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Original Research

Evaluating the association between fruit and vegetable consumption and chronic disease prevalence among food pantry users in the northeastern United States

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Abstract:

Introduction: Fruit and vegetable (FV) consumption can be a protective factor for chronic diseases, but few studies have investigated the association between FV consumption and health risks for chronic disease in the context of the food and nutrition assistance system. The aim of this study was to assess the association between FV consumption and the prevalence of hypertension, type 2 diabetes mellitus, and body mass index (BMI) among food pantry users in small- to mid-sized metropolitan communities in the northeastern United States.

Methods: We used data from three health surveys conducted among residents of communities in upstate New York to construct a predictive model of food pantry use. We then applied the model to a regional subset of SMART Behavioral Risk Factor Surveillance System (BRFSS) data collected in the northeastern United States to identify potential food pantry users. We examined the associations between FV intake and diabetes, hypertension, and BMI through univariate and multivariate logistic and linear regressions. Additionally, we investigated food pantry use as a potential modifier of these associations.

Results: The analysis dataset included 5,257 respondents, of which 634 individuals (12.06%) were estimated to be food pantry users. Vegetables consumption was associated with decreased odds of hypertension and lower BMI, regardless of food pantry use. Fruits consumption was associated with decreased odds of diabetes regardless of food pantry use. The association between fruit consumption and BMI was modified by the use of food pantry. Among food pantry users, consumption of fruits was associated with a higher BMI, while among food pantry non-users, it was associated with a lower BMI.

Conclusion: The overall protective effect of increased FV consumption on chronic disease risks suggest that increasing FV availability in food pantries may not only alleviate hunger but also contribute to better health. Further research is needed to elucidate what is driving the discrepant association between fruit consumption and BMI among food pantry users and non-users.

Keywords: Nutritional epidemiology, Health behavior, Food assistance, Food pantry, Hypertension, BMI

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Introduction

Chronic diseases such as hypertension, diabetes and obesity impose considerable burdens on people and healthcare systems in the US [1] and around the globe [2]. While these chronic diseases have multiple causal pathways and risk factors [3-6], there are also protective factors. Consumption of fruits and vegetables (FVs) is one of the protective factors that are associated with improved blood pressure, lower glycated hemoglobin (A1C), and body mass index (BMI) [7-11]. The levels of FV consumption, however, vary across the US population [12]. Individuals who are food insecure (i.e., those who experience a household-level economic and social condition of limited or uncertain access to adequate food [13]), typically consume fewer amounts of FVs and have a higher prevalence of chronic diseases compared to people who are food secure [14].

Food pantries were initially created to provide temporary nutritional relief to individuals experiencing food insecurity, but they have become an integral part of providing people in need with permanent access to high-quality nutritious food [15, 16]. Interventions to increase the availability of FVs in food pantries have shown improvements in some dietary and health behaviors among their clients [17, 18]. However, more evidence is needed to show that increasing FV consumption in the context of the food and nutrition assistance system can improve the outcomes of chronic diseases. A scarcity of large population-based health datasets with information on food pantry usage and health outcomes has been a primary obstacle to conduct research in this area.

This study seeks to address these research gaps by utilizing multiple existing datasets. By developing and applying predictive models, we identified potential food pantry users and enabled the use of regionally representative health data for analysis. The objective of this study is to assess the association between FV consumption and the prevalence of chronic diseases among potential food pantry users in small- to mid-sized metropolitan communities in the northeastern United States. The information obtained from this study will inform regional nutrition and public health professionals about the potential health benefits of increased FV availability in food pantries.

Methods

The study followed a cross-sectional design. The target population is residents aged 18 or older in small- to mid-sized metropolitan communities in the northeastern United States who have access to a telephone and speak either English or Spanish.

Study community

The study community consists of five small to mid-sized Metropolitan Statistical Areas (MSAs) in the northeastern US. Specifically, the Albany-Schenectady-Troy MSA, the Buffalo-Cheektowaga MSA, the Rochester MSA in New York State (NYS), the Burlington-South Burlington MSA in Vermont, and the Springfield MSA in Massachusetts. These MSAs were selected based on urbanicity and location (small- to mid-sized cities in northeaster US), population size (200,000 to 1,200,000), climate and vegetation (USDA plant hardiness zone 4 or 5), and availability of SMART Behavioral Risk Factor Surveillance System (BRFSS) data. SMART BRFSS is a project by the Centers for Disease Control and Prevention to compile BRFSS telephone health survey data for MSAs and other types of metropolitan divisions with at least 500 completed interviews [19]. Participants were selected for analysis (N=5,454) if they completed the fruit and vegetable (FV) consumption questionnaire, reported their medical history of two chronic diseases (hypertension and type 2 diabetes mellitus), and provided their weight, height, and demographic information. Participants with missing information for these variables were excluded from analysis (N=197). Figure 1 shows the locations of the five selected MSAs.

