Urban-Rural Differences in a Chain Supermarket's Sales to SNAP Shoppers before and since COVID-19

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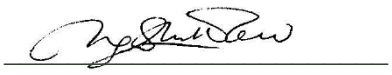

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Introduction

In the United States, a major social support program is the Supplemental Nutrition Assistance Program (SNAP), previously known as Food Stamps.[1] SNAP has been in existence since 1939 and is overseen by the United States Department of Agriculture (USDA).[1] SNAP provides nutrition benefits to help individuals and families with low incomes buy food so they can move towards self-sufficiency.[2] As of 2022, SNAP provided benefits to approximately 41 million Americans with low incomes at the cost of $70 billion.[3] An early goal of SNAP was to address food insecurity, defined as the state of risk of being unable to provide food for oneself or family, which increases risk for diet related outcomes such as chronic disease, obesity, and depression[4]. Besides the health-related arguments to tackle food insecurity, there are also clear economic arguments, as food insecurity in the US has been linked to economic losses of at least $160 billion annually.[5]

Beyond decreasing food insecurity, SNAP also aims to improve the diet quality of its participants.[6] This expands upon the Food Stamp's original singular purpose of aligning post Great Depression hunger and growing food surpluses.[1] SNAP's dual goals have been reflected in the program's name change to include a focus on nutritional quality of food as well as the new commitment to improve "nutrition security" by the USDA.[7] Nutrition Security has become a new focus to build on food insecurity that highlights the importance of equal access to safe, healthy, and affordable foods that promote well-being and optimal health.[7] Despite these efforts, research has found that nationally, SNAP participants may have lower diet quality as measured by the Healthy Eating Index (HEI) than low-income nonparticipants.[6] Even with increased benefits due to the 2009 American Recovery and Reinvestment Act in response to the Great Recession, SNAP participants did not experience meaningful improvements in diet quality.[8] In addition, research has indicated the importance of SNAP participant's perceived distance to full service grocery stores and its relation with poor health risk factors.[9] A perceived distance of 5 miles or more to a grocery store was associated with an increased likeliness to be overweight or obese.[9] Thus, it appears increasing benefits alone may not adequately improve dietary quality, so there is also a need to

focus on the food environment and its components that may lead to a meaningful enhancement of SNAP's focus on improving diet quality.

A major factor affecting purchase behavior and diet is the food environment as it has been observed to have an influence on dietary health indicators.[10] Both urban and rural residents with low incomes suffer from a higher prevalence of diet related morbidity and mortality which are highly linked to lack of access to nutrient dense foods.[11] However, urban versus rural settings can vary considerably in terms of ease of access to public transport, distance to grocery stores, housing value, average socioeconomic status, income level, and economic stability which can in turn influence food access and the food environment.[11] Due to these challenges, in some rural areas fewer food businesses are able to flourish and the retailers that exist face these obstacles of supplier adequacy. Consequently, fewer businesses choose to establish themselves in rural areas compared to more urban settings.[11] Obstacles such as supplier adequacy and overall economic instability can be major challenges faced by rural food retailers.[12] All these factors may contribute to adversely impacting the healthy versus unhealthy food landscape and hence purchasing patterns, quality of diet, and health outcomes of rural residents.[4,13]

SNAP participants in rural areas may also have even larger barriers to meeting dietary recommendations due to structural factors such as income inequality or social factors.[14] The combination of rurality and economic stress on both SNAP shoppers and retailers together may contribute to a lack of support for recommended diet-related behaviors and ultimately lead to health disparities.[14] These factors highlight the need to understand the food purchasing patterns of SNAP participants in rural areas compared to urban areas. However, though there is an international 'urban advantage' to accessing healthful foods, people with low incomes living in urban areas still face obstacles to healthy eating considering lack of resources and income to achieve an adequate healthy lifestyle.[15]

Similar to most rural areas in the US, rural North Carolinians face many economic and geographical challenges as well as limited access to knowledge on health promoting behaviors that may contribute to poor diet and subsequent diet related chronic disease more than their urban counterparts.[14] Rural areas in North Carolina are facing general economic and population decline, while North Carolina's

urban centers are experiencing rapid economic growth.[16,17] More specifically, fifty-four of North Carolina's one hundred counties are rural, with one in five rural residents versus one in eight urban residents participating in SNAP in North Carolina.[18,19] In addition, current research states that lower-income and rural neighborhoods are typically located in food deserts and food swamps, limiting physical access to nutrient-dense foods.[4] This combination of economic decline and lower store availability may contribute to differences in SNAP participants' diet quality and purchase patterns in rural and urban areas.

The onset of the COVID-19 pandemic caused further challenges due to the major social and economic shocks and impacts that followed. School closings, the shift to online work, business closings, a rise in unemployment rates, and strains on the healthcare system may have exacerbated disparities between socioeconomic levels.[20] The pandemic continues to disproportionately affect low income, food insecure households that were already struggling to meet needs even before the start of COVID-19.[21] Prior to the COVID-19 pandemic, more than 35 million Americans participated on SNAP in 2019. In 2021, SNAP participation rose to more than 41 million people.[3] Additionally, national food insecurity levels rose from 31% prior to the pandemic to 39% in the first four months of the pandemic.[20]

Pressure on and greater stress low-income households started early in the pandemic. For example, the Centers for Disease Control (CDC) recommended to buy two weeks of food at a time to combat the unpredictability of the food supply chains and closures.[21] However, low-income families (less than 250% of the FPL) struggled to comply to CDC recommendations due to lower job flexibility, higher rates of job loss, and higher rates of food insecurity.[21] According to the Marketplace report, approximately 40% of the increase in food bank usage comes from individuals experiencing food insecurity for the first time. A national study done by Morales et al., found that before March 13, 2020, about 30% of households in their sample self-reported as food insecure, while the number rapidly increased to 43% in late April 2020.[5] Food insecure households often struggle with greater food procurement obstacles since it takes more time, cognitive bandwidth, and logistical coordination for them to procure it compared to their food secure counterparts.[22] On March 27, 2020, the CARES Act allocated an extra $16 billion dollars to newly

eligible SNAP participants, but this may not have been enough to account for disparities in rural and urban environmental factors discussed earlier.[22]

Food supply chains have also been affected greatly by the pandemic. Food scarcity in grocery stores due to global labor shortages and bulk buying has introduced new obstacles to nutritional food procurement.[5] According to a transnational study by Murphy et al., US participants had a significant increase in difficulty finding ingredients and a significant increase in bulk buying of ingredients.[23] In addition, a study by Ferrante et al., found that parents of children aged 4 to 8 years of age reported an increase in home cooking and online grocery shopping.[24] Very little is known about how rural and urban environmental factors affected food supply inadequacy, but fresh food products were already affected by the rural environment well before the pandemic. Lower variety of fruits and vegetables, poor fresh food quality, and elevated food prices in rural areas were already recognized as obstacles to food procurement.[25] With a general rise in home cooking behaviors and a scarcity in the food supply, magnified pandemic effects on low-income households, as well as a suspected increase in difficulty of procuring healthy foods in rural areas, we can conclude that quantifying how purchasing has changed in vulnerable populations is an important area that currently lacks investigation.

