Journal of Food, Nutrition and Diet Science
https://ojs.luminescience.cn/FNDS

LUMINESCENCE
https://luminescience.cn/

Original Research

Modeled impacts of fruit and vegetable donations at food pantries on cardiometabolic risks among clients

Jiacheng Chen [1*], Akiko S. Hosler [1], Thomas O'Grady [1], Christine T. Bozlak [2], Mariana Torres Arroyo [3], Tianhong Mu [3], Xiaobo X. Romeiko [3], Beth J. Feingold [3]

[1] Department of Epidemiology & Biostatistics, College of Integrated Health Sciences, University at Albany, State University of New York, Pine Bush Building, 1400 Washington Ave, Albany, NY 12222, USA
[2] Department of Health Policy, Management and Behavior, College of Integrated Health Sciences, University at Albany, State University of New York, Pine Bush Building, 1400 Washington Ave, Albany, NY 12222, USA
[3] Department of Environmental Health Sciences, College of Integrated Health Sciences, University at Albany, State University of New York, Pine Bush Building, 1400 Washington Ave, Albany, NY 12222, USA

* Correspondence to: Jiacheng Chen, Email: jchen37@alumni.albany.edu

Abstract: Fruit and vegetable (FV) intake is often inadequate in food-insecure individuals, potentially increasing the risks of cardiometabolic diseases such as hypertension and diabetes. Donating rescued FVs to food pantries (FPs) can be a promising approach to address diet-related health disparities while reducing waste in the food system. Using data from FPs in New York's Capital Region (2017–2018, n = 68) and a household survey (2021, n = 504), we modeled the health impacts of increased FV donations while accounting for food waste at the FP- and household-level. Our analysis integrated individual-level odds ratios from prior research into a Microsoft Excel-based calculator to estimate FP-level outcomes. Results revealed that FP users currently receive around 6 pounds of produce monthly, and that doubling FV donations could reduce hypertension risk by 6% and diabetes risk by 3%, with a marginal BMI increase among FP clients. This study suggests that increasing the FV availability at FPs, coupled with waste reduction practices, is a practical way to lower cardiometabolic disease burdens in food-insecure populations.

Keywords: Food pantries, Cardiometabolic disease, Epidemiology, Nutrition equity, Food security

Received: Mar. 26, 2025; Revised: Jun.24, 2025; Accepted: Jun.26, 2025; Published: Jul.1, 2025

DOI: https://doi.org/10.55976//fnds.32025137971-79

Introduction

Metabolic diseases pose a significant and accelerating health burden across the globe [1, 2]. Among these, hypertension, diabetes, and obesity are the leading modifiable ailments [1]. In 2021, hypertension posed the highest burden among common metabolic diseases, contributing 226 million disability-adjusted life years (DALYs). This was followed by obesity and type 2 diabetes mellitus, which resulted in 129 and 75 million DALYs, respectively [1]. Many studies have linked these diseases to socio-economic determinants [3], as well as behavioral factors such as diet, physical activity, smoking, and alcohol consumption [4-6]. In particular, higher intake of fruits and vegetables is consistently associated with a lower risk of chronic diseases, including blood pressure, glycated hemoglobin (HbA1C) and Body Mass Index (BMI) [7-11].

Fruit and vegetable (FV) consumption, akin to other health determinants, is distributed unevenly across subgroups of the population [12]. In 2019, only 12.3% and 10.0% of the US adult population were able to meet the US Department of Agriculture (USDA) recommendations for daily FV intake, respectively. Individuals below the poverty line had lower FV intakes compared to those in higher income groups [13]. In 2018, an estimated 11.1% of households in the US experienced food insecurity [14], and the COVID pandemic in 2020 significantly increased the number of food insecure households [15], signifying that dietary patterns were disrupted due to financial constraints and other resource shortages, which has worsened in recent years [16]. Individuals living in these households are at higher risk of cardiometabolic diseases compared to food secure individuals. This is at least partly related linked to a lower FV consumption [17-20]. Our prior analysis confirmed these findings, in which we observed a reduced FV intake overall and in almost all subcategories of FVs in food pantry (FP) users compared to nonusers, except for 100% fruit juice [21]. For households experiencing food insecurity, food assistance programs including the Supplemental Nutrition Assistance Program (SNAP), group meals, soup kitchens, food pantries, and FP-based nutrition education can be important in providing the FVs to help households meet intake needs [22-24].

