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Differences in a Chain Supermarket's Sales to SNAP Shoppers Before and Since the COVID-19 Pandemic

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Abstract

Objective: This study 1) compares grocery sales to SNAP shoppers in rural and urban grocery stores and 2) estimate changes in sales to SNAP shoppers in North Carolina (NC) since the pandemic.

Data: Weekly transaction data among loyalty shoppers at a large grocery chain across NC from Oct 2019-Dec 2020 (n=32,182 store weeks) to assess share of total calories sold from: fruits, vegetables, nuts, and legumes (FVNL) with and without additives, sugar sweetened beverages (SSB), junk food (JF) and processed meats (PM).

Analysis: Multivariate random effects models with robust standard errors to examine the association of rural/urban status and pre/since COVID-19 with share of calories sold to SNAP shoppers from each food category. We controlled for county-level factors (e.g., socio-demographic composition, food environment) and store-level factors.

Results: We did not find significant rural-urban differences in the composition of sales to SNAP shoppers in adjusted models. There was a significant decrease in mean share of total calories from SSBs (−0.43%) and JF (−1.32%), and an increase in the share from PM (0.09%) compared to before the pandemic (all $p<0.05$).

Conclusions: Urban-rural definitions are insufficient to understand nuances in food environments and more support is needed to ensure healthy food access.

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

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existence since 1939 and is overseen by the United States Department of Agriculture.[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 access to healthy foods in order to improve diet quality.[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 US Department of Agriculture.[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] Evidence on the effectiveness of SNAP in improving diet quality compared to income eligible nonparticipants is mixed and differences vary across age, region, and gender.[8] Regardless, efforts to support structural and environmental factors that promote healthier diets in SNAP participants is needed.[8]

One major factor affecting purchase behavior and diet is the food environment, which has been observed to have an influence on diet-related disease risk.[9] Both urban and rural residents with low incomes suffer from a higher prevalence of diet related morbidity and mortality.[10] Urban and 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.[10] 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.[10,11] All these factors may adversely impact the healthy versus unhealthy food landscape and hence purchasing patterns, quality of diet, and health outcomes of rural residents.[4,12]

SNAP participants in rural areas may also face large barriers to meeting dietary recommendations due to structural factors such as income inequality or social factors.[13] 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.[13] Additionally, 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.[14] These factors highlight the need to understand the food purchasing patterns of SNAP participants in rural areas compared to urban areas.

Rural areas in North Carolina are facing general economic and population decline, while North Carolina's urban centers are experiencing rapid economic growth.[15,16] More specifically, 54 of North Carolina's 100 counties are rural, with one in five rural residents versus one in eight urban residents participating in SNAP in North Carolina.[17,18] 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.[19] The pandemic continues to disproportionately affect low income, food insecure households that were already struggling to meet needs even before the start of the COVID-19 pandemic.[20] 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.[19] Rural areas suffered these pandemic related effects but may be slower to recover from them partly due to obstacles discussed earlier.[21,22] According to a recent survey study conducted in the rural American West, the pandemic had significantly increased unemployment rates to be higher than the post pandemic national average, and negatively impacted overall life satisfaction, mental health, and economic outlook.[21,22]

Pressure and greater stress on low-income households started early in the pandemic. For example, the Centers for Disease Control recommended to buy two weeks of food at a time to combat the unpredictability of the food supply chains and closures[20] but low-income families struggled to comply with these recommendations due to lower job flexibility, higher rates of job loss, and higher rates of food insecurity.[20] Food supply chains were also affected greatly by the pandemic. Food scarcity in grocery stores due to global labor shortages and bulk buying introduced new obstacles to nutritional food procurement.[5] Very little is known about how rural and urban environmental factors affected food supply inadequacy, but 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.[23] With a general rise in home cooking behaviors[24] and a scarcity in the food supply[20], magnified pandemic effects on low-income households[20], 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 loyalty card associated SNAP sales from a full-service grocery stores retailer (with 496 stores statewide) in North Carolina as well as the separate association of sale composition with the shock of the COVID-19 pandemic. Therefore, we predict that sales to SNAP shoppers in rural stores between 1 October 2019 and 31 December 2020 will contain a lower percentage of fruits, vegetables, nuts and legumes compared to sales to SNAP shoppers in urban areas. Additionally, we predict that sales to SNAP shoppers during the period

of 1 October 2020–31 December 2020 (since COVID-19 pandemic) will contain a lower percentage of junk food compared to 1 October 2019– 31 December 2019 (pre COVID-19 pandemic).