Currently, it is unknown how and if urban and rural environments affect the composition of SNAP sales from full-service grocery stores in North Carolina as well as the separate association of sale composition with the shock of the COVID-19 pandemic. Therefore, the objectives of this paper are to: 1) describe differences in sales to SNAP shoppers in rural and urban stores between October 2019 and December 2020, and; 2) describe differences in sales to SNAP shoppers during the same 13-week period pre and post COVID-19.

Methods

Sample and Scanner Data

This study uses loyalty-card transaction/point-of-sales data spanning 65 weeks (October 2019 through December 2020) from a large grocery chain located in North Carolina with 496 stores located in 86 of

100 North Carolina counties. The transaction data includes every item sold in each shopping episode at the barcode level including barcode/item number, item description, item size, price, unit of measure, quantity sold, tender types used in the transaction, as well as date of sale, the store where each item is sold and the loyalty-card ID used in the transaction. While we do not have demographic information about the loyalty card shoppers, there is information about the store location of every transaction/sale. Our unit of analysis for this study is at the store-week level, and the analytical data contains 32,183 observations with some stores missing data (n=57) due to closing and opening during our study period.

Linkage to Nutrition Data and Outcome Categorization

Existing nutrition label data at the barcode-level from several sources such as USDA National Nutrient Database for Standard Reference and Mintel Global New Product Database[26] were merged with the transaction data and used to categorize items sold as foods or non-foods. Unpackaged items that did not have barcodes and instead had product look up (PLU) codes such as loose fruits or vegetables were linked to the USDA's Food and Nutrient Database for Dietary Studies database for nutrient values and for appropriate categorization. We were thus able to add nutrient values (e.g., calories) and categorized foods into nutritionally-relevant food groups: fruits, vegetables, nuts, and legumes with additives (FVLN all), fruits, vegetables, nuts, and legumes without additives (FVLNNA), junk foods (JF), sugar sweetened beverages (SSB), and processed meat (PM) (see justifications for groupings in Table 1).

Identifying sales to SNAP shoppers

We defined a loyalty card shopper as a SNAP participant if they used SNAP as a payment type one or more times during any rolling 3-month period. We chose a 3-month rolling period because it is possible that a shopper may be a SNAP participant but did not shop at this specific retailer every month. For each store, we aggregated the sales to all SNAP shoppers in a given week for our food groups of interest (i.e., FVLN all, FVLNNA, JF, SSB, and PM).

Outcome measures

The outcome measures are the share of total calories sold coming from each of these food groups. We chose to use the share of calories purchased from each food group as our primary outcome because it is a similar unit of measure across food categories. Calorie density will tell us directly about the diet of the rural versus urban samples and allows us to control for factors such as buying in bulk that may be more common in rural stores due to longer travel distance between residence and store. Other nutritional measures (such as sugar or sodium) would describe only a portion of the data linked to specific chronic health outcomes and can therefore not describe overall sales as well. Share of sales in terms of dollars was also not the best measure due to price differentials by location and inability to compare prices across food groups given different price ranges for these food groups. Share of sales based on volume could be an alternative outcome measure but did not yield significantly different results.

Table 1. Outcome Justifications

Food Purchase Measures, All Weekly	**Example Products**	**Rationale**
Fruits, Vegetables, Nuts, and Legumes without Additives	Fresh vegetables, premixed salads, bulk fruits	- Underconsumed in the US[27] - Linked to positive health outcomes[27]
All Fruits, Vegetables, Nuts, and Legumes with and without Additives	Salted peanuts, canned peaches in syrup, sugared almonds	- Comparison group for FVLN with no additives - Contributes extra sugar and sodium to diet, which is linked to chronic health issues[4] - Often consumed in the rural diet due to long shelf life[4]
Sugar Sweetened Beverages	Coca-Cola, juices with added sugar, Hawaiian Punch, Gatorade	- Overconsumed in the US[27] - Linked to chronic health issues such as diabetes, heart disease, and cancer[27]
Junk Food	Potato chips, cake, flavored coffee creamer, chocolate	
Processed Meats and Seafood	Pre marinated meats, frozen seasoned chicken wings, packaged deli meats	

Primary Exposures

We have two primary exposures of interest. First, whether a store is located in a rural or urban county, and second is the onset of the COVID-19 pandemic. Stores were categorized as either rural or urban based on the county in which they are located following USDA definitions. The USDA defines urban counties as: densely-settled urban entities with 50,000 or more people and outlying counties that are economically tied to the core counties as measured by labor-force commuting[28]. Outlying counties are included if 25 percent of workers living in the county commute to the central counties.[28] The USDA defines rural counties as outside the boundaries of metro areas.[28] The COVID-19 pandemic was defined as starting on March 10th, 2020, the day North Carolina's governor Roy Cooper declared a state of emergency due to COVID-19.[29]

2016 Food Environment Index[30]

Urban and rural status of a county encompasses many different factors of the environment. To account for the heterogeneity even within and between urban and rural counties, the Food Environment Index (FEI) was included as a covariate interpreted as an exposure that can result in differing sales of food categories.[30] The FEI is an index calculated using 2013-2016 data across the country and factor analysis to measure food accessibility on the county level.[30] The three components are labeled 'Unhealthy Access', 'Healthy Food Access', and 'Socioeconomic Status'.[30] Each component score is composed of factors indicating their respective category.[30] The 'Socioeconomic Status' component takes into account the SNAP Participants as a percentage of the total population, food insecurity level, percentage of the total population that is unemployed, and a very low food insecurity level.[30] The 'Unhealthy Access' component takes into account the percentage of lack of car access, number of convenience stores per 10,000, and number of SNAP eligible stores per 10,000 population.[30] The 'Healthy Access' component takes into account the number of grocery stores, full service restaurants, and farmer's markets per 10,000.[30] A higher score in any of the components indicates a healthier food environment to conserve directionality.[30] Each component's numeric score is reported in standard deviations away from the mean national score of 0, with a negative value denoting a category score below the national average, and a positive score denoting a score above the national average.

County and Store Level Data

Since we did not have demographic information on shoppers and the unit of analysis is at the store-week level, county level demographic composition measures were used as covariates in our model. These data were sourced from the North Carolina Office of State Budget and Management (NC OBSM) website and published by NC OBSM and the State Demographer for 2020. The data were projections that included estimates from 2010 to 2020 and population projections from 2021 to 2050. Age, education, race, sex, employment, and ethnicity are measured as continuous percentages of a county's total population. Race and ethnicity are social constructs and were estimated by the North Carolina State Demographer. They were used only to control for differences between counties and results concerning their association with food category outcomes.

Additionally, store level characteristics were computed from our dataset to control for differences between stores. These included the mean number of SNAP and non-SNAP transactions, percent of total transactions involving SNAP, and percent of loyalty cards that belong to SNAP participants. Number of shopping episodes may have been impacted by SNAP and non-SNAP status due to accessibility differences as SNAP participants may have less means of transportation, so the mean number of SNAP transactions per week as well as the mean number of non-SNAP transactions were included. We also controlled for the percent of total transactions and loyalty cards that belong to SNAP participants.