Our previous analysis, which used a subset data of the SMART Behavioral Risk Factor Surveillance System (n=5,257) in the Northeastern United States revealed odds ratios (ORs) for hypertension, diabetes, and BMI associated with a one-cup increase in daily FV intake among estimated FP users and FP nonusers [21]. It has been shown that at the individual level, increased vegetable intake is associated with a lower risk of hypertension and a lower BMI, while increased fruit intake can reduce the risk of diabetes [21]. We also found that the health impact of increased fruit intake on BMI was dissimilar between FP users and nonusers: among FP nonusers, increased fruit intake is associated with a lower BMI, whereas among FP users, it is associated with a higher BMI. (Figure S1, Table S1.1 to Table S1.3 in supplementary material detail these results)

Increasing access to FV among FP users can promote healthier dietary habits and mitigate health disparities among food insecure individuals. Despite the potential benefits, significant challenges persist due to food waste: about one-third of edible food is wasted globally [25], and in the U.S., 133 billion pounds of food are discarded annually, in which FVs have the highest rate of loss and waste at 52 percent [26, 27]. To date, there is a gap in research concerning the health impacts of increased FV access at FPs, particularly studies that consider the food waste at both FP and household levels. This study aims to fill this gap by modeling the potential health benefits of increased FV donations on reducing cardiometabolic risks such as hypertension, diabetes, and obesity among FP users in New York's Capital Region. By incorporating the health impacts of increased FV intake at individual level, as well as food waste among FPs and households into our analysis, we seek to provide comprehensive estimations on health impacts of FV donations among FPs. This approach could provide evidence to inform future work, support the policy development on produce distribution to FPs, and evaluate the effectiveness of current nutrition assistance programs.

Methods

To evaluate the health impacts at FP-level, we used two datasets to estimate food waste at the household- and FP-level. The first dataset was the Food Access Survey 3 or "FAS3" (N=504), derived from the third survey of a series of online food access surveys for adults in the New York State Capital Region [28]. The FAS3 utilized a modified version of a survey questionnaire developed by the National Food Access and COVID Research Team that included additional questions asking about food waste at household level. The survey was conducted in October through December 2021. The goal of FAS3 was to understand and track food security, access, availability, and waste before and after the vaccine rollout of the COVID-19 pandemic in the 11 Capital Region counties. The second dataset is at the FP-level and was derived from another project named "Produce Availability in Food Pantries in the Greater Capital Region." The dataset contains information regarding the donations in the FPs, covering donation sources, food types, volume, usability, frequency, transportation logistics, and food waste. Surveys were distributed to FPs in four counties in the NYS Capital Region (Albany, Schenectady, Saratoga, and Rensselaer) in November 2017, February 2018, May 2018, and August 2018. A total of 78 FP operators responded to the survey, among which 68 FPs provided information on the amount of donations they received.

Based on these two datasets and the individual-level findings from our previous study [21], we computed the health impacts of increased FV intake at the FP-level . This was achieved using an equation that transitioned individual-level health impacts to the FP scale, factoring in the waste percentages at both the FP and household levels. The equation is presented in the Equation 1 below:

$$\frac{A(1-W_{FP})}{N_{FPuser}} \times (1 - W_H)P_{FV} = Cup_{FV} \times Index_{cuptolbs} \times 30$$

Equation 1

where A indicates the amount (lbs. per month) of extra produce required for each FP to have a certain health impact on the FP users it serves. W_{FP} and W_H denote the proportions of food waste at the FP and household level, respectively. N_{FPuser} indicates the number of FP users served. P_{FV} represents the proportion of vegetables or fruits among produce donations, which we assumed to be 51% and 49%, respectively. Cup_{FV} refers to the cups of fruits or vegetables needed (per day*person) to achieve a certain reduction in risk of hypertension and diabetes. $Index_{cupstolbs}$ is the index we used [29] to convert cups to lbs.

