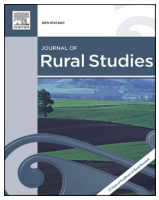
Journal of Rural Studies 107 (2024) 103256

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud



Social determinants of rural food security: Findings from Michigan's Upper Peninsula

Hongmei Lu [a,b,*], Angie Carter [a]

[a] Department of Social Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA
[b] Department of Human Geography and Spatial Planning, Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, the Netherlands

ARTICLE INFO

Keywords:
Food security
Rural areas
Social determinants
Economic conditions
Spatiotemporal patterns
Informal foodways
Local food systems

ABSTRACT

Rural food insecurity is understudied, although many rural-specific characteristics influence rural food security. We used a mixed-mode survey to investigate how economic conditions, food support measures, and geospatial patterns impact rural residents' food insecurity in the six-county region of Michigan's Western Upper Peninsula. Three nested ordinal logistic regressions identify that household income and costs significantly influence rural food insecurity probability. Lack of time is also a key factor in increasing food insecurity probability. The ability to drive oneself to access food offsets the negative impacts of living a far distance from retail food locations; yet, transportation remains a barrier to food access in the region's harsh winters. About 38% of eligible respondents use food assistance programs, yet their use does not improve food security probability. Engagement in informal foodways mitigates food insecurity to some degree.

1. Introduction

This paper shares our analysis of a regional survey assessing motivating food security factors in Michigan's Western Upper Peninsula. In the U.S., and especially during the COVID-19 pandemic, both rural and urban populations have experienced increased food insecurity (Schanzenbach and Pitts, 2020). While rural populations experience food insecurity at similar rates as urban areas, the realities of rural food insecurity have largely been left out of the conversation (Piontak and Schulman, 2014), and large-scale probabilistic studies assessing determinants of rural food security are very limited (Coleman-Jensen et al., 2019). Research studying rural informal foodways and food access is sparse and consists primarily of qualitative studies (Hendrickson et al., 2020; McEntee, 2010; Smith and Miller, 2011). The few existing studies identify how rural residents may participate in their food systems differently than those living in urban areas (Hendrickson et al., 2020). Greater understanding of how rural residents participate in their food systems is important to support food security, defined as "the access by all people at all times to enough food for an active, healthy life" (USDA ERS, 2024).

A region's food system is shaped by its degree of urbanization, natural resources, social contexts, and population (Smith and Miller, 2011). Certain determinants of food insecurity, such as income, age, and number of children, may be consistent across urban and rural regions, but the impact of factors more typical in rural areas, such as inadequate supermarkets, limited availability of specific foods, and higher food costs compared to suburban or urban areas, remains understudied (Hendrickson et al., 2020; Morris et al., 1992). Due to a higher proportion of rural census tracts not having sufficient retail food locations, combined with insufficient or no public transportation to these locations, the quantity and variety of formal food resources available in rural areas are limited (Coleman-Jensen et al., 2019; Smith and Miller, 2011). Informal foodways have the potential to provide significant amounts of nutrition that may not be captured in food frequency questionnaires or national dietary surveys. Informal foodways refer to the social, cultural, and economic practices relating to gardening, hunting, and foraging foods, as well as the bartering or gifting of these foods (Lu and Carter, 2022; Smith and Miller, 2011). These homegrown or wild-harvested foods benefit the community beyond the individual harvester (Hendrickson et al., 2020; Smith and Miller, 2011).

To identify the social determinants of rural food security, we implemented a mixed-mode survey across a six-county region of Michigan's Western Upper Peninsula (WUP) in the spring of 2022. Michigan's WUP is geographically remote and rural, bordered by Wisconsin to the west, Lake Superior to the north and east, and Lake Michigan to the south. The region is rich in natural resource amenities and cultural

* Corresponding author. Department of Social Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, USA.
E-mail addresses: hongmeil@mtu.edu, h.lu@uu.nl (H. Lu), ancarter@mtu.edu (A. Carter).

https://doi.org/10.1016/j.jrurstud.2024.103256
Received 5 September 2023; Received in revised form 10 January 2024; Accepted 29 February 2024
Available online 19 March 2024

heritages, including long histories of Indigenous and immigrant foodways. The Copper Boom of the mid-19th through the mid-20th centuries brought an influx of workers to the region. Today, de-industrialization across the region has resulted in a population decline of over 80% (Winkler et al., 2016). The extractive industries of logging and mining continue to present ecological and cultural challenges today, such as the pollution of the region's waters indicated by the high concentrations of heavy metals present in fish (Groetsch, 2024, n.d.) and the threats this contamination poses to treaty rights of the Ojibwe Great Lakes tribes (GLIFWC, n.d.). Despite this, the region's ethnic groups and two tribal nations continue to participate in and celebrate rich food traditions today.

Our study originated through collaboration with community partners who had asked for our assistance in the co-creation of the survey instrument to study local food systems needs. As emphasized by our community partners in the survey instrument's development, we asked questions related to factors identified in the literature, including demographics and food program use; we also investigated the impact of rural-specific factors, such as spatiotemporal patterns and engagement in informal foodways (Hendrickson et al., 2020). Understanding these can help to identify opportunities to develop appropriate policies that can improve rural food security based on local food infrastructure and, thus, rural public health within and beyond the region of study.

2. Factors influencing food security and research hypotheses

2.1. Demographics and food security (Hypotheses 1 and 2)

We first hypothesize that better economic conditions and higher income improve rural food security (Hypothesis 1). Food insecurity is directly influenced by economic conditions, such as employment, income, and food prices (Gundersen et al., 2011; Gundersen and Ziliak, 2018). Food insecurity increased dramatically during the 2008 economic crisis. During this time, overall food insecurity in the U.S. increased from 12.2% to 16.4%, and the very low food security rate rose from 4.0% to 5.8% (Gundersen et al., 2011). More recently, there was a large increase in unemployment at the start of the COVID-19 pandemic in 2020, from 3.9% in February to 14.7% in April; food insecurity increased from approximately 11% in 2018 to 38.3% in 2020 (Schanzenbach and Pitts, 2020). According to Feeding America West Michigan, (2020), the increase in unemployment explains more than half of the increase in the WUP region's food insecurity.

When the economy is down and unemployment is high, food prices become the primary driving force for choosing where to buy food (Colasanti et al., 2019). One factor leading to lower food prices is the expansion of large-scale retailers into an area. Large-scale retailers are able to have lower prices, and through increased competition, other stores are compelled to lower their prices. Courtemanche et al. (2019) find that the expansion of Walmart Supercenters has led to decreased food prices and a decline in food insecurity in those areas. Another necessity that constitutes a high proportion of expenditures for many low-income households is housing costs. On average, housing costs make up over 40% of low-income households' total expenditures (Schanzenbach et al., 2016). One estimate finds that for each $500 increase in rent per year, there is a 10% increase in a household's probability of food insecurity (Fletcher et al., 2009).

We then hypothesize that households with more children will have lower food security (Hypothesis 2). Child-raising entails extra costs and becomes even harder during crises. Ahn and Norwood (2021) find that COVID-19 has negatively impacted households with children. The percentage of food-insecure households among those with children in 2020 was significantly higher when compared with the 2018 USDA numbers and suggests the COVID-19 pandemic had a similar impact upon food insecurity as did the 2008 Great Recession (Ahn and Norwood, 2021; Ahn et al., 2020). Schanzenbach and Pitts (2020) support this finding and suggest that food insecurity has tripled to 29.5% during the pandemic in families with children compared with those without, but, as Nord and Hopwood (2007) point out, adults may shield children from the direct effects of household food shortages.