Statistical Analysis

All analyses were conducted in StataSE (Version 16.1, 2019). Linear regression with random effects was utilized to account for clustering and repeated measures at the store-level (xtreg, re). Robust standard errors were used because predictors are heteroskedastic. For county demographic composition measures, we omitted one group given that the categories would sum to 100%. For example, among race covariates, White was selected as the omitted group (see Table 4). To examine pre and post COVID-19 differences in sales within rural and urban counties, we compared predicted margins percentages of SNAP sales from

each food category from the adjusted random effects models from weeks that were one year apart were used to account for seasonality differences. Specifically, weeks 1-13 (October 2019 through December 2019) were compared to weeks 52-65 (October 2020 through December 2020). A two tailed test for significant differences was applied using one degree of freedom and an alpha level of 0.05.

Results

County and Store Level Characteristics

Table 2 presents the average county demographics, FEI scores, and store level characteristics of rural and urban status. In total, 127 stores were classified as rural, and 369 stores were classified as urban. Rural counties have an overall older and lower educated demographic makeup compared to urban counties, as well as a higher percentage of Black, American Indian or Alaska Native populations. All other county-level demographic characteristics were similar between urban and rural counties. Rural North Carolina counties on average scored higher than the national average in the 'Unhealthy Access' and 'Socioeconomic Status' FEI components, but lower in the 'Healthy Access' FEI component. Urban North Carolina counties on average scored lower in all three FEI components compared to the national average. Rural counties had a higher percentage of total transactions and loyalty cards from SNAP shoppers compared to urban counties but had a similar mean number of SNAP and Non-SNAP transactions per shopper per week compared to urban counties.

Table 2. Store/County Data Characteristics

Characteristic	Rural	Urban
Age		
0-5y	6.3%	7.0%
6-19y	17.0%	18.2%
20-34y	18.6%	20.2%
35-54y	23.7%	26.0%

55-64y	13.6%	12.7%
65y and older	20.2%	15.9%
Education		
High school diploma or less	43.4%	32.0%
Some College	36.8%	33.2%
Bachelor's Degree	13.7%	23.2%
Greater than a Bachelor's Degree	6.1%	11.4%
Race		
White	68.7%	70.5%
Black	23.6%	22.2%
Asian	1.1%	3.4%
American Indian or Alaska Native	4.2%	1.1%
Other	2.2%	2.7%
Mean Food Environment Index[a]		
Unhealthy Access	0.6	-0.3
Socioeconomic Status	0.1	-0.05
Healthy Access	-0.04	-0.2
Hispanic Ethnicity	9.3%	11.2%
Unemployment	7.6%	7.4%
Sex		
Male	49.2%	48.4%
Female	50.7%	51.6%
Store Level Characteristics		
Percent of total transactions that involve SNAP	27.1%	25.3%
Percent of total loyalty cards that make purchases with SNAP	25.1%	23.6%
Mean (SD) Number of SNAP	1.6 (0.1)	1.5 (0.1)

transactions per shopper per week		
Mean (SD) Number of NonSNAP transactions per shopper per week	1.4 (0.09)	1.4 (0.07)

[a]The Food Environment Index factors are interpreted as standard deviations above a mean national value of 0. A higher score in any of the components indicates a more healthy environment.

Regression Results

Rural versus Urban Store Location

A store being located in a rural county was associated with a lower percentage of total calories sold to SNAP shoppers from JF when compared to SNAP shopper sales in stores located in an urban county (B:-0.51 (95% CI -0.87,-0.15)) (Table 4). An average of 30.42% of total calories sold from rural stores were from JF, while an average of 30.45% of total calories sold from urban stores were from JF (Table 3). The rural or urban status of the county a store was located in was not significantly associated with the share of calories sold to SNAP shoppers coming from FVLNNA (B:0.02 (95% CI -0.11,0.15)), FVLN all (B:0.05 (95% CI -0.24,0.35)), SSB (B:-0.18 (95% CI -0.61,-0.26)) or PM (B:0.09 (95% CI -0.06,0.09)) (Table 4).

Table 3. Model adjusted Mean Share of Calories by Food Category and Rural Status

Food Category	**Rural (95% CI)**	**Urban (95%CI)**
Fruits, Vegetables, Nuts, and Legumes without Additives	8.08% (7.97, 8.18)	8.06% (8.00, 8.11)
All Fruits, Vegetables, Nuts, and Legumes with and without Additives	13.28% (13.09, 13.47)	13.21% (13.11, 13.30)
Sugar Sweetened Beverages**	9.25% (9.00, 9.50)	9.74% (9.61, 9.86)
Junk Food**	30.42% (30.21, 30.63)	30.45% (30.35, 30.55)
Processed Meats and Seafood	5.71% (5.63, 5.80)	5.63% (5.59, 5.67)

**Association of these food categories with rural status was statistically significant ($\alpha = 0.05$) according to our regression model (See Table 4).

FEI Score

The Food Environment Index used factor analysis to evaluate the food environments of counties with a higher score indicating a more healthy environment and was reported in standard deviations from the mean national average. For the two food groups FVLNNA and FVLN all, an increase in the 'healthy access' FEI component score was associated with a 0.24 (95% CI 0.13,0.34) and 0.41 (95% CI 0.21,0.61) percentage point increase, respectively, in the percent of total calories sold to SNAP shoppers coming from that food group (Table 4). It is also significantly associated with a decrease in the percent of calories sold to SNAP shoppers from SSB (B:-1.02 (95% CI -1.30,-0.75) (Table 4). An increase in the 'unhealthy access' FEI component score was significantly associated with an increase in the percent of total calories sold to SNAP shoppers from SSB (B:0.87 (95% CI 0.43,1.32)) (Table 4). A one point increase in the 'socioeconomic' FEI component score was found to be significantly associated with an increase in calories sold from SSB (B: 2.61 (95% CI 0.94,4.29)) (Table 4). No other food category was found to be significantly associated with FEI components.

County Level Characteristics

A county with older age composition was significantly associated with an increase in percentage of total calories sold to SNAP shoppers coming from FVLNNA and FVLN all compared to the referent omitted group, 1-5 year olds (Table 4). However, a county with a higher unemployment rate was significantly associated with a decrease in percentage of total calories sold to SNAP shoppers coming from FVLNNA and FVLN all (Table 4). In terms of race make up of a county's population, a higher percentage of American Indian, Alaskan Native or Asian population was associated with an increase in percentage of total calories sold coming from SSB and a decrease in percentage of total calories sold coming from PM. Share of a county's population made up of Black individuals and those who listed their race as "other"

were shown to have an association with a decrease in percentage of total calories sold coming from SSB and JF (Table 4). All other associations between county level characteristics and SNAP shopper sales were not statistically significant (Table 4).

Store Level Characteristics

An increase in the mean number of non-SNAP transactions per week per shopper was associated with an increase in percentage of total calories sold to SNAP shoppers from FVLNNA, FVLN all, and PM. An increase in percent of total transactions that are SNAP per week was associated with a decrease in percentage of total calories sold to SNAP shoppers coming from SSB (Table 4). Percent of total loyalty cards that are SNAP and Mean Number of SNAP transactions as well as associations between other food categories and aforementioned store level characteristics were not found to be significant (Table 4).