Methods

Sample and Scanner Data

This study uses only loyalty-card transaction/point-of-sales data spanning 65 weeks (1 October 2019 through 31 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. This study was determined to not need IRB approval by the University of North Carolina at Chapel Hill (IRB: 21–1133).

Linkage to Nutrition Data and Outcome Categorization

Existing nutrition label data at the barcode-level from several sources such as US Department of Agriculture National Nutrient Database for Standard Reference and Mintel Global New Product Database[25] were programmatically 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 codes such as loose fruits or vegetables were linked to the US Department of Agriculture's Food and Nutrient Database for Dietary Studies database for nutrient values and for appropriate categorization. 10% of linked records are reviewed manually to ensure that the linkages are appropriate. 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 (FVNL all), fruits, vegetables, nuts, and legumes without additives (FVNLNA), junk foods (JF), sugar sweetened beverages (SSB), and processed meat and processed seafood (PM) (see justifications and examples for groupings in Supplement Table 1). We focused on sales outcomes on foods categories found to be strongly associated with health outcomes.[4]

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., FVNL all, FVNLNA, JF, SSB, and PM).

Outcome measures

The outcome measures are the share of total calories sold coming from each of the 5 food groups. For example, we calculated our SSB measure by dividing the amount of SSB calories sold by the total amount of food and beverage calories sold that month. 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 share 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. Furthermore, our analysis is on the store level and is meant to describe food category composition of sales rather than micro-/macro-nutrient measures of diets at the individual level. Share of sales in terms of dollars was also not the best measure due to potential price differentials by location and inability to compare prices across food groups given different price ranges for these food groups. A sensitivity analysis was conducted on share of sales based on volume (ounces) as an alternative outcome measure but did not yield meaningfully different results.

Primary Exposures

Our exposures of interest were whether a store is located in a rural or urban county, and 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 the US Department of Agriculture definitions. Urban counties are defined 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.[25] Outlying counties are included if 25 percent of workers living in the county commute to the central counties.[25] Rural counties are defined as outside the boundaries of metro areas.[26] 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 the COVID-19 pandemic,[27] thus, weeks 1–13 of our data are considered pre-COVID and weeks 14–65 are since-COVID (with the corresponding weeks to 2019 covering October through December 2020 being weeks 53–65).

Secondary Exposure: 2016 Food Environment Index (FEI)[28]

Urban and rural status of a county encompasses many different factors of the environment and is an important predictor of food access in North Carolina. However, it is a binary indicator and may miss nuance in relevant factors related to county-level food access. Therefore, we chose to explore FEI as a secondary exposure of interest. The FEI is an index calculated using 2013–2016 data across the country and factor analysis to measure food accessibility on the county level.[28] The three components are labeled unhealthy access, healthy food access, and socioeconomic status.[28] Each component score is composed of factors indicating their respective category.[28] 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.[28] 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.[28] The healthy access component takes into account the number of grocery stores, full service restaurants, and farmer's markets per 10,000.[28] A higher score in any of the components indicates a healthier food environment to conserve directionality.[28] Each component's numeric score is reported in standard deviations away from the mean national score of 0, with a negative/positive value denoting a category score in standard deviations below/above the national average.

Covariates

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 website and published by North Carolina Office of State Budget and Management and the State Demographer for 2020.[29] The data were projections that included estimates from 2010 to 2020 and population projections from 2021 to 2050.[29] Age, education, race (American Indian or Alaska Native, Asian or Pacific Islander, Black, White, or Other), sex, employment, and ethnicity were measured as continuous percentages of a county's total population.[29] Race and ethnicity are social constructs and were estimated by the North Carolina State Demographer based off the 2000, 2010, and 2020 censuses using a time series forecast model.[29] The race category named "other" is defined by the State Demographer as those who self-identify as 2 or 3 different races.[29] They were used only to control for differences between counties.

Additionally, store level characteristics were computed from our dataset to control for time-varying 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 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC.). 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. Our primary exposure was urban or rural status of the county. Covariates in our models included were FEI by county, store level characteristics, week indicators (week was a categorical variable), and demographic compositions by county. Since FEI and rural/urban status are important confounders in the other's relationship between the exposure and outcome, we used one model with rural/urban, FEI, and other relevant covariates to get estimates for our primary and secondary exposures (See Supplemental Materials Figure 6). For county demographic composition measures, we omitted a group given that the categories would sum to 100%.

