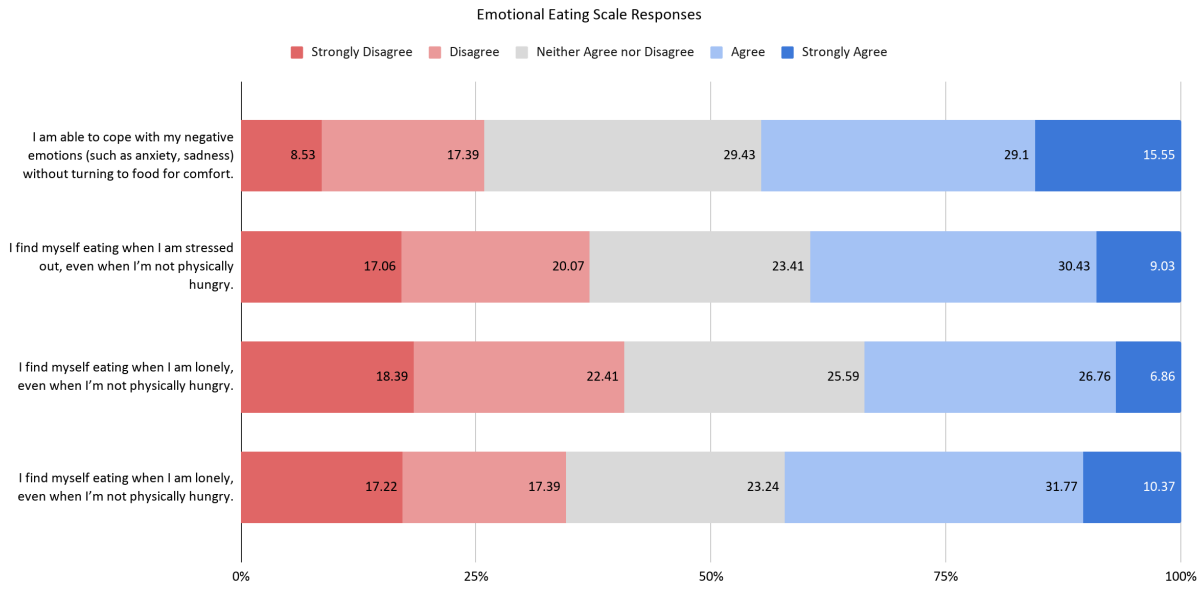
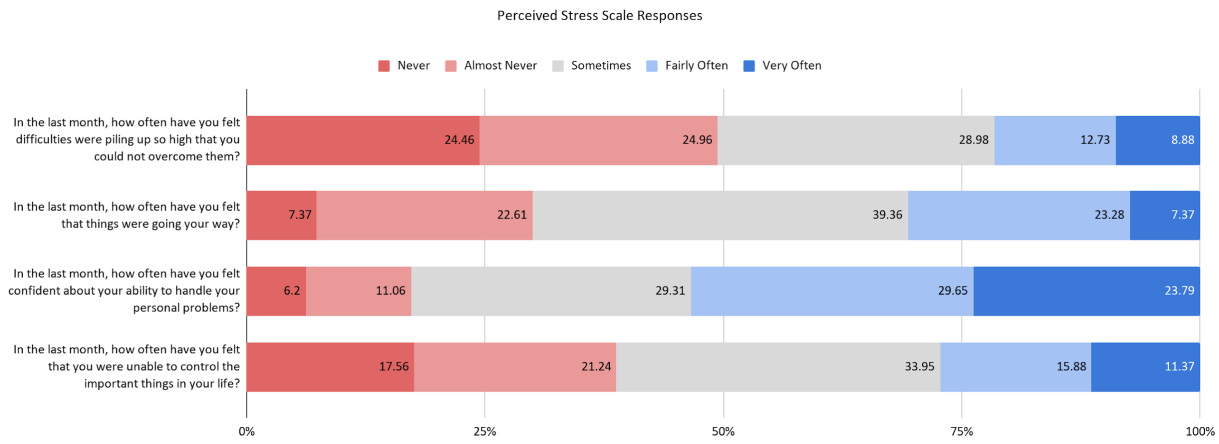


Figure 2. Perceived stress scale responses by percent.