Food pantry user predictive model analysis

The BRFSS surveys, from which the main data in this study were drawn, do not collect information on food pantry use. Therefore, we built a predictive model for food pantry use by using three existing survey data sets from communities of upstate New York State. In 2014, we conducted an in-person health interview survey called UMatter Schenectady (UMS) in Schenectady County [20]. In 2020-2021, we conducted another two surveys: the Food Access Survey 1 (FAS-1) and the Food Access Survey 2 (FAS-2), which were online surveys of residents in 11 New York State counties [21]. FAS-2 was implemented to augment representations of low-income racial/ethnic minorities and rural residents in our research on food access, and it was conducted partially concurrently with FAS-1. These three data sets contained comparable demographic and spatial data, as well as information on food pantry usage collected from English- or Spanish-speaking adults aged 18 and older. From these three surveys, we selected participants who were aged 18 or older and provided information on food pantry use and demographics. The sample sizes of UMS, FAS-1, and FAS-2 were 2,234, 595 and 454, respectively. From these three datasets, demographic and spatial variables, along with food pantry use status were extracted for further analysis. Participants with missing values for these variables (N = 56) were excluded from future analysis such as model building. Table 1 describes the characteristics of the survey data in this study, and Figure 1 shows the locations of the survey communities.

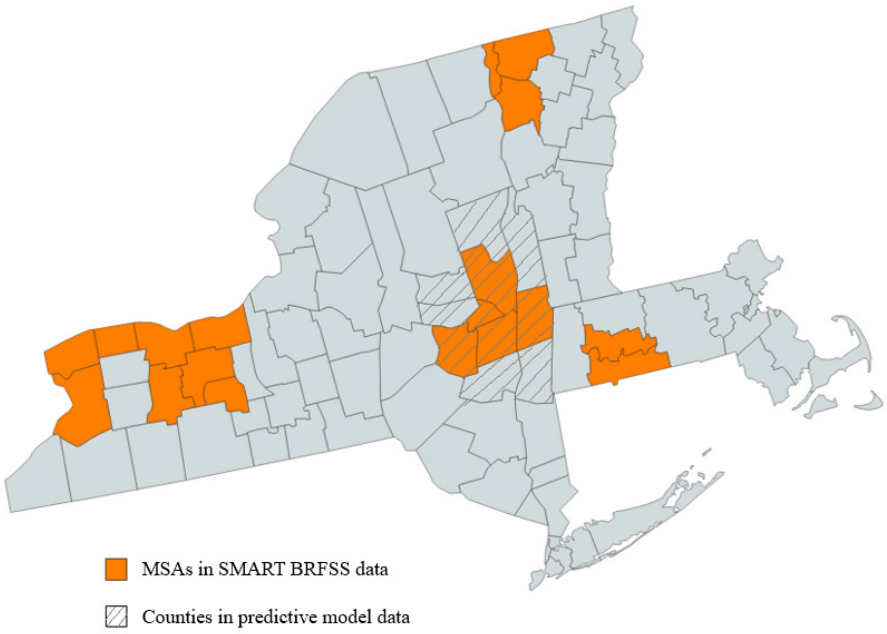

Figure 1. Five Metropolitan Statistical Areas (MSAs) included in the SMART BRFSS dataset and New York State counties where data for the predictive model were collected

Table 1. Characteristics of the survey datasets used in this study

Dataset	Year	Sample size	Geographic coverage	Variable Availability			
				Fruit & vegetable	Chronic diseases	Food pantry	Demo-graphics
UMS	2014	2,234	1 county in NY	Limited (1question)	Yes	Yes	Yes
FAS-1	2020-2021	595	11 counties in NY	Yes (2 questions)	No	Yes	Yes
FAS-2	2021	454	11 counties in NY	Yes (2 questions)	No	Yes	Yes
SMART BRFSS	2015	5,454	3 MSAs in NY, 1 MSA in VT 1 MSA in MA	Yes (6 questions)	Yes	No	Yes

We combined the three data sets and constructed a multivariable logistic regression model for food pantry use. Predictor variables were several demographic and spatial variables commonly shared across these datasets and SMART BRFSS. We converted the county variable into a 6-level urbanicity variable derived from the NCHS Urban-Rural Classification Scheme for Counties [22].