The group we chose to omit was based on which group is perceived to have the highest socioeconomic standing. For example, among race covariates, White was selected as the omitted group (see Table 3). To examine pre and since COVID-19 pandemic 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 53–65 (October 2020 through December 2020). We also considered another method in which we stratified the models by rural and urban status and compared resulting predictive margins to examine the effects of the COVID-19 pandemic. This method did not yield meaningfully different results (see Supplemental Materials Table 2). 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 1 presents the average county demographics, Food Environment Index scores, and store level characteristics of rural and urban status. In total, 125 stores were classified as rural, and 371 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.[28] 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.

Regression Results

Rural versus Urban Store Location—Rural and urban status of a county interacted significantly with time in weeks and therefore cannot be interpreted as significant on its own in our regression. Instead, model adjusted means are used to determine any significant outcomes. Model adjusted means for the entire period (1 Oct 2019–31 Dec 2022) do not show any significant differences between rural and urban county status (Table 2).

FEI Score—For the two food groups FVNLNA and FVNL all, an increase in the healthy access FEI component score was associated with a (p-value <0.000) and (p-value <0.000) percentage point increase, respectively, in the percent of total calories sold to SNAP shoppers coming from that food group (Table 3). An increase in the healthy access FEI score was also significantly associated with a decrease in the percent of calories sold to SNAP shoppers from SSB (p-value <0.000) (Table 3). 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 (p-value <0.000) (Table 3). A one point increase

in the socioeconomic FEI component score was found to be significantly associated with an increase in calories sold from SSB (p-value 0.002) (Table 3). No other food category was found to be significantly associated with FEI components.

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 FVNLNA, FVNL 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 and an increase in percentage of total calories sold to SNAP shoppers coming from PM (Table 3). 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 3).

Pre and Since the COVID-19 Pandemic—Since we did not find statistical difference between rural and urban settings, we looked at changes in sales to SNAP shoppers for the pre- and since-COVID periods across all stores. The model-adjusted outcomes show that all food categories significantly changed between the months of October 2019 to December 2019 (Pre the COVID-19 pandemic) and October 2020 to December 2020 (Since the COVID-19 pandemic) except for FVNLNA and FVNL all (see Supplemental Materials Figure 1b, 1c, 2b, and 2c). SSB, and JF sales were decreased during post COVID-19 pandemic onset compared to their pre COVID-19 pandemic estimated average share of total caloric sales (p-value <0.000 and <0.000 respectively) (Table 4) (see Supplemental Materials Figure 3b, 3c, 4b, and 4c). However, PM increased after the pandemic's onset compared to pre pandemic estimated average share of total caloric sales (p-value <0.000) (Table 4) (see Supplemental Materials Figure 5b and 5c). We also conducted stratified analyses for rural and urban stores separately and found consistent results (see Supplemental Table 2).

As a robustness check we used the share of sales based on volume (rather than calories) as a unit of measure in a sensitivity analysis. Results did not substantively differ in this analysis.

Discussion

SNAP is a major social support program that aims to mitigate the effects of food insecurity and provide nutrition security to its beneficiaries.[4,6,7] Though the SNAP program has proved to be effective in these areas under certain circumstances and in certain demographic groups, many participants still do not meet dietary recommendations.[8] The food environment has been found to affect diet-related disease risk, purchasing patterns, and quality of diet.[9.10] Rural food environments have presented challenges for food retailer success, food supply adequacy, and economic stability.[10,11] When evaluating the barriers to purchasing healthy foods, it is important to examine the intersection of SNAP participation and rural food environment. Therefore, 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 US Department of Agriculture definitions, were not significantly associated with any food category. Increases in the unhealthy access and the socioeconomic

status FEI component measures (meaning a more healthful environment) were associated with an increase in share of total calories from SSBs. An increase in the healthy access FEI component was associated with an increase in the share of total calories from FVNLNA and FVNL all, and a decrease in share of total calories from SSBs. Statistically significant changes associated with the societal shock of the COVID-19 pandemic were observed in the SSB, JF, and PM food categories.