Demographics Associated with Emotional Eating and Perceived Stress

Using multivariable regression models, we examined the relationship of demographic factors to emotional eating and perceived stress (Tables 3 and 4). We found similar results across both scales. Women were significantly more likely to eat for emotional reasons, rather than physical needs (b=-0.391, p<0.001) and to have higher perceived stress levels since COVID-19 (b=0.627, p=0.036). We also found higher rates of emotional eating (b=-0.157 p=0.062) and perceived stress (b=1.194, p<0.001) among those with a negative job change. Higher rates of perceived stress were also found among low-income households (b=1.524, p<0.001). We found lower rates of emotional eating among people over 55 (b=0.443, p<0.001) and those with children in the household (b=0.182, p=0.076). We found lower perceived stress levels since the start of the COVID-19 pandemic among those who lived in households with children (b=-0.909, p=0.008), and those over age 55 (b=-2.748, p<0.001).

Table 3. Regression of emotional eating by demographics. Higher score = less emotional eating.

	Coefficient	Std. Error	t	p>t	95% Confidence Interval	
Less 50k	0.069	0.084	0.820	0.412	-0.096	0.234
Female	-0.391	0.090	-4.330	0.000	-0.568	-0.214
Children in Household	0.182	0.103	1.780	0.076	-0.019	0.008
Over 55	0.443	0.097	4.560	0.000	0.252	0.635
BIPOC/Hispanic	0.218	0.151	1.440	0.149	-0.078	0.514

Negative Job Change	-0.157	0.084	-1.870	0.062	-0.322	0.008

Table 4. Regression model predicting perceived stress scale by demographics. Higher score = more stress.

	Coefficient	Std. Error	p>t	95% Confidence Interval	
Less 50k	1.524	0.277	0.000	0.979	2.069
Female	0.627	0.299	0.036	0.041	1.214
Children in Household	-9.09	0.339	0.008	-1.575	-0.243
Over 55	-2.748	0.322	0.000	-3.382	-2.155
BIPOC/Hispanic	-0.833	0.498	0.095	-1.812	0.145
Negative Job Change	1.194	0.278	0.000	0.649	1.740

Home Food Procurement and Emotional Eating

Using a matching approach to examine the effect of AHFP on emotional eating patterns, we find engaging in AHFP to be positively associated with eating for physical, rather than emotional reasons (b=0.275, p=0.002), while controlling for gender, children in the household, negative job change, income, race/ethnicity, and household size. When examining the effect of specific HFP activities during the pandemic on emotional eating patterns, we also find gardening (b=0.349, p<0.001) or canning (b=0.304, p=0.003) during the pandemic to be associated with eating for physical, rather than emotional reasons. However, we find engaging in fishing (b=-0.64, p=0.003) or canning (b=-0.427, p=0.015) more intensely or for the first time during the COVID-19 pandemic to be associated with eating for emotional, rather than for physical reasons.

Table 5. Emotional Eating outcomes as related to HFP using nearest neighbors matching analysis. Each row indicates a separate matching analysis, where the HFP variable was used as a "treatment" while using six demographic controls (Female, Children in HH, BIPOC/Hispanic, Negative Job Change, Less $50k, HH size) to conduct the matching.

	Coefficient	Robust Std. Error	p=	95% Confidence Interval		Model n=
Any HFP	0.275	0.089	0.002	0.100	0.449	565
Garden During Pandemic	0.349	0.091	0.000	0.17	0.528	570

Fishing During Pandemic	0.125	0.173	0.469	-0.214	0.464	570
Foraging During Pandemic	0.214	0.174	0.2.18	-0.127	0.556	570
Hunting During Pandemic	0.267	0.188	0.155	-0.101	0.635	570
Livestock During Pandemic	-0.061	0.212	0.772	-0.476	0.354	570
Canning During Pandemic	0.306	0.104	0.003	0.101	0.507	570
HFP More During Pandemic	-0.063	0.139	0.650	-0.336	0.210	240
Gardens More During Pandemic	-0.083	0.147	0.569	-0.372	0.205	227
Fishing More During Pandemic	-0.640	0.215	0.003	-1.062	-0.218	93
Foraging More During Pandemic	0.184	0.288	0.522	-0.379	0.748	67
Hunting More During Pandemic	-0.312	0.312	0.317	-0.924	0.299	71
Livestock More During Pandemic	-0.412	0.294	0.161	-0.989	0.165	49
Canning More During Pandemic	-0.427	0.176	0.015	-0.772	-0.082	155

Home Food Procurement and Perceived Stress

Using a matching approach to examine the effect of AHFP on perceived stress levels, we do not find a statistically significant association between AHFP and stress levels. However, when examining the effect of specific HFP activities during the pandemic on perceived stress levels, we find that gardening during the pandemic is associated with lower perceived stress levels (b=-0.739, p=0.017). We further find that fishing (b=1.537, p=0.05), hunting (b-1.582, p=0.078), or canning more (b=1.026, p=0.052) were all associated with higher levels of perceived stress since COVID-19 at the time of the survey.