2.2. Food assistance program use and food security (Hypothesis 3)

Given the existing literature on the impact of food assistance programs on food security, we hypothesize that food assistance programs may have a limited role in improving rural food security (Hypothesis 3). Ratcliffe et al. (2011) report that the Supplemental Nutrition Assistance Program (SNAP) can reduce the possibility of food insecurity by about 30% and reduces the possibility of high food insecurity by 20%; however, other studies point to complex challenges of food security and the inefficiency of federal food assistance programs in meeting the needs of recipients. AbuSabha et al. (2011) studied the Commodity Supplemental Food Program's influence upon elders' food security and found no significant difference between those who use the program and those who do not. Likewise, Gibson-Davis and Foster (2006) found that SNAP has no statistically significant effect on participants' food security or food sufficiency. Rather, Wilde and Nord (2005) have even found that SNAP participants are more likely than nonparticipants to be food insecure or insufficient. Moreover, as previous studies have noted, rural residents face unique challenges in accessing transportation, availability of specific foods, and proximity of supermarkets (Morris et al., 1992; Smith and Miller, 2011); these challenges may pose barriers to using food assistance benefits or programs in rural areas. Further, Smith and Miller (2011) find that the business hours for food assistance program applications are abbreviated and lack coordination with other programs, which restricts the amount and types of food provisioning available to food-insecure residents.

2.3. Rural geophysical conditions and food insecurity (Hypotheses 4 and 5)

We hypothesize that the geographic distance rural residents must travel to access food will contribute to their food insecurity (Hypothesis 4). Additionally, given the unique characteristics of Michigan's WUP, we hypothesize that the harsh winters of this rural area will contribute negatively to residents' food security (Hypothesis 5). For instance, Mackie and Force-Emery (2012) find that doing social work in rural areas proves very challenging when the area is large, and the population density is low. Similarly, in rural areas, access to retail food locations is challenging because of geographic distance and insufficient public transit. A substantial number of rural people have to travel outside the county for their grocery shopping (Colasanti et al., 2019). Thus, we hypothesize that the geographic distance between population centers, the region's low population density, and the lack of community infrastructure, such as public transportation or affordable groceries in smaller towns, will present challenges to food access.

Seasonality is another important consideration in our study region. Seasonal factors such as adverse weather, higher utility bills, and reduced outdoor work can contribute to higher food assistance needs (Colasanti et al., 2019). In Michigan's WUP, many residents engage in seasonal work, such as leisure and hospitality jobs, dependentent upon good weather and/or summer tourism (Winkler et al., 2016). The seasonality of work and the impact of the pandemic upon this work, combined with the adverse driving conditions and the need for reliable vehicles in winter, informed our hypothesis that winter would negatively impact food security. However, there are limited measures assessing comfort with driving in winter conditions.

2.4. Rural foodways and food security (Hypothesis 6)

Rural communities have environmental and cultural resources, including informal foodways, that can be utilized to reduce food insecurity. This contrasts with urban residents' food resources, which

include grocery stores where food assistance programs are accepted (Smith and Miller, 2011). Thus, in addition to the above-identified factors in the literature, we assume rural-specific nature-based informal foodways may also influence residents' food security, especially in harsh seasons. We hypothesize that respondents' engagement in informal foodways would improve their food security (Hypothesis 6). We followed Hendrickson et al.'s (2020) conceptualizations of the contributions of informal economies to local food systems when developing our survey questions regarding informal foodways. Our survey included questions about informal foodway activities that may not be reported, or may be underreported, as contributions to household food security. Rural residents in the WUP can also directly access food from producers through community-supported agriculture farms in the region, as well as local farm stands and farmers' markets. According to the Western UP Food Systems Collaborative's most recent count, there are at least 13 farmers markets in the region (WUPFSC, n.d.), though, at the time of our study, few of these accepted food assistance programs.

Compared with gardening, there are fewer studies of the impact hunting and fishing have on reducing food insecurity and improving diet quality, although several qualitative studies indicate wild foods are an important dietary component in rural communities (Buck-McFadyen, 2015). However, the findings are mixed about whether hunting and fishing are just recreational pastimes or supplemental food resource activities. Some may pursue hunting and fishing as both a recreational activity and as a source of food procurement. For generations, hunting has been an important component of local culture in the WUP. Many rural households treat hunting as a rite of passage. Anecdotal evidence and our own observations note that November 15, the opening of firearm deer-hunting season, is traditionally a day of higher-than-average absenteeism from workplaces and schools across the region; some school districts even cancel classes on this day. This reflects the importance the regional culture places upon this activity as a source of recreation and self-sufficiency. Many rural Minnesota residents report eating game meat frequently, one to five times per week, suggesting that it provides an important source of protein for rural families (Smith and Miller, 2011). In 2018, in the WUP, 82% of the over 52,000 deer hunters licensed shared venison, with an average of 5.3 individuals (Frawley, 2019). Food sharing and bartering within social networks cannot necessarily prevent food insecurity, but they can fill gaps in food security.

3. Methodology

3.1. Study area

Michigan's WUP is exclusively rural, with the six counties' Rural-Urban Continuum Codes ranging between 5 and 9 (Fig. 1); a code value of 5 or above implies a rural area (US Census, 2020; USDA ERS, 2023). Table 1 details the demographics for the region; Houghton County accounts for the most residents (47%) and Keweenaw County the least (only about 3%) of the region's total 77,000 residents. About 24.4% of the residents in the region were over 65 years old (compared to 16.8% at the national level), with many living alone (US Census, 2020). Given this is a post-industrial area (Winkler et al., 2016), unemployment is high and there is a high poverty rate of 17% (US Census, 2020). Further, insufficient retail food locations are associated with low population density. Many residents have to travel to neighboring counties to buy food. Meanwhile, public transportation is inadequate; residents have differing levels of access to retail food.

The timber industry dominates land use across the region; there are so few food crop or livestock farm operations in the region that the USDA Census of Agriculture suppresses some county-level data to avoid disclosing identities of individual operations due to the limited types of operations within each county. Of the six studied counties, Keweenaw County has the fewest number of farms (9) and Houghton County has the most (208) (USDA NASS, 2017). Given the area is close to the Great Lakes, the winters have an average of over 200 inches of snow annually. Electricity rates (21.8 ¢/kWh) are among some of the highest in the nation (17 ¢/kWh on average), contributing to the high cost of heating homes in winter (Mackie and Force-Emery, 2012).

3.2. Research design

Our target survey population was all residents of the six-county region. We consulted colleagues who had experience with public health surveys in the same region for advice on surveying residents. Overall, there are three main concerns regarding survey sampling: (1) the extremely uneven population distribution may result in low representation of small population counties, (2) low response rate, which has been declining over the years, and (3) elders and women are more likely to respond to health- or nutrition-related surveys.

Taking these concerns into consideration, we used a mixed survey mode combining mail and online surveys. Mixed-mode strategies can be employed to compensate for coverage error, to reduce non-response error, or to compensate for the weaknesses of each individual mode at an affordable cost (De Leeuw, 2005). First, our community partners wished to have respondents from each county to inform their programming. Thus, we purchased a mailing list of 1,002 households from the data platform Dynata for the mail-based survey sample. The list was stratified by county, with 167 potential respondents per county. We used the Dillman Tailored Design Method (Dillman, 2011), consisting of five mailings designed and pre-tested to improve the response rate. The five mailings included: 1) a pre-notification letter introducing the survey, 2) an invitation letter and survey, 3) a reminder or thank you postcard, 4) a

Fig. 1. Location of the study area and the Rural-Urban Continuum Code of each county.

Table 1
The Western Upper Peninsula's demographic characteristics.