We applied a backward-deletion strategy and used the Akaike Information Criterion (AIC), likelihood ratio tests, and the receiver operating characteristic (ROC) curve to examine the model fit. The final model contained education, race/ethnicity, household income and urbanization scale as predictors. The output of the predictive model had a value from 0 to 1. To find the optimal cut-point to identify food pantry users, we employed Youden's J statistic based on the ROC curve. The optimal cut-point is the threshold that maximizes the distance to the identity line, which is also the point at which the sum of sensitivity and specificity is maximized.

SMART BRFSS associative model analysis

We conducted analyses to assess the associations between FV consumption and three indicators of chronic disease and to examine whether food pantry use would modify the associations. We obtained the 2015 SMART BRFSS data subsets for the Albany-Schenectady-Troy, Buffalo-Cheektowaga, Rochester, Burlington-South Burlington, and Springfield MSAs. In all BRFSS surveys,

the fruit and vegetable questions were asked in odd years. We selected the data in 2015 because it was the last and most recent year of data collection in which vegetable consumption was assessed by nutrient groups.

Fruit consumption was measured by two questions asking about the times that 100% fruit juice and fruits were taken in the last 30 days. Vegetable consumption was measured by four questions asking about the times that beans, dark green vegetables, orange-colored vegetables and other vegetables including 100% vegetable juice were taken in the last 30 days. All forms of fruits and vegetables, whether cooked or raw, fresh, frozen or canned, were considered. After determining the frequency of FV consumption, we used the linear regression model developed by Moore et al. to estimate the daily amount consumed in cups [23]. This model included age, gender, race/ethnicity and poverty-income ratio as factors to estimate FV consumption in cups. In the model of unit conversion, age and gender served as effect modifiers, while other variables acted as predictors.

The outcomes of chronic diseases hypertension and diabetes, are both based on self-reported diagnosis (yes/no), and BMI (kg/m^2) which was computed using self-reported height and weight. We estimated food pantry use by applying the prediction model described in the previous section. We constructed logistic regression models for diabetes and hypertension, and linear regression models for BMI, with fruit and vegetable consumption separately. We included age groups, gender, employment status, physical activity, smoking and alcohol consumption as covariates in the initial models. The categorization of covariates was consistent with that used in the SMART BRFSS subset [19]. To avoid overadjustment, we excluded the variables that were used as predictors in the prediction model for food pantry use [24].

We employed a backward-deletion strategy to incrementally exclude covariates with large p-values ($p > 0.05$). We used the interaction terms "food pantry use * vegetable consumption" and "food pantry use * fruit intake" to examine a potential effect modification of food pantry use. When a significant ($p < 0.05$) effect modification was detected, we stratified the health effects of FV consumption for food pantry users and non-users. The level of significance we applied to all our analyses was 0.05.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving study participants were approved by the University at Albany Institutional Review Board.

Results

In the predictive model analysis, 3,227 complete cases were included in the combined data set (Table S1). Low education level, being a racial/ethnic minority, living in areas with higher levels of urbanization, having lower household incomes or not responding to the income question were positively associated with food pantry use. The optimal cut-point of the ROC curve was 0.177.

Equation 1

$$\text{Logit}(FPuse) = -2.05 + \beta_1 \times Education + \beta_2 \times RaceEth + \beta_3 \times Income + \beta_4 \times NCHS$$

Whereas β_1 to β_4 indicate beta estimates. indicates educational levels, indicates categories of race and ethnicity, indicates income categories, and indicates NCHS urbanization scales. The values of beta estimates are presented in Table S2.

The analysis dataset of SMART BRFSS included 5,257 respondents. When we applied the prediction model to the dataset, 634 individuals (12.1%) were identified as potential food pantry users. The demographic characteristics of SMART BRFSS respondents are described in Table 2. Briefly, 68.3% were working-age adults (age < 65 years), 57.6% were women, and 85.8% were non-Hispanic whites. Over 40% of the participants held a college degree or higher, 44.9% had an annual household income over $50,000, and 52.7% were employed.