These findings are slightly different from previous literature examining the nutritional quality of packaged food purchases bought by households in rural and urban settings.[30] This previous research found that low-income rural households bought less JF among other foods than low-income urban households.[29] 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.[30] More differences between rural and urban stores may have surfaced if a variety of retailer data was included since in-store environments were kept the same in our dataset.

The overall share of calories from SSB, JF, and PM categories were large compared to food categories like FVNLNA and FVNL 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.[31] They found that SNAP participating households' purchases across the US averaged 29.74% of total calories per person per day attributed to JF.[31] This is similar to our analysis (limited to North Carolina) that found 30.41% 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 13.25% and 13.22% of rural and urban (respectively) total calories per store per week from FVNL all.[31] 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 packaged food purchases from all retailers rather than loose and packaged 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 SBBs and JF 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 purchasing more fruits, vegetables, nuts, and legumes. 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 increased fruits and vegetable sales to SNAP participants regardless of where they live.[32] Although we could not include every product that is conducive to health, the stark differences in proportion of calories bought between FVNL categories and JF and SSB categories illustrates the importance of programs such as the Healthy Food Financing Initiative and the Gus Schumacher Nutrition Incentive Programs that support stocking

of healthier products and providing financial support to increasing fruits and vegetable purchasing.[33,34,35,36, 37]

It is unclear why there were associations between increases in each FEI[28] component measure and increases in share of calories from SSBs in our study. Since an increase in FEI[28] 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.[38] 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.[28] Further investigation into these measures as well as repeated analyses may clarify these findings. However, an increase in the healthy access FEI score was associated with an increase in share of total calories from FVNLNA and FVNL all, which did align with expectations. Results indicate that FEI score and its specifications may be more informative than simply using rural and urban indicators.

On COVID-19 pandemic related sale changes, we found that since the onset of the COVID-19 pandemic, there were significant decreases in the share of calories from 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 since pandemic related closures.[39] 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.[39] 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.[40] The self-reported study was[40] 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.[40] 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.

The transaction data we used was extremely robust spanning October 2019 to December 2020, before and since the onset of the COVID-19 pandemic. The data is also objective data that came from a chain grocery store that is among the most popular grocery stores in North Carolina.[41] 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 and was based on its total sales data, so we could not capture all the purchases made by SNAP participants who may do additional grocery shopping elsewhere. While this analysis is unable to directly account for potential changes in stocking or food options available across store locations, we included store random effects and other time-varying store-level characteristics. Finally, our data only captures sales and do not reflect dietary intake and therefore cannot strongly reflect population level diet changes.

Implications for Research and Practice

As evidenced by existing literature, SNAP incentive programs may be a useful strategy in improving the purchase composition of SNAP shopper sales. Lack of results concerning rural and urban status and presence of significant associations in FEI results may indicate that future studies should use nuanced definitions that can account for differences in rural and urban environments instead of a simple binary urban/rural measures. Exploring different rural and urban definitions other than the USDA definition may also yield new results. There are currently few datasets available for research that can accurately capture sales before and since the COVID-19 pandemic, so this data is important to addressing that gap in the literature. The 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. In the case of protective measures against catastrophes or emergency situations like the COVID-19 pandemic, more support is needed to ensure healthy food access through policies aimed at increasing resiliency in the food supply chain. The COVID-19 pandemic has exposed many of the fragilities of our current food system and environments and how they are unable to support healthier diets among the most vulnerable.[42] It is possible to learn from the experience through the COVID-19 pandemic towards updating existing programs and policies to better achieve the USDA’s goal of improving nutrition security.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Chain Grocery Store Characteristics and North Carolina County Food Environment and Demographic Breakdown by Rural/Urban Status

Characteristic	Rural[a] (SD)	Urban[b] (SD)
Total Population (in 2020)	N=2,089,997	N=8,163,122
Age		
0–5y	6.8%	7.0%
6–19y	17.1%	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	43.3%	32.3%
Some College	36.8%	33.2%
Bachelor's Degree	13.7%	23.1%
Greater than a Bachelor's Degree	6.2%	11.4%
Race		
White	68.4%	70.5%
Black	23.9%	22.1%
Asian	1.1%	3.4%
American Indian or Alaska Native	4.3%	1.1%
Other Race	2.3%	2.7%
Mean Food Environment Index [c]		
Unhealthy Access[d]	0.6	−0.3
Socioeconomic Status[e]	0.1	−0.05
Healthy Access[f]	−0.04	−0.2
Hispanic Ethnicity	9.2%	11.3%
Unemployment	7.6%	7.4%
Sex		
Male	49.2%	48.4%
Female	50.7%	51.6%
Participating Retailer's Store Level Characteristics		
Percent of total transactions that involve SNAP	26.3%	24.4%
Percent of total loyalty cards that make purchases with SNAP	24.6%	23%
Mean (SD) Number of SNAP transactions per shopper per week	1.5 (0.1)	1.5 (0.1)
Mean (SD) Number of NonSNAP transactions per shopper per week	1.3 (0.09)	1.4 (0.07)
Mean Number of participating retailer's stores per County	2.3	8.1