Table 4. Primary Model Outcomes and County Level Characteristics (n=32,183)

	Fruits, Vegetables, Nuts, and Legumes without Additives	**All Fruits, Vegetables, Nuts, and Legumes**	**Sugar Sweetened Beverages**	**Junk Food**	**Processed Meats and Seafood**
	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)
Food Environment Index[a]					
Unhealthy Access	0.10 (-0.05,0.25)	0.25 (-0.05,0.54)	0.87** (0.43,1.31)	-0.19 (-0.51,0.12)	-0.09 (-0.24,0.05)
Healthy Access	0.24** (0.13,0.34)	0.41** (0.21,0.61)	-1.02** (-1.30,-0.75)	0.00 (-0.19,0.19)	0.01 (-0.07,0.10)
Socioeconomic Status	-0.11 (-0.71,0.49)	-0.18 (-1.29,0.93)	2.61** (0.94,4.28)	-0.86 (-2.12,0.40)	-0.56 (-1.20,0.07)
Urban/Rural Status					
Urban*	-	-	-	-	-

Rural	-0.01 (-0.18,0.16)	0.05 (-0.24,0.35)	-0.18 (-0.61,-0.26)	-0.51** (-0.87,-0.15)	0.09 (-0.06,0.24)
Age Breakdown					
Ages 1-5*	-	-	-	-	-
Ages 6-19	0.06 (-0.02,0.13)	0.11 (-0.03,0.25)	-0.05 (-0.27,0.18)	0.01 (-0.13,0.14)	0.01 (-0.07,0.08)
Ages 20-34	0.11** (0.05,0.17)	0.20** (0.09,0.31)	0.19** (0.02,0.36)	-0.01 (-0.12,0.09)	-0.03 (-0.08,0.03)
Ages 35-54	0.13** (0.06,0.20)	0.25** (0.12,0.38)	0.17 (-0.04,0.38)	-0.05 (-0.18,0.08)	-0.06 (-0.13,0.01)
Ages 55-64	0.03 (-0.04,0.10)	0.04 (-0.08,0.17)	0.04 (-0.13,0.20)	0.03 (-0.10,0.17)	0.08** (0.02,0.14)
Ages 65+	0.13** (0.07,0.19)	0.24** (0.12,0.36)	0.08 (-0.10,0.26)	-0.01 (-0.13,0.10)	-0.04 (-0.11,0.02)
Employment					
Unemployment Rate	-0.12** (-0.19,-0.05)	-0.24** (-0.36,-0.12)	-0.06 (-0.25,0.12)	0.02 (-0.13,0.18)	0.04 (-0.03,0.11)
Sex					
Male*	-	-	-	-	-
Female	-0.02 (-0.05,0.02)	-0.03 (-0.10,0.04)	0.22** (0.12,0.32)	-0.00 (-0.08,0.07)	-0.06** (-0.10,-0.02)
Education					
High School Diploma or less*	-	-	-	-	-
Some College or Associate's Degree	-0.02 (-0.04,-0.00)	-0.03 (-0.07,0.00)	0.03 (-0.02,0.09)	0.03 (-0.00,0.06)	-0.02** (-0.04,-0.01)
Bachelor's Degree	0.01 (-0.01,0.03)	0.01 (-0.02,0.05)	-0.06** (-0.11,-0.01)	-0.02 (-0.05,0.01)	-0.00 (-0.02,0.01)
Master's Degree or More	-0.02 (-0.04,0.01)	-0.02 (-0.06,0.03)	-0.04 (-0.11,0.02)	0.00 (-0.04,0.05)	0.01 (-0.01,0.03)
Race					
White*	-	-	-	-	-
American Indian or Alaskan Native	-0.01 (-0.01,0.00)	-0.01 (-0.02,0.00)	0.06** (0.04,0.09)	0.01 (-0.00,0.03)	-0.02** (-0.02,-0.01)
Asian	0.01 (-0.03,0.05)	0.03 (-0.04,0.10)	0.13** (0.03,0.22)	-0.09** (-0.17,-0.01)	-0.05** (-0.08,-0.02)

Black	0.00 (-0.01,0.01)	0.00 (-0.01,0.01)	-0.05** (-0.06,-0.03)	-0.02** (-0.03,-0.01)	0.01** (0.01,0.02)
Other	0.21** (0.12,0.30)	0.37** (0.21,0.54)	-0.23** (-0.46,-0.00)	-0.10 (-0.26,0.07)	-0.04 (-0.12,0.04)
Hispanic Origin					
NonHispanic*	-	-	-	-	-
Hispanic	0.02** (0.00,0.03)	0.04** (0.01,0.07)	0.02 (-0.02,0.06)	-0.02 (-0.05,0.00)	-0.02** (-0.03,-0.01)
Store Level Characteristics					
Percent of total transactions that are SNAP	-0.02 (-0.06,0.03)	-0.03 (-0.13,0.04)	-0.07** (-0.14,-0.00)	0.05 (-0.06,0.16)	0.04** (0.00,0.09)
Percent of total loyalty cards that are SNAP	0.01 (-0.04,0.05)	0.01 (-0.07,0.10)	0.07 (-0.00,0.14)	-0.07 (-0.18,0.04)	-0.04 (-0.08,0.01)
Mean Number of SNAP transactions	0.15 (-0.42,0.72)	0.29 (-0.69,1.27)	0.45 (-0.32,1.22)	-0.38 (-1.62,0.87)	-0.44 (-0.98,0.09)
Mean Number of NonSNAP transactions	0.94** (0.16,1.72)	1.37** (0.08,2.66)	-0.87 (-2.01,0.27)	0.59 (-1.13,2.31)	0.72** (0.18,1.27)

*Eliminated due to collinearity

**Statistically significant ($\alpha = 0.05$)

[a]The Food Environment Index factors are interpreted as standard deviations above a mean national value of 0. A higher score in any of the components indicates a more healthy environment.

Pre and Post COVID-19

The model-adjusted outcomes show that all food categories significantly changed between the months of October 2019 to December 2019 (Pre COVID-19) and October 2020 to December 2020 (Post COVID-19) except for FVLNNA. FVLN all, SSB, and JF sales were decreased during post COVID-19 compared to their pre COVID-19 estimated average share of total kcal sales (Diff: -0.20% (95% CI -0.30,-0.10), Diff: -0.43% (95% CI -0.53,-0.33), and Diff: -1.32% (95% CI -1.41,-1.22) respectively) (Table 5). However, PM increased during post COVID-19 compared to pre COVID-19 estimated average share of total kcal sales (Diff: 0.87% (95% CI 0.05,0.13)) (Table 5).

As a robustness check we used the share of volume from each food group as a unit of measure in a sensitivity analysis. We found no significant differences between using volume and calories as a measure of our outcomes.