County	Population	Size (Mi^2)	Population density ($/Mi^2$)	Urban population (%)	Rural-Urban Continuum Code
Houghton	37,361	1,009.09	37.02	54.79%	5 (less rural)
Gogebic	14,380	1,102.13	13.05	35.92%	7
Iron	11,631	1,165.99	9.98	0.00%	7
Baraga	8,158	898.42	9.08	0.00%	9
Ontonagon	5,816	1,310.97	4.44	0.00%	9
Keweenaw	2,046	540.11	3.79	0.00%	9 (very rural)

Source: US Census, 2020

second invitation letter and survey mailing to those whose surveys had not yet been returned, and 5) a non-response postcard asking non-respondents why they chose not to participate. All mailings were sent via USPS. The initial invitation letter to the mailed survey sample was sent on February 21, 2022. Mailings 1–4 were sent first class with postage stamps so as to increase the response rate and allow a return if the address was bad. This allowed us to update the mailing list for subsequent mailings accordingly. When mailings were returned with forwarding addresses still in the study area, these mailings were re-addressed and resent to the potential respondent's new address. The fifth mailing, the non-response postcard, was sent bulk mail to those residents for whom we had good addresses but who had not yet responded to earlier mailings.

Second, given our limited budget, we could not afford to purchase a large sampling list to compensate for the potentially low response rate. To complement the mailed survey, we implemented an online survey via the SurveyMonkey platform during February 21-March 31, 2022. We advertised our survey via local T.V. stations, newspapers, sponsor's press releases, etc. The link to the online survey was also included in the mailed survey invitation letter, should respondents prefer to complete the survey online. Mailed survey respondents who completed the survey online were tracked using their survey identification number so we could record completion.

Third, to reach a diversity of ages and genders, mailed surveys contained instructions for the adult in the household who had most recently celebrated their birthday to complete the survey.

The mailed survey sample frame consisted of 656 individuals after we excluded from the sample those individuals reported as deceased or who had moved out of area, as well as those for whom addresses were listed as incorrect or vacant; the adjusted response rate was about 35% after these individuals were removed. Then, we include the analysis of online samples. Data were cross-checked for duplicates: one respondent returned the mailed survey twice, and four completed a survey online and in hard copy. For these respondents, we used an online coin toss generator to determine which response was included. In total, we analyzed the data of 679 respondents from both mail (232) and online (447) survey modes.

We measured the dependent variable, food security, using a revised USDA household food security short-form survey module (USDA ERS, 2012). Based on the questions asked in the national food security survey, we asked eight questions regarding our respondents' occasions of food insufficiency and eating less in a typical week. Each question has a value from 0 (never) to 2 (a lot). Each respondent's final food insecurity score ranges from 0 (food secure) to 16 (extremely food insecure). To follow USDA's defining rules, we also dichotomize scores 0–2 as food secure and 3–16 as food insecure.

4. Results

4.1. Demographics of the respondents and their food security

Of the 679 respondents, 94.7% were white, and 72.1% were female. The average age was 56.6 years old, with 33.9% of respondents 65+ years old. The average household size was 2.65, with 0.69 kids (Table 2).

Table 2
Respondent characteristics (n = 679) compared to 2022 U.S. Census characteristics.

	Mail-based (n = 232)				Online (n = 447)				Combined (n = 679)				2022 U.S. Census*
Characteristics	Percentage	Mean	SD	Range	Percentage	Mean	SD	Range	Percentage	Mean	SD	Range	
Gender: Woman	61.3%				76.6%				72.1%				46.9%
Age	65+ (62.5%)	65.0	14.6	30–94	65+ (21.3%)	51.7	15.5	19–82	65+ (33.9%)	56.6	16.4	19–94	65+ (24.4%)
Race: white	95.1%				94.3%				94.7%				91.9%
Marital status: married	63.1%				69.8%				67.4%				
Education: bachelor's degree or higher	33.5%				54.8%				46.9%				37.9%
Household size		2.2	1.4	1–10		2.63	1.8	1–14		2.49	1.7	1–14	
Number of children (<18)/Household	15.4% with children	0.34	1.0	0–8	30.4% with children	0.69	1.3	0–9	25.0% with children	0.56	1.23	0–9	
House ownership: yes	90.3%				81.9%				84.9%				
Household Income >$58,100	34.5%				48.0%				43.2%				$46,840 (mean)
Food insecurity	21.7%				24.4%				23.5%				
Qualified for SNAP	23.6%				18.3%				20.1%				
Used SNAP	7.9%				7.7%				7.8%				
Self-driving	93.1%				94.4%				94.0%				
Six counties in WUP	**Sample size**		**Percentage**		**Sample size**		**Percentage**		**Sample size**		**Percentage**		**U.S. Census**
Baraga	41		18%		20		5%		61		9.7%		10%
Gogebic	37		16%		52		13%		89		14.1%		18%
Houghton	44		19%		224		56%		268		42.5%		47%
Iron	25		11%		27		7%		52		8.2%		15%
Keweenaw	41		18%		27		7%		68		10.8%		3%
Ontonagon	40		17%		53		13%		93		14.7%		7%

Source: compiled from US Census, (2022) data

For comparison, the 2022 US Census estimates the region's residents to be 56.9% female and 24.4% of the region's residents to be 65+, so women and respondents 65+ were over-represented in our study. Nevertheless, our sample distribution is consistent with Smith and Miller's (2011) study on rural food systems in Minnesota, in which they investigated 59 focus group participants from both urban and rural areas. Their rural group had 81% females with an average age of 53.9; the average household size is 2.8, and the number of children is 0.9, respectively. In this sense, our sample is comparable to other studies.

Reported food insecurity (score 3–16) among WUP respondents was as high as 23.5%, with 20.1% of respondents eligible for SNAP (calculated based on their household income and size). We further asked about respondents' considerations in food purchases and found that freshness, cost, and healthiness are the top three concerns (Table 3). Freshness was the top concern of 95% of respondents. While respondents were most concerned about food freshness, 38.8% of respondents reported that they did not find fresh food affordable (Fig. 2). We also analyzed the data to quantify the difference in food procurement activities between those in more urban counties (Houghton and Gogebic) and the rest; however, we did not identify any county-level patterns.

4.2. Factors influencing food insecurity

We performed three ordinal logistic regressions with "food insecurity" as the dependent variable. Given food insecurity is ordinal with 17 orders (0–16), we transformed it into an ordinal variable: 0 = food secure; 1–5 mild insecure; 6–10 moderate insecure; 11–16 severely insecure. The independent variables are divided into three types: 1) food-supporting measures (food program use and informal foodway engagement), 2) economic conditions (household income & cost), and 3) spatiotemporal patterns (distance, transportation & time). Other factors noted in the literature, such as demographics (excluding income) and number of children, are used as control variables (Table 4). The independent variables were tested to verify there was no multicollinearity. We also did the Parallel Line test to ensure that the proportional odds assumption of ordinal logistic regression is satisfied ($p = 0.558$, 0.875, 0.073 in three models). Model 1 aims to determine the food support measures that could explain differences in food security while controlling for other (non-economic) demographic variables. The stepwise regressions demonstrate how the addition of rural-specific spatiotemporal factors (Model 2) and economic factors (Model 3) improved our ability to explain the social determinants of food insecurity probability over the baseline Model 1 that included only non-economic demographic and food support factors identified in the literature. The *Pseudo* r^2 in the three models increased from 0.140 to 0.281 to 0.676, respectively.

4.2.1. Demographic factors

The demographic factors of age, education, and number of children had inconsistent impacts on food security across the three models. In Model 1, when one's age (Estimate = −0.020, $p = 0.01$) and education (Estimate = −0.222, $p < 0.01$) increases, their food insecurity probability decreases. In other words, older and well-educated people are more likely to be food secure. However, in Model 3, when the spatiotemporal and economic factors are added, the impacts of age and education on food insecurity disappear. However, the number of children does increase food insecurity (Estimate = 0.219, $p = 0.027$) when a family's economic condition is taken into consideration. During the pandemic, federal food assistance relaxed its rules to support emergency food provision (Jablonski et al., 2021); food assistance expanded to include eligibility for all children in K-12 schools, including free lunch all school year and summer, without parents needing to apply for the assistance. Such easy-to-use programs were likely beneficial to those households with children at home. However, some families may not have been aware of the expansion of this policy (Jablonski et al., 2021) or may have chosen not to apply for assistance programs (more analysis in *Section 4.2.2*). Thus, the number of children still increases a family's food insecurity probability in our study. According to Parekh et al. (2021), there was a 2.8% increase in food insecurity among households with children during the pandemic.