To proceed with our analysis, we first utilized the FP dataset to determine the amount (lbs.) of donated produce each FP received during the survey period - November 2017, February 2018, May 2018, and August 2018. A one-way ANOVA for repeated measures indicated no seasonal variation in donation amounts, leading us to utilize the monthly average for calculations.

Upon obtaining the monthly average of donations for each FP, we consolidated them to determine the overall monthly donations across the sampled FPs. Using the defined equations, we deduced the additional produce donations required to attain a specific health impact among NYS FP users, accounting for food waste at both the FP and household levels. Food waste data at the FP level, indicated by the unusable percentage of donations, was sourced from the FP dataset, while individual-level waste was determined from the FAS3 dataset.

We made three assumptions for the calculations:

1) Additive assumption: We assumed that FP users add all the produce they received from FP to their meals, instead of replacing some or all of the FVs in their meals.
2) We assumed that FP users are not selective and choose produce without preferences regarding the sources of the donations.
3) No seasonal pattern: Monthly produce donation remains constant throughout the year. This is supported by the one-way ANOVA test using the FP dataset.

In order to factor in food waste at the levels of household and FPs, we created a Microsoft Excel-based calculator (Table. 2) based on the Equation 1. After setting the expected risk reduction in hypertension and diabetes, this calculator returned the amount of extra produce donations needed for each FP user (lbs./(month*person)). By adjusting the calculator inputs, we evaluated various scenarios and chose the most applicable scenario for further interpretation. This calculator is included in the supplemental materials.

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

Results

Among 68 FPs in the NYS Caption Region, a total of 26,333 FP users were served from November 2017 to August 2018. Each FP received varying amounts of produce [30]. Over 60 percent (41 FPs) reported receiving smaller produce donations (<800 lbs.) monthly. In contrast, a few large FPs serving over 2500 clients per month received over 5000 lbs. per month, accounting for one-fifth (13 FPs) of the sample (Table 1). Monthly fresh fruit and vegetable donations were not normally distributed across food pantries. After ln ($\log_e$) transformation, which normalized the distribution, the ANOVA test results (p=0.52) indicated no significant seasonal fluctuations in produce donations.

Further analysis of the survey responses from the FP dataset showed that the proportion of FPs responding to all four surveys was relatively low (8.82%; 6 FPs), suggesting potential variability in data reporting during the study period. Regarding produce wastage, a significant range was observed: around one third of the FPs (22 FPs) reported a wastage of 5% or less, whereas 15 percent (10 FPs) reported high wastage rates exceeding 20%. The average produce waste rate at FP-level is 10%, while the FAS3 dataset revealed an average household-level produce waste rate of approximately 20%.

On average, FP clients in the NYS Capital Region received 6.07 pounds of produce monthly, without considering the FP-level food waste. This amount corresponds to a daily vegetable intake of 0.24 cups and a daily fruit intake of 0.16 cups (Figure 1; Table 2, column B). We used the calculator based on Equation 1 to determine the amount of FV required to achieve specific risk reductions in hypertension and diabetes. To reduce the risk of hypertension and diabetes, by 6% and 3%, respectively, each person needs an extra 3.05 lbs. of vegetables and an extra 3.04 lbs. of fruit per month, taking into account waste at the FP-level and the household-level. This totals 6.09 lbs. of additional vegetables and fruits, which is almost equal to the amount of produce they currently receive from the FP each month (6.07 lbs.). Such an increase in produce also corresponds to an increase in BMI of 0.04 units. For more details, please refer to Table 2.