Table 5. Pre and Post COVID-19 Differences of Model adjusted Means by Food Category

Food Category	**Pre COVID (95% CI)**	**Post COVID (95% CI)**	**Difference (95% CI)**
Fruits, Vegetables, Nuts, and Legumes without Additives	8.26% (8.18, 8.33)	8.20% (8.13,8.27)	-0.06% (-0.11,0.00)
All Fruits, Vegetables, Nuts, and Legumes with and without Additives	13.56% (13.42, 13.71)	13.37% (13.24,13.50)	-0.20%** (-0.30,-0.10)
Sugar Sweetened Beverages	10.33% (10.10, 10.55)	9.89% (9.71,10.08)	-0.43%** (-0.53,-0.33)
Junk Food	31.36% (31.22,31.49)	30.04% (29.91,30.17)	-1.32%** (-1.41,-1.22)
Processed Meats and Seafood	5.51% (5.44,5.58)	5.60% (5.54,5.66)	0.87%** (0.05,0.13)

**Statistically significant ($\alpha = 0.05$)

Discussion

We investigated whether and to what extent there were differences in sales to SNAP participants from a large grocery chain with stores located in urban vs rural counties in NC between October 2019 and December 2020. We found that stores located in rural counties, according to USDA definitions, were associated with a lower share of total calories from JF compared to stores located in urban counties. The magnitude of the difference in JF was less than a percent between urban and rural store sales but was deemed statistically significant. Due to the store-level measure, it is unclear what the effects of this difference is on public health and this should be investigated in future studies. Meanwhile, the sales of

FVLNNA, FVLN all, SSBs, and PM to SNAP participants were not significantly different between stores in urban and rural counties. These findings are similar to previous literature examining the nutritional quality of packaged food purchases bought by households in rural and urban settings.[31] This previous research also found that low-income rural households bought less JF than low-income urban households.[31] Though this previous study did not specify SNAP use, it is the most comparable study available to our knowledge. Previous research has shown that grocery purchases made in rural areas also largely come from convenience stores and mass merchandisers (which are not included in our present work), so it is possible that a notable share of rural shoppers' food purchases are not captured within this dataset.[31]

While we found that rural stores sold a lower share of total calories attributed to JF to SNAP participants compared to urban stores, the overall share of calories for these categories was large compared to healthier food categories like FVLNNA and FVLN all. These results are similar to that of a study by Grummon et al. that examined national household purchases from 2012 to 2013 that examined SNAP participating households' purchases.[32] They found that SNAP participating households' purchases across the US averaged 29.74% of total calories per person per day attributed to JF.[32] This is similar to our analysis (limited to North Carolina) that found 30.42% and 30.45% of rural and urban (respectively) total calories per store per week were attributed to JF. In addition, the share of total calories per person per day of SNAP participants from fruits, vegetable (starchy and non starchy), legumes, and nuts from the Grummon et al. study amounted to approximately 6.24%, lower than our comparative result of 13.28% and 13.21% of rural and urban (respectively) total calories per store per week from FVLN all.[32] Regardless, a minimal share of calories came from healthy foods, while a larger share of total calories were attributed to foods linked to chronic disease risk. Though these results may differ due to the breadth of the data (Grummon et al. covered all purchases rather than just chain grocery store purchases and is from a national sample) and time frames (our data spanned the COVID-19 pandemic which may have affected purchasing and sale patterns), both studies found that the overall makeup of SNAP purchases were made up of many unhealthful foods not unlike the current average American diet. Reasons for the imbalance cannot be made clear through these studies, but these results can support SNAP policy changes

that support participants in making more healthful food purchases. Strengthening current SNAP vendor standards and ability to stock more frozen, shelf-stable or fresh vegetables, fruits, nuts and legumes as well as SNAP incentive programs for such products for participants may lead to healthier sale outcomes for SNAP participants regardless of where they live. Currently, there are initiatives that are addressing certain aspects such as the Healthy Food Financing Initiative, which opens food hubs and full service grocery stores in low income areas.[33,34,35] Though the effects on diet quality improvement of this initiative have been small to none in some natural experiments, it has been shown to decrease food insecurity and intake of added sugars in SNAP populations.[33,34,35] Tailored incentive programs for healthy foods and cooking supplies, disallowing SNAP benefits to be spent on SSBs, and decreasing unhealthy food promotion in stores are all proposed to help in reshaping sale patterns in both rural and urban settings.[36] Grants such as the Gus Schumacher Nutrition Incentive Program from the USDA allows for such programs to be developed, administered, and evaluated, by providing funding.[37]

It is unclear why there were associations between increases in each FEI[30] component measure and increases in share of calories from SSBs in our study. Since an increase in FEI[30] component scores would indicate an environment more conducive to healthy eating and healthy food access, food categories that include products linked to chronic disease were expected to decrease. However, an increase in 'unhealthy access' and 'socioeconomic status' were found to be associated with an increase in the share of calories from SSBs. Possible explanations for these results may include the ubiquity of unhealthy food advertising and its detrimental effects regardless of level of access and socioeconomic status. In addition, the Food Environment Index and its components were calculated using measures that may not completely reflect a healthy or unhealthy food environment, such as the number of SNAP eligible stores per 10,000 population.[30] Further investigation into these measures as well as repeated analyses may clarify these findings.

Concerning COVID-19 related sale changes, we found that after the onset of the COVID-19 pandemic, there were significant decreases in the share of calories from FVLN all, SSB, and JF, but an increase from PM. One study that found some similar results analyzed a SNAP incentive program

purchase data at a food co-operative pre and post pandemic related closures.[38] They found that although there were increases in discounts on fresh fruits and vegetables, there was a decrease in the mean number of fresh fruits and vegetables purchased.[38] Parallels between our studies include a similar population and time frame. SNAP retailers may have seen the same decline in SNAP sales of fresh fruits and vegetables due to several reasons that cannot be concluded from these studies. For example, supply chain inconsistencies and extreme economic turbulence may have contributed to these changes in sales. It is unclear why the share of calories from PM increased in our results, but a study using self-reported food purchasing behavior observed an initial decrease in purchases of canned meat and a later increase in purchases of canned meat in April of 2020.[39] The self-reported study was[39] different in the sample characteristics, timing of the surveys, and use of subjective data, but both studies saw a later increase in processed meat purchases or sales.[38] Again, we are unable to draw clear conclusions on why this was observed, but hypothesize that concerns with supply shortages and scarcity of meat and seafood products due to the pandemic may be one potential reason. Panic buying may have caused the shift of sales, but we were not able to obtain data on availability of products in stores and whether they were different to pre-pandemic times. In the future, policies may need to also consider how to support more resilient food supply chains particularly around healthier food options.

Strengths and limitations

The transaction data we used was extremely robust spanning October 2019 to December 2020, before and since the onset of COVID-19. Not many datasets available for research can accurately capture sales before and since COVID-19, so this data is important to addressing that gap in the literature. The data is also objective data that came from a chain grocery store that is among the most popular grocery stores in North Carolina.[40] While we were able to successfully identify SNAP participants through a corresponding payment type for every item sold, our data was limited to only those patrons that used a loyalty card, so most but not all transactions were recorded. Our data was also limited to one chain grocery store, so we could not capture all the purchases made by SNAP participants who may do more grocery shopping elsewhere. Finally, our data only captures sales and do not reflect dietary intake and therefore cannot

strongly reflect population level diet changes. To address these limitations, future work can use 24 hour diet recall to analyze diet and purchase differences and similarities or use data from different store types to get a comprehensive look at SNAP purchases and dietary intake.