Table 3
Important considerations in purchasing food (n = 679).

		Importance
1.	Freshness	95.0%
2.	Cost	81.9%
3.	Healthy	76.9%
4.	Customer service	62.6%
5.	Get all foods in one place	61.1%
6.	Distance	57.3%
7.	Local grown	56.5%
8.	Local-owned store	52.0%
9.	Sustainability	40.5%
10.	Organic	39.9%
11.	Culture	18.1%
12.	Transport	9.0%

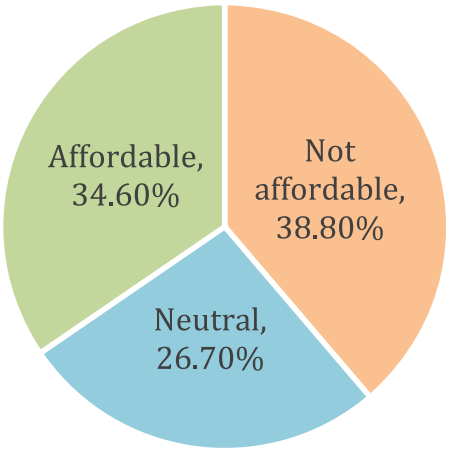


Fig. 2. Affordability of fresh food (n = 634).

4.2.2. Food support measures' effect

As aforementioned, we look at food assistance program use and informal foodways' impact on food security. While food insecurity is high in the WUP, we find eligible WUP residents underuse federal food assistance programs. We compare the percentages of eligibility and respondents' reported application for SNAP. We determined SNAP eligibility based on household income (130% of poverty) in correspondence with household size (Center on Budget and Policy Priorities CBPP, 2023). Of all the 679 respondents, we excluded 133 samples missing either income or household size values. For the remaining 546 samples, 110 respondents (20.1%) were at or below 130% poverty and SNAP-eligible, yet only 49 (or 44.5%) of these respondents had applied for SNAP. This is much lower than the reported 85% of all eligible Michigan individuals participating in SNAP or 78% of all national individuals eligible in 2020 before the pandemic (USDA FNS, 2023).

We further examine the pandemic's impact on respondents' food security and food assistance program use. As is clear from Table 5, the pandemic greatly impacted respondents' food quantity and desired food types. The percentage of respondents with enough food that they want to eat decreased from 60.5% to 36.2% during the pandemic. Nevertheless, there was not much increase in food assistance program use. Only two more individuals used the Michigan Electronic Benefits Transfer card during the pandemic (52 before and 54 during the pandemic, respectively). We further asked a hypothetical question about people's willingness to use the Double Up Food Bucks (DUFB) program. To offset the higher cost of fresh foods, DUFB matches SNAP participants' fresh food purchases dollar for dollar at participating vendors, up to $20 a day. Of

Table 4
Ordinal logistic regression of probability of food insecurity.

	Model 1 (n = 538)				Model 2 (n = 532)				Model 3 (n = 508)			
Pseudo Nagelkerke R^2	0.140***				0.281***				0.676***			
	Estimate	S.E.	Sig.	95% CI	Estimate	S.E.	Sig.	95% CI	Estimate	S.E.	Sig.	95% CI
Age	−0.020**	0.006	0.001	−0.031 ~ −0.008	0.001	0.007	0.895	−0.013 ~ 0.015	0.010	0.008	0.257	−0.007 ~ 0.026
Number of children	0.060	0.077	0.438	−0.092 ~ 0.212	0.142	0.081	0.080	−0.017 ~ 0.301	0.219*	0.099	0.027	0.025 ~ 0.413
Gender (W = 1 M = 0)	0.015	0.196	0.939	−0.368 ~ 0.398	−0.017	0.206	0.933	−0.421 ~ 0.386	−0.023	0.249	0.926	−0.511 ~ 0.465
Education	−0.222***	0.048	<0.001	−0.316 ~ −0.128	−0.231***	0.051	<0.001	−0.331 ~ −0.132	−0.048	0.065	0.460	−0.177 ~ 0.080
Food program use (snap)	1.455***	0.314	<0.001	0.839 ~ 2.071	1.478***	0.322	<0.001	0.847 ~ 2.110	0.434	0.387	0.261	−0.324 ~ 1.192
Food system engaging type	0.076	0.071	0.283	−0.063 ~ 0.215	0.078	0.074	0.293	−0.067 ~ 0.223	−0.006	0.089	0.950	−0.179 ~ 0.168
Preserving extra food	−0.387	0.208	0.063	−0.794 ~ 0.020	−0.460*	0.218	0.035	−0.888 ~ −0.032	−0.214	0.260	0.411	−0.724 ~ 0.296
Distance to store					0.035	0.066	0.589	−0.093 ~ 0.164	−0.012	0.077	0.879	−0.163 ~ 0.140
Self-driving					−0.878*	0.396	0.027	−1.655 ~ −0.101	−0.331	0.465	0.476	−1242 ~ 0.580
No time					0.758***	0.094	<0.001	0.575 ~ 0.942	0.405***	0.113	<0.001	0.183 ~ 0.626
Winter transportation harder					−0.011	0.019	0.565	−0.048 ~ 0.026	0.252*	0.114	0.028	0.028 ~ 0.475
Household income									−0.216***	0.046	<0.001	−0.306 ~ −0.126
Household costs									0.370***	0.044	<0.001	0.284 ~ 0.456
Winter high utility costs									0.556***	0.109	<0.001	0.342 ~ 0.770

*: 95% confidence; **: 99% confidence; ***: 99.9% confidence.

Table 5
The pandemic's impact on people's food consumption (n = 634).

	Before pandemic	During pandemic
Enough, **always** the kinds of food we want to eat.	60.5%	36.2%
Enough, but **not always** the kinds of food we want to eat.	30.2%	39.0%
Usually enough, but not always the kinds of food we want to eat.	7.7%	21.3%
Sometimes not enough to eat.	1.4%	2.4%
Often not enough food to eat.	0.2%	1.1%

all the 143 eligible respondents, 33.6% reported they would not participate in the DUFB program. We will discuss potential reasons why people are not using food programs later.

While food assistance programs are underused, food program use does not reduce food insecurity probability in this study. In Models 1–2, while respondents use food assistance programs, they still have higher food insecurity probability (Estimate = 1.455, $p < 0.01$; Estimate = 1.478, $p < 0.01$). However, in Model 3, the effect of food program use disappears when the household's economic conditions are taken into consideration, which points to the significance of economic conditions in deciding one's food security.

We were curious about why respondents do not participate in food assistance programs. As Fig. 3 shows, respondents who qualify for food assistance programs do not use them for many different reasons, with

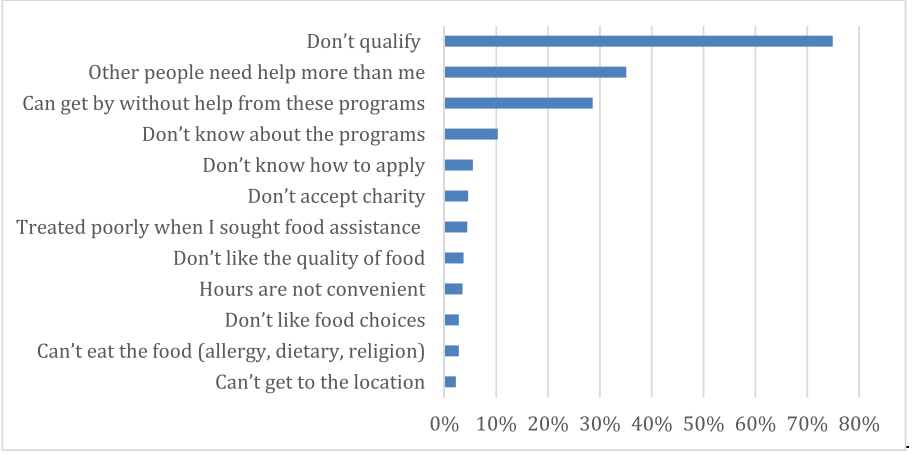


Fig. 3. Reason for not using food assistance programs (n = 679).

the top three being "Other people need help more than me" "Can get by without the help of these programs" and "Don't know about these programs". This implies that more education about food assistance programs is necessary to have those in need apply for the programs, but also that there is important work to do to reduce the stigma of assistance, ease of application, or understanding about how assistance works.