Characteristic	Rural[a] (SD)	Urban[b] (SD)
Number of participating retailer's stores per 10,000	0.6	0.5

[a]Rural is defined as any county that does not fulfil standards specified in Urban definition.

[b]Urban is defined by the USDA as metropolitan. This includes central counties where at least 50% of the population resides within urban areas of 10,000 or more population or contain at least 5,000 people residing within a single urban area of 10,000 or more population and Metro/Micro Statistical Areas if they meet specified requirements of commuting to or from the central counties.

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

[d]The Unhealthy Access FEI component is calculated based on a county's percentage of lack of car access, number of convenience stores per 10,000, and number of SNAP eligible stores per 10,000 population

[e]The Socioeconomic Status FEI component is calculated based on a county's 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

[f]The Healthy Access FEI component is calculated based on a county's number of grocery stores, full service restaurants, and farmer's markets per 10,000.

Table 2.

Model[a] adjusted Mean Share of Calories by Food Category and Rural/Urban Status

Food Category	Rural (95% CI)	Urban (95%CI)
Fruits, Vegetables, Nuts, and Legumes without Additives[b]	8.06% (7.96,8.16)	8.06% (8.01,8.12)
All Fruits, Vegetables, Nuts, and Legumes with and without Additives[b]	13.25% (13.06,13.45)	13.22% (13.13,13.31)
Sugar Sweetened Beverages	9.25% (8.98,9.50)	9.74% (9.62,9.86)
Junk Food[**]	30.41% (30.19,30.62)	30.45% (30.35,30.56)
Processed Meats and Processed Seafood	5.72% (5.63, 5.82)	5.63% (5.59, 5.67)

[**] Association of these food categories with rural status was statistically significant ($p<0.05$ based on a two-tailed $\alpha = 0.05$) according to our linear regression model (See Table 3).

[a] The model used was a linear regression with random effects and robust standard errors to account for clustering and repeated measures at the store level using data from 1 Oct 2019 through 31 Dec 2020. Models controlled variables included in Table 3.

[b] Additives refer to any salt, sugar, or fats that work to preserve or flavor food.

Table 3.

Primary Model[a] Outcomes and County Level Characteristics (n=32,183)

	Outcomes				
	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)**
Urban/Rural Status					
Urban*	-	-	-	-	-
Rural[f]	−0.03 (−0.20,0.14)	0.02 (−0.28,0.31)	−0.20 (−0.64,0.25)	−0.52** (−0.88,−0.15)	0.11 (−0.04,0.26)
Week indicators	Included but not reported; available upon request				
Rural and Week Interactions	Included but not reported; available upon request				
Food Environment Index[b]					
Unhealthy Access[c]	0.10 (−0.05,0.25)	0.26 (−0.03,0.55)	0.87** (0.42,1.31)	−0.19 (−0.50,0.12)	−0.10 (−0.24,0.05)
Healthy Access[d]	0.24** (0.13,0.34)	0.41** (0.21,0.61)	−1.01** (−1.29,−0.73)	0.00 (−0.19,0.19)	0.01 (−0.08,0.10)
Socioeconomic Status[e]	−0.09 (−0.69,0.52)	−0.13 (−1.25,0.98)	2.68** (0.99,4.36)	−0.84 (−2.11,0.44)	−0.59 (−1.23,0.05)
Age Breakdown					
Ages 1–5*	-	-	-	-	-
Ages 6–19	0.06 (−0.02,0.14)	0.11 (−0.03,0.25)	−0.03 (−0.26,0.19)	0.01 (−0.13,0.15)	0.01 (−0.07,0.08)
Ages 20–34	0.11** (0.05,0.17)	0.20** (0.09,0.31)	0.19** (0.03,0.36)	-0.01 (−0.12,0.09)	-0.03 (−0.08,0.03)
Ages 35–54	0.13** (0.06,0.20)	0.24** (0.12,0.36)	0.17 (−0.04,0.39)	−0.05 (−0.18,0.08)	−0.06 (−0.13,0.00)
Ages 55–64	0.03 (−0.04,0.10)	0.04 (−0.09,0.16)	0.04 (−0.13,0.21)	0.03 (−0.10,0.16)	0.08** (0.02,0.14)
Ages 65+	0.13** (0.07,0.19)	0.24** (0.12,0.36)	0.09 (−0.10,0.27)	−0.01 (−0.13,0.10)	−0.04 (−0.11,0.02)
Employment					
Unemployment Rate	−0.12** (−0.19,−0.05)	−0.25** (−0.38,−0.12)	−0.07 (−0.26,0.11)	0.02 (−0.14,0.18)	0.04 (−0.03,0.11)
Sex					
Male*	-	-	-	-	-
Female	−0.02 (−0.06,0.02)	−0.04 (−0.11,0.03)	0.22** (0.12,0.32)	−0.01 (−0.08,0.07)	−0.06** (−0.09,−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 (−0.03,0.08)	0.03 (−0.00,0.06)	−0.02** (−0.04,−0.01)