Conclusions

This is one of the first studies to examine store transaction data in the context of comparing urban and rural SNAP populations in North Carolina before and since COVID-19. Overall, results indicate that healthier food environment scores and rural status of a county is generally associated with a lower share of calories attributed to SSB sales to SNAP participants. In addition, COVID-19 pandemic exposure was associated with a general increase in the share of total calories sold attributed to foods linked to chronic disease risk. These results indicate a need for stronger SNAP vendor standards that encourage stocking of healthful foods as well as the economic and policy support essential for such standards to be upheld in rural and urban environments. SNAP incentive programs may also contribute to this cause. In the case of protective measures against global catastrophes like COVID-19, more support is needed to ensure healthy food access through policy conserving the supply chain.

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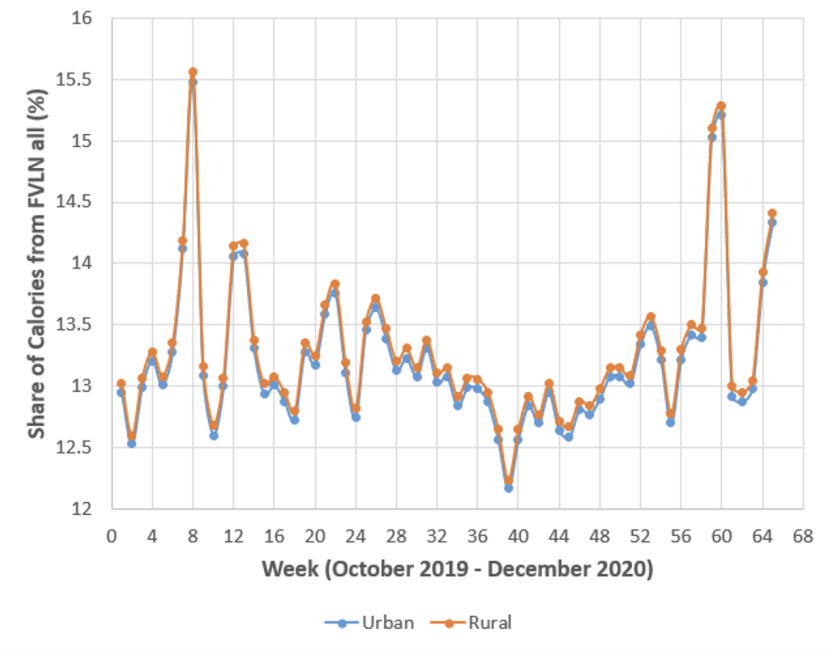
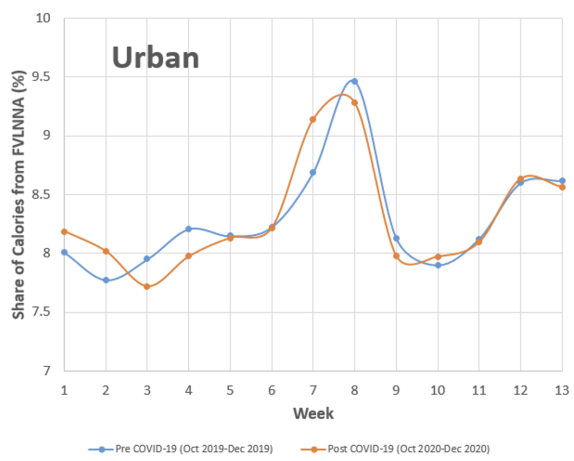
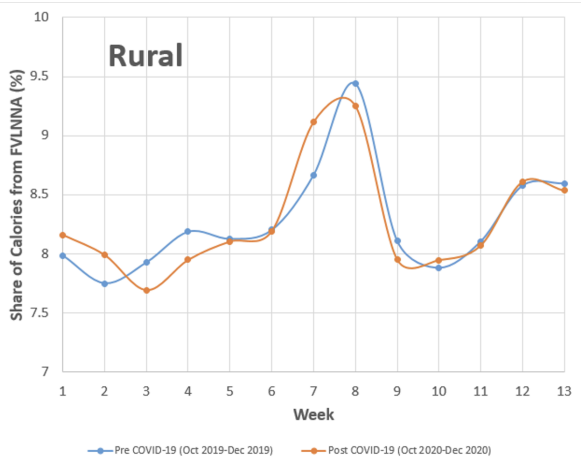
Appendix

Figure 1. Graphs of Fruits, Vegetables, Legumes, and Nuts without Additives Outcome as Share of Calories versus Time in Weeks



1a. Share of total calories from FVLNNA in percentage versus total study period in weeks spanning October 2019 to December 2020.