In the associative model analysis, we found that food pantry use did not modify the effect of fruit and vegetable (FV) consumption on hypertension or diabetes. According to the covariate-adjusted final models, fruit consumption was not associated with the prevalence of hypertension. However, consuming an additional cup of vegetables daily was associated with a 21% reduction in the odds of hypertension (OR: 0.79), regardless of food pantry use (Table 3). As for diabetes, increasing fruit consumption by one cup per day was associated with a 17% reduction in the odds of self-reported diabetes (OR: 0.83). Conversely, vegetable consumption was neither positively nor negatively associated with the odds of diabetes.

We observed that food pantry use modified the effect of fruit consumption on continuous BMI. In the covariate-adjusted final models, consuming an additional cup of fruit daily was associated with a BMI increase of 1.09 kg/m^2 among food pantry users, whereas it was associated with a BMI decrease of 0.40 kg/m^2 among non-users. Vegetable consumption consistently had a protective effect on BMI across all groups. Increasing daily vegetable consumption by one cup was associated with a BMI reduction of 0.6 kg/m^2 in the final model, regardless of food pantry use.

Discussion

This study aimed to investigate the association between fruit and vegetable (FV) consumption and chronic disease outcomes among individuals receiving food assistance, using a large, regionally representative health survey dataset. Food pantry use was estimated by applying a prediction model constructed from three community

Table 2. Characteristics of the analysis dataset of SMART BRFSS (N = 5,257)

Characteristic		N	%
Age (years)	18-34	811	15.4
	35-54	1,527	29.0
	55-64	1,252	23.8
	65 and older	1,667	31.7
Gender	Male	2,227	42.4
	Female	3,030	57.6
Race/Ethnicity	Hispanic	242	4.6
	Black, not Hispanic	268	5.1
	White, not Hispanic	4,511	85.8
	Asian	91	1.7
	Multiple Races/Other	145	2.8
Education	High school or less	1,718	32.7
	Some college or Associate degree	1,319	25.1
	College degree or advanced	2,220	42.2
Household Income	Less than $10,000	195	3.7
	$10,000 - 49,999	1,851	35.2
	$50,000 or more	2,361	44.9
	Unreported	850	16.2
Employment	Employed	2,771	52.7
	Unemployed	243	4.6
	Not in the labor force	2,242	42.6
MSA	Albany-Schenectady-Troy, NY	888	16.9
	Rochester, NY	756	14.4
	Buffalo-Niagara Falls, NY	722	13.7
	Burlington, VT	1,746	33.2
	Springfield, MA	1.145	21.8
Food pantry use (estimated)	Yes	634	12.1
	No	4,623	87.9

Table 3. Multivariable logistic regression models for hypertension and diabetes

		Hypertension OR (95% CI)[a]	Diabetes OR (95% CI)
Daily Fruit Consumption (Cup)	Crude Model	Crude Model	0.83 (0.70, 0.99)
	Final Model[b]	Final Model[b]	0.83 (0.69, 0.99)
Daily Vegetable Consumption (Cup)	Crude Model	Crude Model	0.59 (0.49, 0.70)
	Final Model[b]	Final Model[b]	0.92 (0.76, 1.09)

a. 95% CI not including reference value (1.0) indicates significant association ($p < 0.05$).
b. Final model is adjusted for age groups, smoking status, alcohol consumption and physical activity.

Table 4. Multivariable linear regression models for BMI (kg/m²)

		BMI: Food Pantry Users Beta (95% CI)[a]	BMI: Food Pantry Non-users Beta (95% CI)[a]
Daily Fruit Consumption (Cup)	Crude Model	1.00 (0.22, 1.78)	-0.49 (-0.80, -0.17)
	Final Modelb	1.09 (0.32, 1.86)	-0.40 (-0.72, -0.08)
		BMI: All Respondents Beta (95% CI)[a]	
Daily Vegetable Consumption (Cup)	Crude Model	-0.92 (-1.18, -0.66)	
	Final Modelb	-0.60 (-0.87, -0.32)	

a. 95% CI not including reference value (0) indicates significant association ($p < 0.05$).
b. Final model is adjusted for age groups, smoking status, alcohol consumption and physical activity.

survey datasets from the same region. Among 5,257 participants, the proportion of food pantry users (12.1%) was very close to the estimated percentage of American households experiencing food insecurity in 2015 (12.5%) [25].