Meanwhile, we examine the influence of rural residents' engagement in informal foodways on food security. While respondents are not very active in participating in food assistance programs, they are very active in engaging in local food systems activities, which helps to improve food security to some degree. In rural areas, residents can obtain food through gardening, fishing, hunting, foraging, or raising livestock (Table 6). In this survey, about 73.0% of respondents engaged in at least one informal foodway activity; 75.2% reported having extra food from informal foodways, and 62.0% preserving extra food. Perhaps because rural towns usually have plenty of land and many residents have yards, gardening is the most popular activity; 59.4% of respondents reported engaging in gardening as a food source. Yet, livestock raising is the least engaged informal foodway activity (10.2% of respondents). When reporting why they do not raise livestock, 263 (44%) respondents expressed no interest; among the 334 respondents interested but not currently engaged, the top reason was "not allowed in zoning" (20%), followed by no land (15%) and no time (13%).

We also investigated how the pandemic affected respondents' frequency of engagement in local food systems (You grew, hunted, foraged, or fished for more food) and their food gifting and bartering activities (You gave more food gifts to friends, family, and/or community members) (Fig. 4). Overall, 32.0% of respondents reported engaging more, and 41.2% reported giving more food to others. There is also a positive correlation between "provisioned more" and "gave more" (Pearson's r $= 0.448$, $p < 0.001$).

In all three models, the number of types of local food systems activities in which people engage does not contribute to mitigating food insecurity probability. However, as shown in Model 2, when the spatiotemporal patterns are added, extra food preservation can decrease food insecurity probability (Estimate $= -0.460$, $p = 0.035$). In other words, preserving extra food is what matters, especially for residents who are busy and live far away from groceries, not the types of food activities engaged.

Given the challenge of obtaining sufficient and desired foods, respondents are willing to support community-related local food system opportunities (Fig. 5). Farmers' markets, both indoor and outdoor, are highly desired by respondents. It is also interesting that respondents would like to have farmers' markets in winter. In a region with a six-month-long winter season, farmers markets are not just a place to obtain food, but also serve as a community event to allow residents to interact with each other.

4.2.3. Spatiotemporal patterns' effects

Rural spatiotemporal patterns increase residents' challenges in obtaining food. Given the large area and low population density, grocery store density is very low in the WUP. About 82.6% of respondents travel over one mile, and 17.6% travel over 20 miles to the nearest food store (Table 7). In Fig. 6, we mapped the average driving distance to the nearest grocery and found the driving distance is largely consistent with

Table 6
Respondents' engagement types of informal foodways (n = 679).

Rate of engagement	Percentage
Gardening	59.4%
Foraging	40.8%
Fishing	38.9%
Hunting	30.5%
Livestock	10.2%

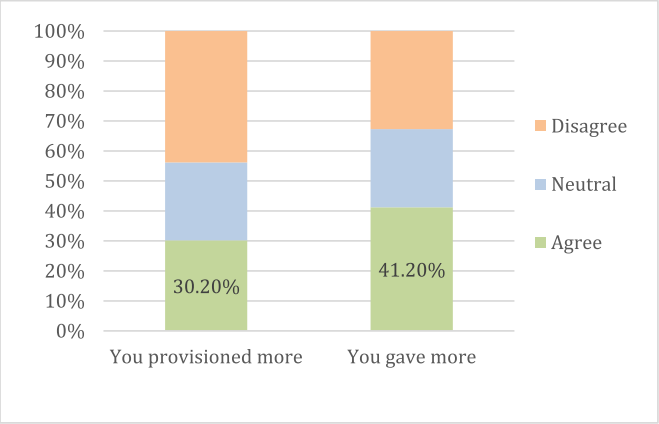


Fig. 4. Local food system engagement and food gifting during the pandemic.

the extent of rurality and population density. The two less-rural counties, Houghton and Gogebic, have an average driving distance of about 5–7 miles; while the two most rural counties, Keweenaw and Ontonagon, have an average driving distance between 15 and 20 miles. These distances are high, especially compared to national-level data; the median distance to the nearest food store for the overall U.S. population was 0.9 miles (Ver Ploeg et al., 2015). The USDA considers being 20 miles or more from the nearest food store a food insecurity risk factor. In this sense, 17.6% of respondents are already at risk for food insecurity based on their proximity to groceries alone. Meanwhile, public transit in the WUP is underdeveloped, and 94.4% of respondents reported that they drive themselves to retail food locations.

Spatiotemporal factors, including distance, transportation, and spare time, present complex influences on rural food insecurity. First, the distance to the food store in itself does not significantly increase food insecurity probability ($p > 0.05$, Model 2–3). But driving oneself to the food store decreases food insecurity probability (Estimate $= 0.878$, $p = 0.027$, Model 2). We created a crosstab to understand the correlation between driving oneself and food security (Table 8). The Chi-square test shows a significant food security difference between those who self-drive and those who do not ($p < 0.001$). According to Ver Ploeg et al. (2015), households with food insecurity are less likely to drive their own car to the store than food-secure households and are more likely to rely on someone else or alternative forms of transportation. In other words, when rural lower-income households do not drive themselves, they would have a higher food insecurity probability.

Second, when 94.4% of respondents drive themselves to retail food locations, distance's negative impact on food access is seemingly mitigated. Nevertheless, this does not mean distance is not a concern. When we asked respondents about their main consideration in food purchases, 57.3% reported that distance to the store is a main consideration. But when most people drive, only 9.0% reported that transport is a concern (Table 3).

Third, the realities of rural life may provide respondents with limited time to buy or cook food. Our respondents reported driving long distances to buy food; this is consistent with other research finding Upper Peninsula residents have to travel substantial distances for employment or food access (Mackie and Force-Emery, 2012). "No time" significantly increases the probability of food insecurity (Estimate $= 0.758$, $p < 0.01$, Model 2). The service sector in rural areas tends to have a large share of nonstandard, especially part-time work. McLaughlin and Coleman-Jensen's (2008) analysis of contingent work finds that nonmetropolitan or rural residents are more likely to work in nonstandard work types: contingent, part-time, and varied hour work with relatively lower wages and benefits. Additionally, they found that female (31.9%) and senior (65.9%) residents in nonmetro areas have higher participation in nonstandard work compared to male (19.9%) and those aged 55–64