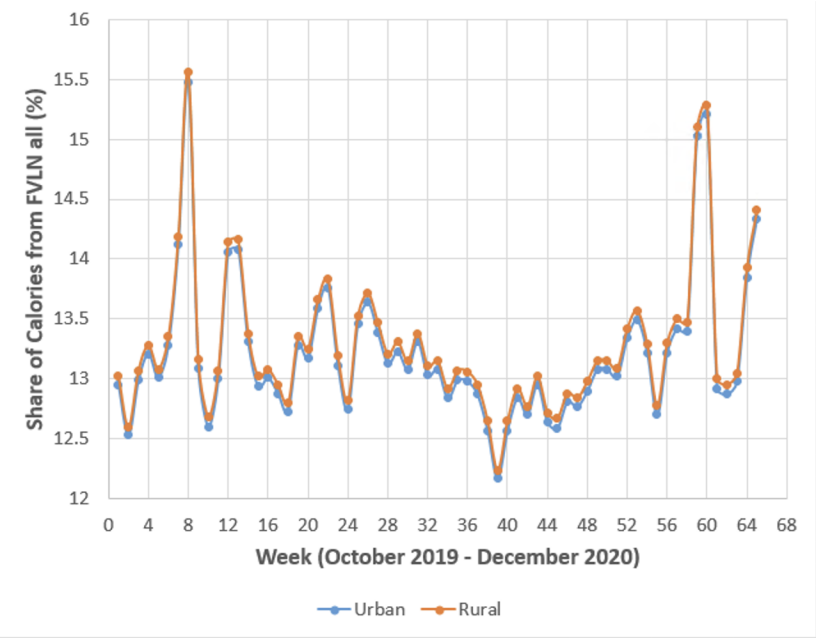




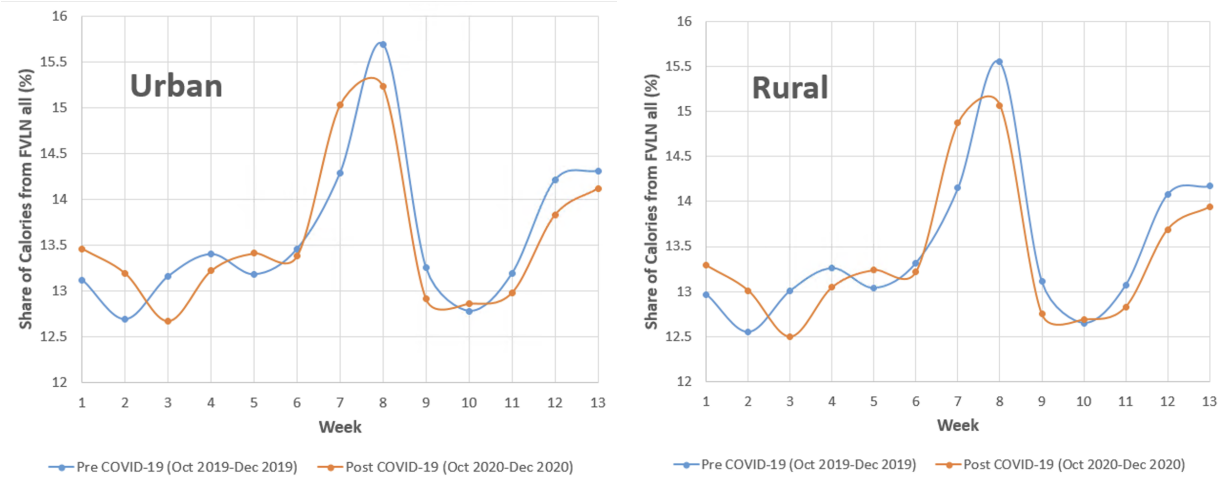
1b. Share of total calories from FVLNNA in percentage versus weeks 1 - 13 from stores in Urban Counties

1c. Share of total calories from FVLNNA in percentage versus weeks 1 - 13 from stores in Rural Counties

Figure 2. Graphs of Fruits, Vegetables, Legumes, and Nuts with and without Additives Outcome as Share of Calories versus Time in Weeks



2a. Share of total calories from FVLN all in percentage versus total study period in weeks spanning October 2019 to December 2020.



2b. Share of total calories from FVLN all in percentage versus weeks 1 - 13 from stores in Urban Counties

2c. Share of total calories from FVLN all in percentage versus weeks 1 - 13 from stores in Rural Counties

Figure 3. Graphs of Sugar Sweetened Beverages Outcome as Share of Calories versus Time in Weeks

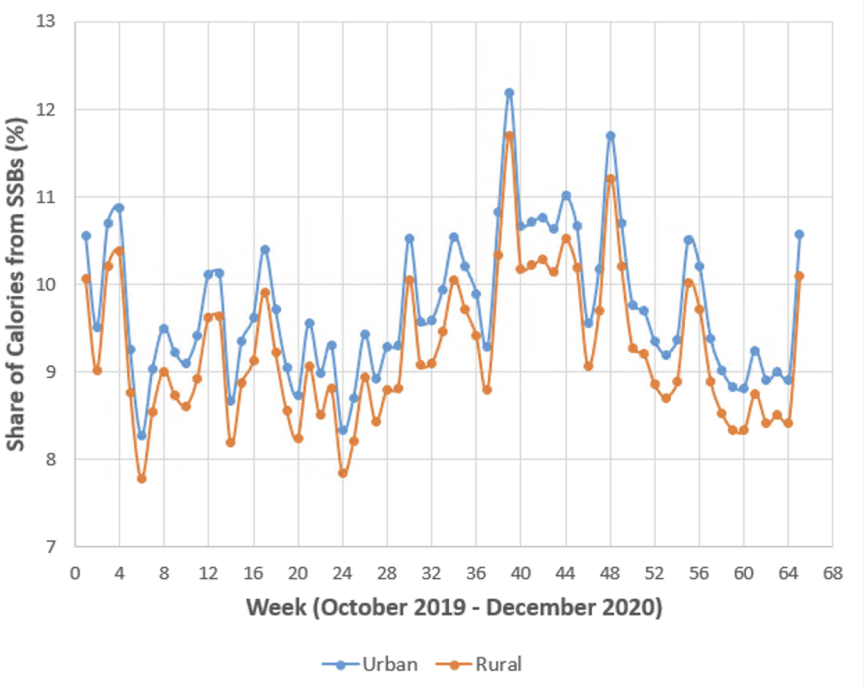
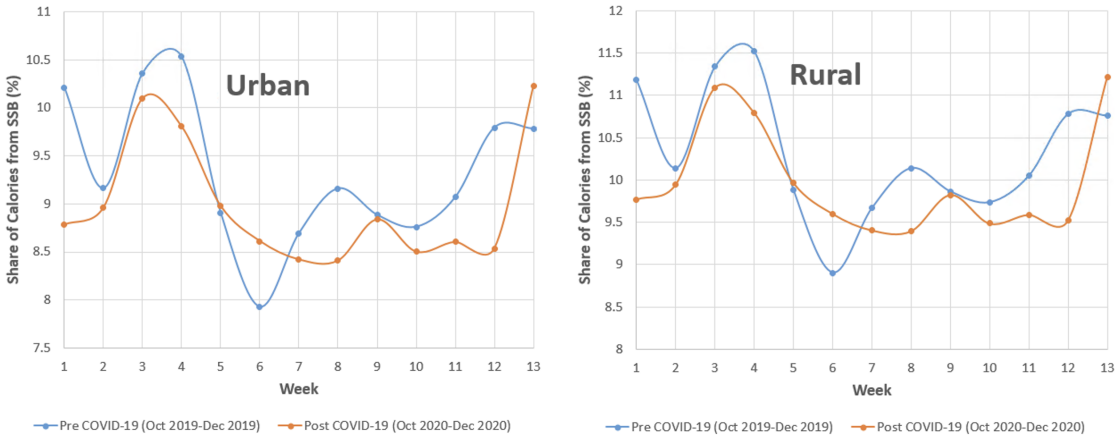


Figure 3a. Share of total calories from SSBs in percentage versus total study period in weeks spanning October 2019 to December 2020.



3b. Share of total calories from SSB in percentage versus weeks 1 - 13 from stores in Urban Counties

3c. Share of total calories from SSB all in percentage versus weeks 1 - 13 from stores in Rural Counties