Overall, this study found that FV consumption has a protective association with chronic disease outcomes. Increasing daily consumption of fruit or vegetables by one cup was associated with decreasing odds of diabetes or hypertension and decreasing BMI. These findings are consistent with previous studies that have focused on various regional populations in the US [7-10].

This study also found that food pantry use did not modify the association between FV consumption and chronic diseases, with the exception of the association between fruit consumption and BMI. The association between fruit consumption and increasing BMI among FP users has not been reported elsewhere. Additional investigation revealed that food pantry users had a higher BMI (Mean 30.07 kg/m², SD 8.19 kg/m²) compared to food pantry non-users (Mean 27.48 kg/m², SD 5.86 kg/m²), and the t-test comparing the means of the two groups yielded a significant difference ($p < 0.001$). Additionally, food pantry users had a lower amount of total daily fruit consumption (1.30 cups vs 1.51 cups), but a higher consumption of 100% fruit juice (0.51 cup vs 0.37 cup) compared to food pantry non-users. Although 100% fruit juice may contain as much sugar as a regular soft drink, there is no conclusive evidence that 100% fruit juice increases BMI in US adults [26]. It is also argued that 100% fruit juice provides important vitamins, minerals and dietary bioactives that contribute to overall health [27]. Further investigation on the association between fruit consumption and BMI in food pantry users is warranted.

This study has several strengths. First, it utilized regionally representative data with a large sample size. Second, interaction terms were added in building the associative model to assess effect modification. This approach avoids the loss of analytical power that can occur when data are divided and analyzed separately. Third, to the best of our knowledge, this study is the first to evaluate the association between FV consumption and risks of chronic diseases within the context of a food/nutrition assistance system among residents of northeastern United States.

This study is not without limitations. First, the use of variables created by regression model, such as food pantry use and daily FV consumptions in cups, can introduce Berkson bias [28], a random error that reduces statistical power. However, the sample size for the associative model analysis (5,227) was large enough to overcome the reduction in statistical power that may have been introduced by Berkson bias. Second, in the model for predicting food pantry use, the model included only demographic variables and urbanicity scales. Adding variables such as participation in the Food and Nutrition Assistance Program (SNAP) and use of group meal sites would significantly improve the fit of the overall prediction model [29]. However, this was not feasible because SMART BRFSS does not collect such information. Third, because there are no eligibility criteria or membership registration requirements for food pantry use, the term "food pantry users" is a fluid concept. Finally, the cross-sectional design prevents the establishment of causality between FV intake and chronic disease risks.

The implications of this study for public health and policy are substantial, particularly in the context of food assistance programs. Although fruit consumption is associated with a small increase in BMI among food pantry users, the overall health benefits of increasing FV consumption are much greater. FVs provided by FPs represent an important way to alleviate hunger and food insecurity while also contributing to better health among FP users. This study provides valuable information that could help FPs prioritize and promote FV donations by highlighting the potential health benefits of increased FV consumption. With a clear understanding of these benefits, FPs can be more effectively strategic in their efforts to not only meet immediate nutritional needs, but also to improve the long-term health of their clients. The information provided by this study approach could be helpful in policy making, where increasing support and funding for food assistance programs could have enhanced health impacts and improved the well-being of food-insecure populations.

Conclusion

This study highlights the association between FV consumption and chronic disease risks among participants receiving food assistance and living in small- to mid-sized metropolitan communities in the northeastern United States. Given the overall beneficial impacts of increased FV consumption among individuals receiving food assistance, FPs should consider increasing the availability of FVs. This could contribute to improved health outcomes and help alleviate hunger. Further research is needed to understand the varying impacts of fruit consumption on BMI between FP users and non-users.

Author contributions

J.C. analyzed the data and wrote the article. A.S.H. designed the study and co-wrote the article. B.F. is the principal investigator for the FAS-1 and FAS-2 data collections. T.O., B.F., and X.X.R. participated in constructive criticism and co-wrote the article.

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Conflict of interest

The authors declare no conflict of interest.

Institutional review board statement

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving study participants were approved by the Institutional Review Board.

Informed consent statement

Informed consent has been obtained from all subjects participating in the study.

Supplementary material

The supplementary tables (Table S1, Table S2) mentioned in this research are available at https://file.luminescience.cn/FNDS-267%20Supplementary%20material.pdf.