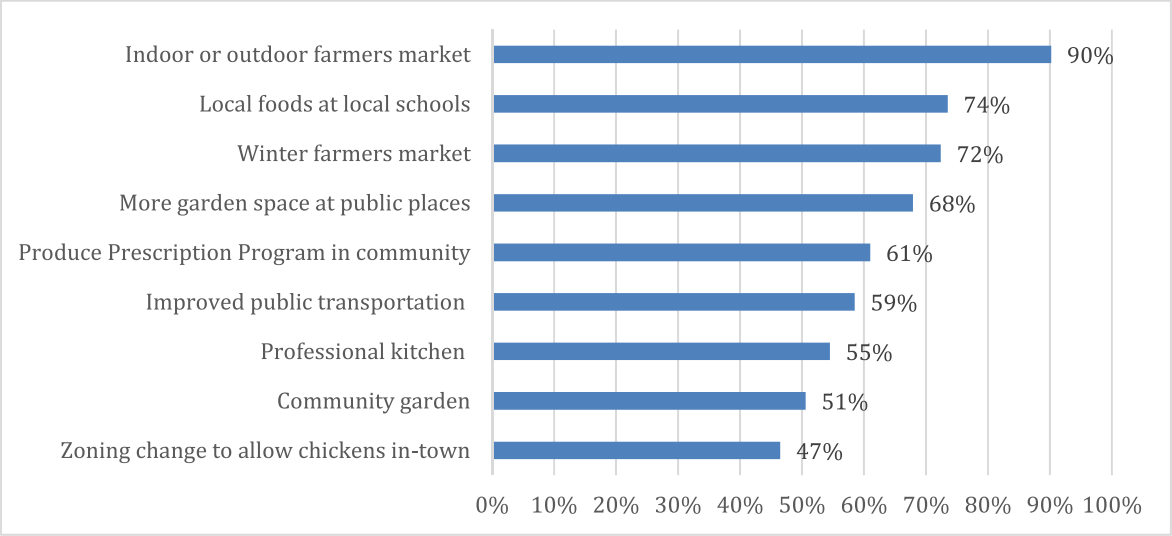


Fig. 5. Respondents' support for local food systems infrastructure and programs.

Table 7
Distance to the nearest food store in WUP (n = 679).

Distance (miles)	0–1	1–5	5–10	10–20	>20
Percentage of respondents	17.4%	29.2%	19.0%	16.9%	17.6%

(30.3%) in the US. Our findings suggest that when rural residents work multiple part-time jobs or must drive long distances to access food, their time to prepare food is compromised.

4.2.4. Economic condition's effect

While the above-analyzed predictors significantly affect food security, the overall explanatory power remains low (*Pseudo* $R^2 = 0.281$); we find household economic conditions are the most important factors impacting food security. In Model 3, three economic factors, including household income (Estimate = −0.216, $p < 0.001$), household costs (Estimate = 0.370, $p < 0.001$), and winter utility costs (Estimate = 0.556, $p < 0.001$), are added, which significantly improve our capability to explain food insecurity probability (*Pseudo* $R^2 = 0.676$). Here, household costs include home (rent, mortgage, home insurance, utility costs), school, childcare, medical, and car-related expenditures.

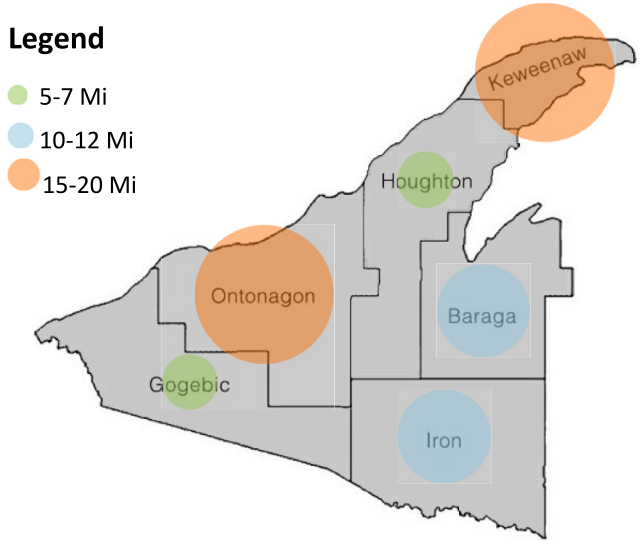


Fig. 6. Driving distance to the nearest grocery in the six counties.

Table 8
Crosstab showing relationship between food security and driving oneself.

	Does drive	Does not drive	In all
Food security	466 (96.9%)	15(3.1%)	481
Food insecurity	130 (87.8%)	18(12.2%)	148
Total	629		

Pearson Chi-square value = 18.620, $p < 0.001$ (n = 629).

Economic conditions not only directly but also indirectly impact food insecurity probability by influencing the significance of other factors. For instance, in Model 3, when a household's economic condition is considered, the significance of education, preserving extra food, and self-driving disappears ($p > 0.05$). On the contrary, the impact of the number of children becomes significant (Estimate = 0.219, $p = 0.027$), which implies that child-related costs could increase a household's food insecurity probability. Similarly, harsh winter's effect upon transportation becomes significant in Model 3 as well (Estimate = 0.252, $p = 0.028$). It is better to examine the effects of driving oneself and winter transportation together. In winter, although people have a car and are able to drive, they may still hesitate to travel due to the driving risks in bad weather and/or the condition of their car. In other words, the challenge of harder winter transportation becomes so prominent that it largely offsets the positive role of self-driving in food access. Finally, in Model 3, although "No time" still significantly increases food insecurity probability, the weight has decreased with the estimate decreased from 0.758 in Model 2 to 0.405 in Model 3. This may be explained by the fact that even if people are too busy to prepare food, they can order takeout or eat at restaurants if they have good economic conditions.

5. Discussion and conclusions

This study investigates the social determinants of food insecurity in the rural and geographically isolated region of Michigan's Western Upper Peninsula. All determinants, including economic conditions, spatiotemporal patterns, and food support measures, interact to impact food security. We find that in this rural area, household income and cost remain the two most important factors deciding food security. Food insecurity is a problem of poverty (Piontak and Schulman, 2014). Employment in rural areas tends to be low-wage work, lacking sufficient support such as childcare. According to Feeding America West Michigan, (2020), unemployment directly leads to food assistance program use; a 1% increase in unemployment will result in a 10% increase in

reliance on food assistance systems. This points to the importance of increasing rural job opportunities and household income. Compared with large cities, where big manufacturing or high-tech companies recruit numerous full-time employees, rural communities may take advantage of local natural resources to create business opportunities in tourism, recreation, and other related services (Winkler et al., 2016).

Compared with income, household costs also have a significant impact on food insecurity. The high winter utility fees are a big expenditure for our respondents, and this is a trend also identified in other research in the region per Mackie and Force-Emery (2012). The high utility costs in the WUP make energy an issue not only of energy justice, but also food justice. The residential buildings in rural areas are more likely to be older and less energy-efficient than those homes built in cities. Improving the energy efficiency of such residential buildings can reduce overall costs to the residents. Although WUP's energy companies have always encouraged residents to use energy-efficient facilities, including solar panels and LED bulbs, more retrofit and rebate policies and programs could be implemented (Malekpour Koupaei et al., 2022). Thus, homes' energy efficiency retrofits are a measure to indirectly improve food security in the long run.

While food is a household issue, spatiotemporal patterns of food insecurity show that it is also shaped by broader spatial inequality (Piontak and Schulman, 2014). In rural areas, the severity of household food insecurity increases with low density of retail food locations, under-developed public transit, and long distances from retail food locations or food banks. Blanchard and Matthews (2007) find the trend in the consolidation of large grocers, which has led to a decrease in the number of local stores in favor of large supermarkets and, accordingly, longer average distance to retail food locations, although Gundersen et al. (2011) argue that the expansion of large-scale retailers into an area can substantially decrease food prices. However, in low-population density areas, retailers are less likely to open new large-scale stores. The two Walmart Supercenters in the region are 105 miles apart. A limited number of retail food locations implies two negative impacts on food security. One is the high price. When market competition is low, food prices usually become high, especially in small grocery stores. Actually, food price becomes the second significant consideration of 81.9% of respondents in food procurement. The other is the far distance; 17.6% of respondents have to drive over 20 miles to get to the nearest store. People need to fit grocery and food shopping into their daily activities and travel patterns. From a city planning perspective, a compact city model can improve infrastructure and facility efficiency. However, given the rural development model, namely, rural residents prefer to live in the country even if they have to drive longer to facilities (Smith and Miller, 2011), the current situation of the commercial food infrastructure and public transit system are less likely to be changed or improved in the short term. In other words, to combat food insecurity, rural residents need to resort to other approaches such as food assistance program use or informal foodways.