Figure 4. Graphs of Junk Food Outcome as Share of Calories versus Time in Weeks

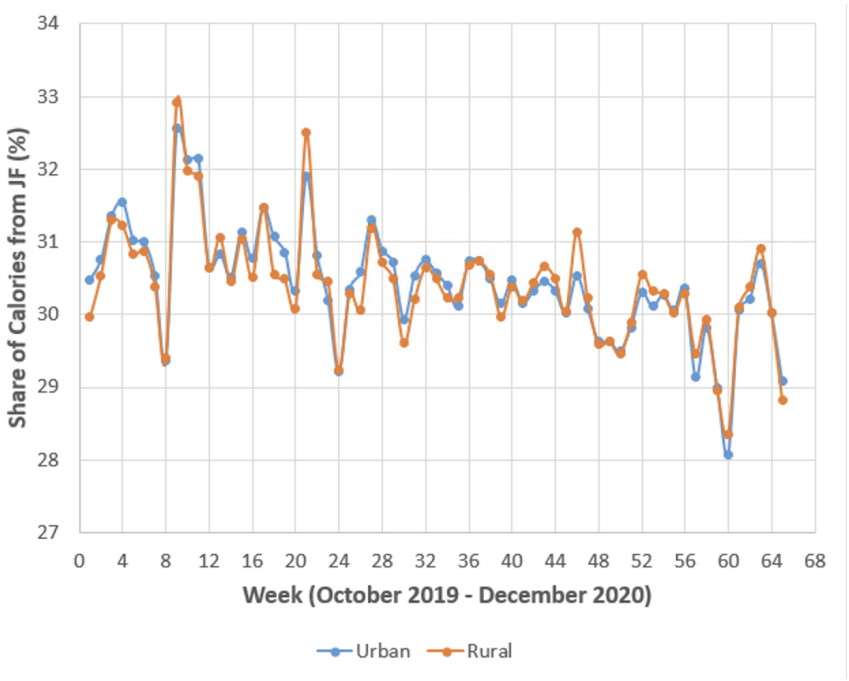
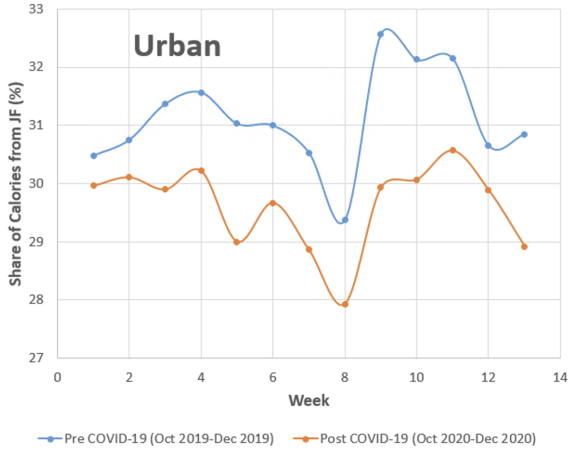
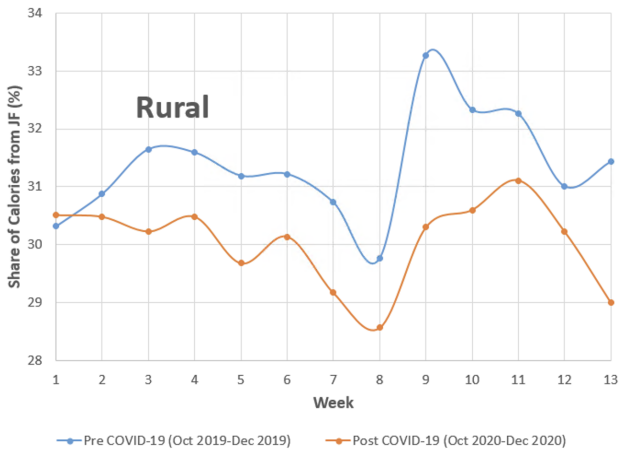


Figure 4a. Share of total calories from JF in percentage versus total study period in weeks spanning October 2019 to December 2020.





4b. Share of total calories from JF in percentage versus weeks 1 - 13 from stores in Urban Counties

4c. Share of total calories from JF all in percentage versus weeks 1 - 13 from stores in Rural Counties

Figure 5. Graphs of Processed Meat and Seafood Outcome as Share of Calories versus Time in Weeks

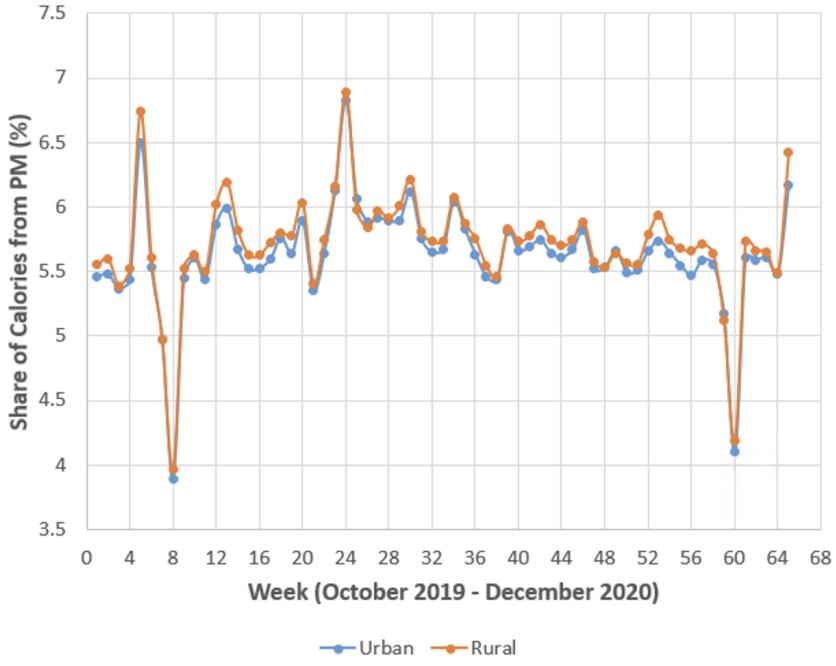
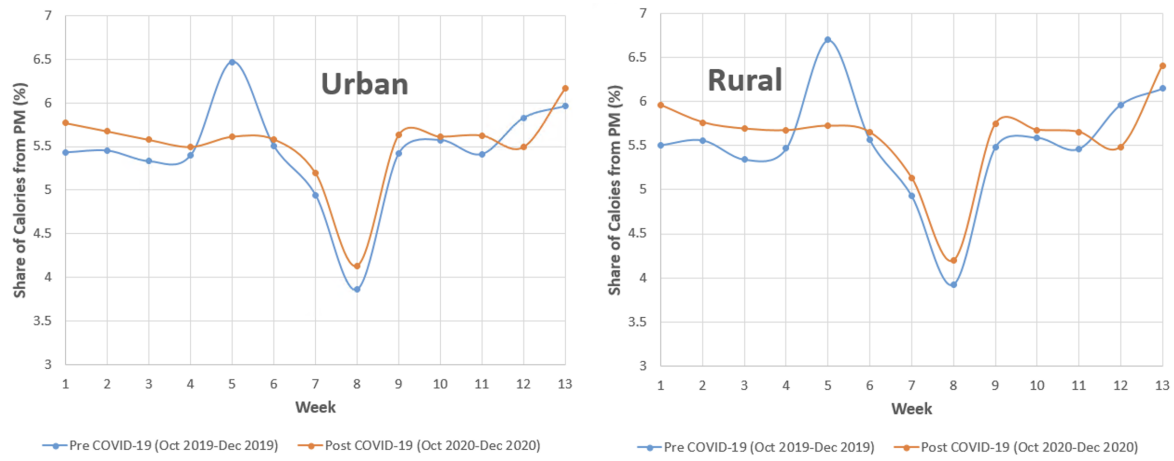


Figure 5a. Share of total calories from PM in percentage versus total study period in weeks spanning October 2019 to December 2020.



5b. Share of total calories from PM in percentage versus weeks 1 - 13 from stores in Urban Counties

5c. Share of total calories from PM all in percentage versus weeks 1 - 13 from stores in Rural Counties