Reference

[1] Druss BG, Marcus SC, Olfson M, Tanielian T, Elinson L, Pincus HA. Comparing the national economic burden of five chronic conditions. *Health Affairs*. 2001; 20(6): 233-41. doi: 10.1377/hlthaff.20.6.233.

[2] Forouzanfar MH, Afshin A, Alexander LT, Anderson HR, Bhutta ZA, Biryukov S, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*. 2016; 388(10053): 1659-724. doi:10.1016/S0140-6736(16)31679-8.

[3] Ahmed S, Dupuis V, Tyron M, Running Crane M, Garvin T, Pierre M, et al. Intended and Unintended Consequences of a Community-Based Fresh Fruit and Vegetable Dietary Intervention on the Flathead Reservation of the Confederated Salish and Kootenai Tribes. *Front Public Health*. 2020; 8:331. doi: 10.3389/fpubh.2020.00331.

[4] Diaz KM, Shimbo D. Physical activity and the prevention of hypertension. *Current Hypertension Reports*. 2013; 15(6): 659-68. doi: 10.1007/s11906-013-0386-8.

[5] Kington RS, Smith JP. Socioeconomic status and racial and ethnic differences in functional status associated with chronic diseases. *American Journal of Public Health*. 1997; 87(5): 805-10. doi: 10.2105/ajph.87.5.805.

[6] Naber T, Purohit S. Chronic Kidney Disease: Role of Diet for a Reduction in the Severity of the Disease. *Nutrients*. 2021; 13(9): 3277. doi: 10.3390/nu13093277.

[7] Bryce R, Guajardo C, Ilarraza D, Milgrom N, Pike D, Savoie K, et al. Participation in a farmers' market fruit and vegetable prescription program at a federally qualified health center improves hemoglobin A1C in low income uncontrolled diabetics. *Preventive Medicine Reports*. 2017; 7:176-9. doi: 10.1016/j.pmedr.2017.06.006.

[8] Cavanagh M, Jurkowski J, Bozlak C, Hastings J, Klein A. Veggie Rx: an outcome evaluation of a healthy food incentive programme. *Public Health Nutrition*. 2017; 20(14): 2636-41. doi: 10.1017/S1368980016002081.

[9] Chan Q, Stamler J, Brown IJ, Daviglus ML, Van Horn L, Dyer AR, et al. Relation of raw and cooked vegetable consumption to blood pressure: the INTERMAP Study. *Journal of Human Hypertension*. 2014; 28(6): 353-9. doi: 10.1038/jhh.2013.115.

[10] Bryce R, WolfsonBryce JA, CohenBryce A, Milgrom N, Garcia D, Steele A, et al. A pilot randomized controlled trial of a fruit and vegetable prescription program at a federally qualified health center in low income uncontrolled diabetics. *Preventive Medicine Reports*. 2021; 23:101410. doi: 10.1016/j.pmedr.2021.101410.

[11] Demark-Wahnefried W, Clipp EC, Lipkus IM, Lobach D, Snyder DC, Sloane R, et al. Main outcomes of the FRESH START trial: a sequentially tailored, diet and exercise mailed print intervention

among breast and prostate cancer survivors. *Journal of Clinical Oncology*. 2007; 25(19): 2709-18. doi: 10.1200/JCO.2007.10.7094.

[12] Lee-Kwan SH, Moore LV, Blanck HM, Harris DM, Galuska D. Disparities in State-Specific Adult Fruit and Vegetable Consumption — United States, 2015. *MMWR Morbidity and Mortality Weekly Report*. 2017; 66(45): 1241-7. doi: 10.15585/mmwr.mm6645a1.

[13] USDA E. *Definitions of Food Security* [Internet]. Available from: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/definitions-of-food-security/ [Accessed 5th August 2024].

[14] Seligman HK, Laraia BA, Kushel MB. Food Insecurity Is Associated with Chronic Disease among Low-Income NHANES Participants. *The Journal of Nutrition*. 2010; 140(2): 304-10. doi: 10.3945/jn.109.112573.

[15] Mabli J, Jones D, Kaufman P. Characterizing Food Access in America: Considering the Role of Emergency Food Pantries in Areas without Supermarkets. *Journal of Hunger & Environmental Nutrition*. 2013; 8(3): 310-23. doi: 10.1080/19320248.2013.786663.