Table 6. Perceived Stress outcomes as related to HFP using nearest neighbors matching analysis. Each row indicates a separate matching analysis, where the HFP variable was used as a "treatment" while using six demographic controls (Female, Children in HH, BIPOC/Hispanic, Negative Job Change, Less $50k, HH size) to conduct the matching.

	Coefficient	AI Robust Std. Error	p=	95% Confidence Interval		Model n=
Any HFP	-0.376	0.302	0.212	-0.967	0.215	564
Garden During Pandemic	-0.739	0.309	0.017	-1.344	-0.133	569
Fishing During Pandemic	-0.114	0.483	0.814	-1.06	0.833	569
Foraging During Pandemic	-0.361	0.553	0.514	-1.443	0.722	569
Hunting During Pandemic	-0.562	0.781	0.472	-2.094	0.969	569
Livestock During Pandemic	0.150	0.758	0.844	-1.334	1.635	569
Canning During Pandemic	-0.293	0.323	0.364	-0.927	0.340	569
HFP More During Pandemic	0.300	0.413	0.469	-0.510	1.120	239
Gardens More During Pandemic	0.005	0.400	0.990	-0.779	0.789	226
Fishing More During Pandemic	1.537	0.785	0.050	-0.002	0.308	92
Foraging More During Pandemic	0.396	0.921	0.668	-1.411	2.203	66
Hunting More During Pandemic	1.582	0.898	0.078	-0.179	3.342	70
Livestock More During Pandemic	0.550	1.069	0.607	-1.545	2.645	48

Canning More During Pandemic	1.026	0.529	0.052	-0.011	2.063	155

Discussion

Here we explore the relationships between HFP, including increasing intensity of HFP, and emotional eating and perceived stress outcomes since the start of the COVID-19 pandemic among a representative sample of people in Vermont, a rural US state. We find that certain demographics, especially women and people with a negative job change since COVID-19, were more likely to experience higher levels of perceived stress and emotional eating. Engaging in AHFP activities is associated with lower levels of emotional eating overall. Specifically, this is true especially for individuals gardening and canning. However, we also find that those who engaged in fishing and canning more since the COVID-19 pandemic began were more likely to eat for emotional reasons. Similarly, those who have gardened during the pandemic had lower perceived stress levels, while those who were fishing, hunting, or canning more than they did before the pandemic had higher perceived stress levels.

The results of this study have several important implications. First, our findings suggest that women and those with a negative job change since COVID-19 experience higher perceived stress and emotional eating outcomes. This builds on other emerging research from the pandemic period that has found an association between perceived stress levels and emotional eating, especially among women (Wan Shen et al. 2020). Another recent study found a 61.2% increase in stress eating during the pandemic among a sample of adults with obesity (Almandoz et al. 2020). Our findings complement this research and suggest that higher stress levels from a job change may in fact be directly influencing emotional eating patterns. This also points to a clear need for easy and cost effective interventions that may be able to help people manage the stress of this unprecedented period, such as gardening and spending time in nature.

In terms of the relationship between gardening and mental health outcomes, our results support the large body of previous research that has demonstrated the beneficial effects of gardening on mental health (Clatworthy et al. 2013; de Sexias et al 2017; Parr 2017; Sempik 2020) and builds on the more limited research of these impacts outside of clinical settings (Van Lier et al. 2017; Machida and Kushida 2020; Ambrose et al. 2020; Dunnett and Qasim 2000). Those who gardened during the pandemic had lower rates of emotional eating and lower perceived stress levels. This may be due to a variety of factors, including the opportunity to spend time outside breathing fresh air and connecting to nature, gardening as a social activity with family or socially-distanced near others in a community garden, or reduced financial stress and availability of money for other needs. In addition, our previous research on the demographics of HFP participation found that low income households were less likely to garden specifically (as opposed to other HFP), so these results may be due to the fact that higher income

people are gardening, and therefore have increased financial stability and reduced stress (Niles et al. 2021).