Unfortunately, in this study, we find eligible people underuse food assistance programs. Additionally, food assistance program use does not significantly improve food security, and there are more food-insecure people than those qualified for the programs. These food assistance program-related findings are largely consistent with previous research, and we highlight the necessity to re-examine the program design to address these concerns. Smith and Miller (2011) find that enrollment of eligible residents for government-funded food assistance programs is lower in rural Minnesota, further exacerbating food insecurity in these areas. Program underuse might be related to rural social context (interpersonal relationships). Strong social networks can help match food needs and resources within the community and can facilitate reciprocity and altruism (Lee et al., 2018), but they can also be detrimental in tightly-knit communities if accessing food assistance is stigmatized. Mackie and Force-Emery (2012) find living and working in small-population communities can present challenges, including maintaining privacy or having a personal life. In this research, qualified respondents do not participate in food assistance programs because they think other people are more in need of help while they can still get by without these programs. Such altruism or stigma thoughts make it difficult for decision-makers to figure out real community needs. Moreover, those who are in poverty and qualified for income-based federal assistance (20.1% in our study) are the people who are usually thought to be food insecure, but we find that those who are food insecure are actually a larger group of people (23.5%). Some families might be above the eligibility line but still struggle to access food. These people will not be aided by existing income-based federal food assistance. The existing underuse of food assistance programs among our respondents suggests some changes need to be made to increase enrollment. For instance, programs to lower prices for low-income and seniors at direct farm-to-consumer sales can reduce food costs and increase affordability (Smith and Miller, 2011). In addition to keeping more dollars within the local economy, programs such as Double Upper Food Bucks that help offset the cost of fresh foods at farmers' markets, may also help to relieve altruism or stigma concerns by allowing residents to obtain healthy foods while also participating in local market economic exchange (Archambeau, 2023).

In our study, food assistance program use does not significantly improve people's food security. Perhaps this is because only a small portion of eligible respondents participated in these programs, which makes the sample size very small (only 49 out of 679 respondents). It might also be because the food varieties provided through these programs are limited and undesirable. Even though people can get food to eat, they are not necessarily getting the healthy and fresh food they report wanting. In this sense, they are still not food sufficient. Huffman and Jensen (2008) have found that SNAP participation has no significant effect on food insecurity or insufficiency. It might be useful for further studies to understand rural program users' experiences.

While the effect of participating in food assistance programs is compromised, engaging in local foodways is a feasible way to obtain fresh and affordable food. In Detroit, urban residents highlighted customer service and in-store treatment as key factors in choosing food shops (Hill, 2021). For rural residents, the top considerations are freshness and cost. When the stores are far away, when they have a tight schedule for frequent food shopping, and when transportation is hard in inclement weather, they find their own way to self-sustain. Engaging in informal foodways through gardening, fishing, hunting, and foraging might be a more convenient way to obtain fresh food. This research also shows that residents are very willing to support local food systems infrastructure, such as farmers' markets, community gardens, and professional kitchens. Findings also identify the opportunity to review city zoning to allow more respondents to raise livestock, such as chickens, in backyards.

Sharing food within one's social network is important to maintaining food security (Lee et al., 2018). Among our respondents, during the pandemic, 32.0% of respondents engaged more than before in informal foodways, and 41.2% gave more food to others. This might mean some respondents do not directly obtain food through their own engagement, but receive and further share food gifts within their social networks. This also illustrates the importance of strong reciprocity in rural communities. Within such social networks, people share food and support each other, which are very important during hard times, such as pandemics or harsh winters when food access is limited. In this sense, close social networks might prevent residents from applying for food assistance programs, as such networks boost residents' food exchange activities.

We see a few limitations of this research. First, combining the mailed and online samples may pose an issue of representation. While the mail-based respondents included more elders and the online respondents were relatively younger people, the overall sample still does not match very well with the ages of the target population. Additionally, elders and women were over-represented among our respondents, which likely influenced our findings. For instance, SNAP was substantially underused among our respondents; elders may have limited mobility to apply for

SNAP, and they may not be familiar with the online application system or be challenged in accessing it due to rural internet availability. While respondents engaged in informal foodways, women may engage less in activities like hunting or fishing due to gendered cultural norms, but more in gardening and foraging; additionally, elders may have mobility or other health issues that prohibit them from engaging in these activities. In this sense, our findings may not be directly generalized to other rural areas but could provide useful comparisons as more rural-focused research studies these trends. Second, when measuring respondents' food security, we asked about their food eating in a typical week, but not specifically asked about this in a typical winter week, in order to avoid survey fatigue. To better understand food security in winter, it would be better if we had asked two separate sets of food security questions in both winter and non-winter period. These limitations point to the direction of future research. One is to study younger people's and men's food security in future research. While those subgroups are less likely to actively engage in surveys, other qualitative research approaches might be used to engage them. The other is to do comparative studies on rural residents' food security in winter and non-winter seasons. For northern rural areas with harsh winters, such research would have important practical implications.

Funding

This work was supported by a Michigan Technological University/ Portage Health Foundation Research Excellence Fund award, as well as funding from the Portage Health Foundation and the Western Upper Peninsula Planning and Development Region.

CRediT authorship contribution statement

Hongmei Lu: Conceptualization, Formal analysis, Methodology, Software, Writing – original draft, Writing – review & editing. **Angie Carter:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

The authors would like to thank the Western Upper Peninsula Food Systems Collaborative as well as Dr. Rebecca Christoffel, Dr. Gwenyth Lee, and the anonymous reviewers for their constructive comments on previous versions of the manuscript.

References

AbuSabha, R., Shackman, G., Bonk, B., Samuels, S.J., 2011. Food security and senior participation in the commodity supplemental food program. J. Hunger Environ. Nutr. 6 (1), 1–9.

Ahn, S., Norwood, F.B., 2021. Measuring food insecurity during the COVID-19 pandemic of spring 2020. Appl. Econ. Perspect. Pol. 43 (1), 162–168.

Ahn, S., Smith, T.A., Norwood, F.B., 2020. Can internet surveys mimic food insecurity rates published by the US government? Appl. Econ. Perspect. Pol. 42 (2), 187–204.

Archambeau, C.A., 2023. *Feeding Our Local Communities-The Benefits of Food Assistance Programs at Local Farmers Markets*. Open Access Master's Thesis, Michigan Technological University. https://doi.org/10.37099/mtu.dc.etdr/1554.

Blanchard, T.C., Matthews, T.L., 2007. Retail concentration, food deserts, and food-disadvantaged communities in rural America. Remaking the North American food system: Strategies for sustainability. Hinrichs, C. C. and Lyson, T.A. University of Nebraska Press, pp. 201–215.

Buck-McFadyen, E.V., 2015. Rural food insecurity: when cooking skills, homegrown food, and perseverance aren't enough to feed a family. Can. J. Public Health 106, e140–e146.

Colasanti, K., Spivey, D., Campbell, H., Parks, C., 2019. Striving to Meet Food Needs: Food Access Survey of Oscoda County, MI. Michigan State University Center for Regional Food Systems. Retrieved May 3, 2023 from: http://foodsystems.msu.edu/resources/foodaccess-survey-oscoda-county-michigan.

Coleman-Jensen, A., Rabbit, M.P., Gregory, C.A., Singh, A., 2019. Household Food Security in the United States in 2018. USDA-ERS Economic Research Report (270). Retrieved May 3, 2023 from: https://www.ers.usda.gov/webdocs/publications/94849/err-270.pdf.

Courtemanche, C., Carden, A., Zhou, X., Ndirangu, M., 2019. Do Walmart supercenters improve food security? Appl. Econ. Perspect. Pol. 41 (2), 177–198.

De Leeuw, E.D., 2005. To mix or not to mix data collection modes in surveys. J. Off. Stat. 21 (5), 233–255.

Dillman, D.A., 2011. *Mail and Internet Surveys: the Tailored Design Method–2007 Update with New Internet, Visual, and Mixed-Mode Guide*. John Wiley & Sons.