[16] Racine EF, Batada A, Solomon CA, Story M. Availability of Foods and Beverages in Supplemental Nutrition Assistance Program−Authorized Dollar Stores in a Region of North Carolina. *Journal of the Academy of Nutrition and Dietetics*. 2016; 116(10): 1613-20. doi: 10.1016/j.jand.2016.03.014.

[17] Eicher-Miller HA. A review of the food security, diet and health outcomes of food pantry clients and the potential for their improvement through food pantry interventions in the United States. *Physiology & Behavior*. 2020; 220: 112871. doi: 10.1016/j.physbeh.2020.112871.

[18] Ippolito MM, Lyles CR, Prendergast K, Marshall MB, Waxman E, Seligman HK. Food insecurity and diabetes self-management among food pantry clients. *Public Health Nutrition*. 2017; 20(1): 183-9. doi: 10.1017/S1368980016001786.

[19] Pickens CM. Surveillance for Certain Health Behaviors and Conditions Among States and Selected Local Areas — Behavioral Risk Factor Surveillance System, United States, 2015. *Surveill Summaries*. 2018; 67(9): 1-90. Available from: https://www.cdc.gov/mmwr/volumes/67/ss/ss6709a1.htm [Accessed 23th July 2024].

[20] Hosler AS, Michaels IsaacH, Buckenmeyer EM. Food Shopping Venues, Neighborhood Food Environment, and Body Mass Index Among Guyanese, Black, and White Adults in an Urban Community in the US. *Journal of Nutrition Education and Behavior*. 2016; 48(6): 361-368.e1. doi: 10.1016/j.jneb.2016.03.003.

[21] Feingold B, Arroyo MT, Hosler A, Craft T, Myo HWL, Bozlak C, et al. Impacts of the First Year of COVID-19 on Food Security in the New York's Capital Region. *Environmental Health Sciences Faculty Scholarship*. 2021. Available from: https://scholarsarchive.library.albany.edu/ehs_fac_scholar/5 [Accessed 3rd April 2023].

[22] Ingram DD, Franco SJ. 2013 NCHS Urban-rural Classification Scheme for Counties. National Center for Health Statistics. *Vital and Health Statistics*. 2014; Series 2, Number 166: 88. Availble at: https://www.cdc.gov/nchs/data/series/sr_02/sr02_166.pdf [Accessed 6th September 2023].

[23] Moore LV, Dodd KW, Thompson FE, Grimm KA, Kim SA, Scanlon KS. Using Behavioral Risk Factor Surveillance System Data to Estimate the Percentage of the Population Meeting US Department of Agriculture Food Patterns Fruit and Vegetable Intake Recommendations. *American Journal of Epidemiology*. 2015; 181(12): 979-88. doi: 10.1093/aje/kwu461.

[24] Schisterman EF, Cole SR, Platt RW. Overadjustment Bias and Unnecessary Adjustment in Epidemiologic Studies. *Epidemiology*. 2009; 20(4): 488-95. doi: 10.1097/EDE.0b013e3181a819a1.

[25] Coleman-Jensen A. *Household Food Security in the United States in 2015*. 2015; Available from: https://www.ers.usda.gov/webdocs/publications/79761/err-215.pdf [Accessed 3rd April 2024].

[26] Auerbach BJ, Littman AJ, Tinker L, Larson J, Krieger J, Young B, et al. Associations of 100% fruit juice versus whole fruit with hypertension and diabetes risk in postmenopausal women: Results from the Women's Health Initiative. *Preventive Medicine*. 2017;105: 212-8. doi: 10.1016/j.ypmed.2017.08.031.

[27] Byrd-Bredbenner C, Ferruzzi MG, Fulgoni III VL, Murray R, Pivonka E, Wallace TC. Satisfying America's Fruit Gap: Summary of an Expert Roundtable on the Role of 100% Fruit Juice. *Journal of Food Science*. 2017; 82(7):1523-34. doi: 10.1111/1750-3841.13754.

[28] Berkson J. Are there Two Regressions? *Journal of the American Statistical Association*. 1950; 45(250):164-80.

[29] Hosler AS, Cong X, Alharthy A. Food Pantry Use and Its Association with Food Environment and Food Acquisition Behavior among Urban Adults. J*ournal of Hunger & Environmental Nutrition*. 2021; 16(3): 356-69. doi: 10.1080/19320248.2020.1848687.