Our work is novel in its examination of other HFP activities as well. We find in several cases that increased intensity of other HFP is related to higher levels of emotional eating and perceived stress. Those who increased their intensity of fishing and canning were more likely to be eating for emotional reasons, and those who increased their intensity of fishing, hunting, and canning had higher levels of perceived stress. There are several potential explanations for these results. First, we have previously reported that food insecure households are more likely to be engaging more intensely in HFP (Niles et al. 2021). Perhaps those who started certain HFP activities for the first time or did it more than in years prior did so due to increased financial burdens and potential cost savings, and were already experiencing high levels of stress. Previous research has demonstrated a clear link between food insecurity and perceived stress levels (Pourmotabbed et al. 2020) as well as emotional eating patterns (Lopez et al. 2020). Indeed, the impact of food insecurity on mental illness appears to worsen in situations of high stress and social isolation (Martin et al. 2016). As such, the unique context of the pandemic is likely adding myriad complex and overlapping influences on mental health outcomes.

Second, these findings suggest that, similar to de Bell (2020)'s findings, something inherent in the act of gardening may lead to improvements in mental health, rather than the fact that gardeners are simply spending time in nature. Pollard et al. (2018) found tradition and connection to others to be motivations for both home and community gardeners. As well, each of the studies we examined on the impacts of gardening in clinical mental health settings listed social engagement and inclusion as top benefits of participating in gardening programs (Clatworthy et al. 2013; de Sexias et al 2017; Parr 2017; Sempik 2020). Gardening may also be an important part of family traditions and ties to ancestral heritage, perhaps bringing a sense of satisfaction and meaning not found in other HFP activities.

Additionally, it is possible that those who garden are doing so more consistently than those who are hunting, fishing, and canning. Watering, weeding, and caring for a garden is a near-daily practice for many gardeners, while fishing and hunting may be more infrequent. While previous literature has found short-term benefits of engaging in HFP regardless of duration of a single exposure (Pretty et al. 2007), long-term benefits and increased enjoyment seem to be correlated with more regular exposure (Dunnett & Qasim 2000). For example, while Bennet et al. (2017) found significant mental health outcomes immediately after the fly-fishing trip for veterans, those impacts were short-lived, suggesting that these activities may need to be practiced frequently to have a sustained impact. Future studies should examine, not just the perceived increase in these activities, but the amount of time spent engaging in them individually over the course of a season. Similarly, future research should examine yields from individual HFP activities and their relationship with mental health outcomes. Perhaps if gardeners were producing a higher quantity of food than was sourced from the other HFP activities, they might have had fewer financial concerns at the time of the survey.

There are several limitations to this study and opportunities for future research to explore. First, the lack of data about yields from HFP activities limits our understanding of the results. Future research should seek to quantify the amount of food produced from the individual HFP activities, as well as perceived cost savings, and compare those results with mental health outcomes. Future research should also seek to quantify the amount of time respondents spent on the different HFP activities to determine if the increased mental health benefits of gardening compared to other strategies may be due to the frequency with which they were practiced. The Vermont context we explored is unique for a variety of reasons and future research should examine these results in other locations and contexts. Seasonality is particularly important in this context. The data were collected in August and September, at the height of the gardening season in Vermont, and well before peak hunting seasons, likely having an impact on the intensity with which respondents were engaging in these activities. Lastly, this study would have been greatly enhanced with additional qualitative data to determine respondents' motivations for engaging in HFP during the pandemic period, challenges experienced, as well as the benefits they perceive from engaging in these activities. Interviews and focus groups could help put these results into context and provide information on educational and resource needs to enhance and sustain the various benefits of HFP.

Conclusion

This study examined a state-wide representative sample of residents in a rural US state during the first six months of the COVID-19 pandemic to assess the relationship between mental health outcomes and gardening, backyard livestock production, fishing, foraging, hunting, and canning/preserving. Our results are mixed but build on the existing body of research demonstrating the mental health benefits of gardening. More research is needed to determine why gardening in particular demonstrated more significant impacts on mental health than many of the other HFP activities. Future studies should examine the quantity of food procured from the different HFP activities, time spent engaged in each activity, ease of engagement and barriers to entry, and original motivations for starting or expanding HFP during the pandemic period specifically, in order to conceptualize the results. Nonetheless, while the results on mental health impacts require further exploration, interest and engagement in HFP has increased overall and points to a need for education and outreach efforts to support those starting or expanding HFP to maximize yields, cost-effectiveness, overall enjoyment. Additionally, our findings of the positive relationship between gardening and mental health during the pandemic period point to the need to prioritize investment in community gardens and to allow them to remain open during times of lockdown, even amidst more stringent operating and safety precautions.

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