Feeding America West Michigan, 2020. COVID-19 Impact Report. Retrieved June 1, 2023 from: https://www.feedwm.org/wp-content/uploads/2020/10/Impact-Report-final.pdf.

Fletcher, J.M., Andreyeva, T., Busch, S.H., 2009. Assessing the effect of changes in housing costs on food insecurity. J. Child. Poverty 15 (2), 79–93.

Center on Budget and Policy Priorities (CBPP), 2023. A Quick Guide to SNAP Eligibility and Benefits. Retrieved June 3, 2023 from: https://www.cbpp.org/research/food-assistance/a-quick-guide-to-snap-eligibility-and-benefits#.

Frawley, B.J., 2019. Michigan Deer Harvest Survey Report 2018 Seasons. Retrieved June 3, 2023 from: https://www.michigan.gov/-/media/Project/Websites/dnr/Documents/WLD/Reports/2018_deer_harvest_survey_report.pdf.

Gibson-Davis, C.M., Foster, E.M., 2006. A cautionary tale: using propensity scores to estimate the effect of food stamps on food insecurity. Soc. Serv. Rev. 80 (1), 93–126.

Great Lakes Indian Fish and Wildlife (GLIFWC), N.d. Treaty Rights Reserved. Retrieved December 18, 2023 from https://glifwc.org/TreatyRights/#:~:text=Treaty%20Rights%20Reserved,gather%20in%20the%20ceded%20territories.

Groetsch, K., 2024. Total Mercury and Copper Concentrations in Lake Trout and Whitefish Fillets from Lake Superior. Great Lakes Indian Fish and Wildlife Commission. Retrieved January 3, 2024 from: https://glifwc.org/Environmental/Activity%2019-23.pdf.

Gundersen, C., Kreider, B., Pepper, J., 2011. The economics of food insecurity in the United States. Appl. Econ. Perspect. Pol. 33 (3), 281–303.

Gundersen, C., Ziliak, J.P., 2018. Food insecurity research in the United States: where we have been and where we need to go. Appl. Econ. Perspect. Pol. 40 (1), 119–135.

Hendrickson, M.K., Massengale, S.H., Cantrell, R., 2020. "No money exchanged hands, no bartering took place. But it's still local produce": understanding local food systems in rural areas in the US Heartland. J. Rural Stud. 78, 480–490.

Hill, A., 2021. "Treat everybody right": examining foodways to improve food access. Journal of Agriculture, Food Systems, and Community Development 10 (3), 9–16.

Huffman, S.K., Jensen, H.H., 2008. Food assistance programs and outcomes in the context of welfare reform. Soc. Sci. Q. 89 (1), 95–115.

Jablonski, B.B., Casnovsky, J., Clark, J.K., Cleary, R., Feingold, B., Freedman, D., Gray, S., Romeiko, X., Olabisi, L.S., Torres, M., 2021. Emergency food provision for children and families during the COVID-19 pandemic: examples from five US cities. Appl. Econ. Perspect. Pol. 43 (1), 169–184.

Lee, G.O., Surkan, P.J., Zelner, J., Olórtegui, M.P., Yori, P.P., Ambikapathi, R., Caulfield, L.E., Gilman, R.H., Kosek, M.N., 2018. Social connectedness is associated with food security among peri-urban Peruvian Amazonian communities. SSM-population health 4, 254–262.

Lu, H., Carter, A., 2022. Emergent regional collaborative governance in rural local food systems development. Community Dev. 54 (2), 228–256. https://doi.org/10.1080/15575330.2022.2135550.

Mackie, M., Force-Emery, P., 2012. Social work in a very rural place: a study of practitioners in the Upper Peninsula of Michigan. Contemporary Rural Social Work Journal 4 (1), 6.

Malekpour Koupaei, D., Cetin, K.S., Passe, U., Poleacovschi, C., Kimber, A., 2022. Characterizing residential energy consumption patterns in the rural midwest. Construction Research Congress.

McEntee, J., 2010. Contemporary and traditional localism: a conceptualisation of rural local food. Local Environ. 15 (9–10), 785–803.

McLaughlin, D.K., Coleman-Jensen, A.J., 2008. Nonstandard employment in the nonmetropolitan United States. Rural Sociol. 73 (4), 631–659.

Morris, P.M., Neuhauser, L., Campbell, C., 1992. Food security in rural America: a study of the availability and costs of food. J. Nutr. Educ. 24 (1), 52S–58S.

Nord, M., Hopwood, H., 2007. Recent advances provide improved tools for measuring children's food security. J. Nutr. 137 (3), 533–536.

Parekh, N., Ali, S.H., O'Connor, J., Tozan, Y., Jones, A.M., Capasso, A., Foreman, J., DiClemente, R.J., 2021. Food insecurity among households with children during the COVID-19 pandemic: results from a study among social media users across the United States. Nutr. J. 20, 1–11.

Piontak, J.R., Schulman, M.D., 2014. Food insecurity in rural America. Contexts 13 (3), 75–77.

Ratcliffe, C., McKernan, S.-M., Zhang, S., 2011. How much does the Supplemental Nutrition Assistance Program reduce food insecurity? Am. J. Agric. Econ. 93 (4), 1082–1098.

Schanzenbach, D., Pitts, A., 2020. How Much Has Food Insecurity Risen? Evidence from the Census Household Pulse Survey. Institute for Policy Research Rapid Research Report, pp. 1–10.
Schanzenbach, D.W., Nunn, R., Bauer, L., Mumford, M., 2016. Where Does All the Money Go: Shifts in Household Spending over the Past 30 Years. Brookings Institution, The Hamilton Project.
Smith, C., Miller, H., 2011. Accessing the food systems in urban and rural Minnesotan communities. J. Nutr. Educ. Behav. 43 (6), 492–504.
United States Census Bureau (US Census), 2020. State-level Urban and Rural Information. Retrieved June 3, 2023 from: https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html.
United States Census Bureau (US Census), 2022. American Community Survey Demographic and Housing Estimates. Retrieved June 3, 2023 from: https://data.census.gov/table?q=Houghton%20County,%20Michigan%202022%20population.
United States Department of Agriculture Economic Research Service (USDA ERS), 2012. U.S. Adult Food Security Survey Module. Retrieved June 3, 2023 from: https://www.ers.usda.gov/media/8279/ad2012.pdf.
United States Department of Agriculture Economic Research Service (USDA ERS), 2024. Food Security in the U.S.: Overview. Retrieved January 6, 2024 from: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s.
United States Department of Agriculture National Agricultural Statistics Service (USDA NASS), 2017. States. In: Census of Agriculture. Volume 1, Chater 3. State Level Data, Michigan. Retrieved January 6, 2024 from: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Michigan/.
United States Department of Agriculture Economic Research Service, (USDA ERS), 2023. Rural-Urban Continuum Codes. Retrieved June 6, 2023 from: https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/.
Ver Ploeg, M., Mancino, L., Todd, J.E., Clay, D.M., Scharadin, B., 2015. Where Do Americans Usually Shop for Food and How Do They Travel to Get There? Initial Findings from the National Household Food Acquisition and Purchase Survey. United States Department of Agriculture Economic Research Service. Retrieved June 3, 2023 from: https://www.ers.usda.gov/publications/pub-details/?pubid=79791.
Western Upper Peninsula Food Systems Collaborative (WUPFSC), 2023. Western Upper Peninsula Food Systems Collaborative. Retrieved June 3, 2023 from: https://www.wupfoodsystems.com/farmersmarkets.
Wilde, P., Nord, M., 2005. The effect of food stamps on food security: a panel data approach. Rev. Agric. Econ. 27 (3), 425–432.
Winkler, R., Oikarinen, L., Simpson, H., Michaelson, M., Gonzalez, M.S., 2016. Boom, bust and beyond: arts and sustainability in calumet, Michigan. Sustainability 8 (3), 284.