	Outcomes				
	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)**
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)	−0.01 (−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 ** (0.03,0.09)	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 (−0.45,−0.02)	−0.09 (−0.26,0.08)	−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 (−0.11,0.05)	−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)	0.02 (−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	0.16 (−0.41,0.72)	0.30 (−0.68,1.28)	0.45 (−0.32,1.22)	−0.39 (−1.63,0.85)	−0.44 (−0.98,0.09)
Mean Number of NonSNAP transactions	0.93 ** (0.15,1.71)	1.35 ** (0.06,2.64)	−0.87 (−2.01,0.28)	0.60 (−1.12,2.32)	0.72 ** (0.17,1.27)

* Eliminated due to collinearity

** Statistically significant ($p<0.05$ based on two-tailed $\alpha = 0.05$)

[a] The model used was a linear regression with random effects and robust standard errors to account for clustering and repeated measures at the store level.

[b] The Food Environment Index (FEI) factors indicate 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.

[c] The Unhealthy Access FEI component is calculated based on a county's percentage of lack of car access, number of convenience stores per 10,000, and number of SNAP eligible stores per 10,000 population

[d] The Healthy Access FEI component is calculated based on a county's number of grocery stores, full service restaurants, and farmer's markets per 10,000.

[e] The Socioeconomic Status FEI component is calculated based on a county's 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

[f] Urban/Rural status of a county and its association with outcome measures is not considered significant since it interacts significantly with time in weeks.

Table 4.

Pre and Post COVID-19 pandemic Differences of Model[a] adjusted Means by Share of Total Calories by Food Category

Food Category	Pre COVID[b] (95% CI)	Post COVID[c] (95% CI)	Difference (95% CI)
Fruits, Vegetables, Nuts, and Legumes without Additives	8.27% (8.23,8.32)	8.27% (8.23,8.31)	−0.00% (−0.03,0.03)
All Fruits, Vegetables, Nuts, and Legumes with and without Additives	13.56% (13.48,13.6 4)	13.52% (13.45,13.5 9)	−0.04% (−0.09,0.01)
Sugar Sweetened Beverages	9.58% (9.48,9.67)	9.24% (9.15,9.32)	−0.34% ** (−0.38, −0.30)
Junk Food	31.17% (31.09,31.2 6)	29.73% (29.65,29.8 0)	−1.44% ** (−1.50, −1.40)
Processed Meats and Seafood	5.45% (5.42,5.48)	5.53% (5.50,5.56)	0.08% ** (0.06,0.10)

** Statistically significant ($p<0.05$ based on a two-tailed $\alpha = 0.05$)

[a] The model used was a linear regression with random effects and robust standard errors to account for clustering and repeated measures at the store level using data from 1 Oct 2019 through 31 Dec 2020. Models controlled variables included in Table 3.

[b] Predicted outcomes limited to the 13 weeks pre-Covid from 1 Oct 2019 through 31 Dec 2019.

[c] Predicted outcomes limited to the 13 weeks post-Covid from 1 Oct 2020 through 31 Dec 2020.