Table 1. Characteristics of the food pantries in the survey

Parameter	Range	Quantity	Proportion
Number of Surveys Responded	Responded 1 of 4 surveys	34	50.00%
	Responded 2 of 4 surveys	12	17.65%
	Responded 3 of 4 surveys	16	23.53%
	Responded 4 of 4 surveys	6	8.82%
Amount of Produce Received Monthly	<=800 lbs.	41	60.29%
	800 - 2500 lbs.	8	11.76%
	2500 - 5000 lbs.	6	8.82%
	>5000 lbs.	13	19.12%
Produce Wasted %	<= 5%	22	32.35%
	5 - 10%	25	36.76%
	10 - 20%	11	16.18%
	> 20%	10	14.71%
Number of People Served	<=500	48	78.69%
	500 - 2500	7	11.48%
	2500 - 5000	4	6.56%
	>5000	2	3.28%

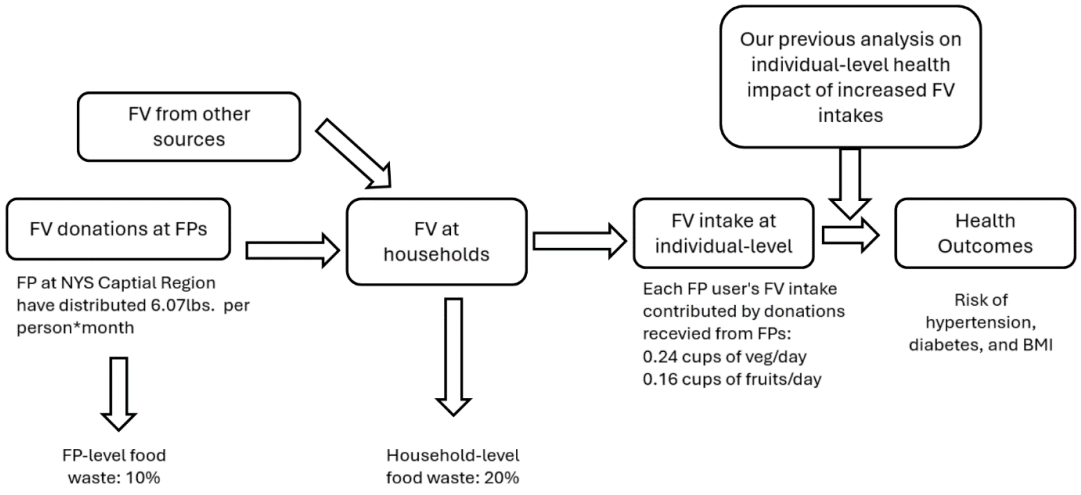

Figure 1. The logical model showing the connection between FP-level FV donations and individual-level health outcomes

Table 2. Calculator of food-pantry level health impact

Column A. Numbers for Input	Results
Monthly Total Produce/Person (lbs/(month*person))	6.07
Veg/Fruit Ratio	51/49
Risk Reduction of hypertension	-6.00%
Risk Reduction of diabetes	-3.00%
Beta of Veg intake, hypertension model	-0.26[1]
Beta of Fruit intake, diabetes model	-0.18[1]
Beta of Veg intake, BMI model	-0.60[1]
Beta of Fruit intake, BMI model	1.09[1]
Pantry-level produce waste[2]	10%
Household-level produce waste	20.01%

Column B. Individual-level Estimations	Results
Monthly Total Veg from FP/Person (lbs./(month*person))	3.09
Monthly Total Fruit from FP/Person (lbs./(month*person))	2.97
Daily Veg Intake from FP/Person (cups/(day*person))	0.24
Daily Fruit Intake from FP/Person (cups/(month*person))	0.16
Veg needed for HYP risk reduction (cups/(day*person)	0.24
Fruit needed for DM risk reduction (cups/(day*person)	0.17
BMI increase	0.04
Column C. FP-level Estimations	**Results**
Veg needed for HYP risk reduction (lbs./(month*person))	3.05
Fruit needed for DM risk reduction (lbs./(month*person))	3.04
Total Produce needed for risk reduction (lbs./month)	6.09
Increase compared to current donations at food pantry	100.30%

1.Source of beta values: derived from our previous FVs individual health impact study [21]. More details are available in the Supplemental Tables S1.x. Exponential calculation is needed for beta values to odds ratios transformation.
2.Pantry-level produce waste: 10% estimated from Food Pantry data.

Discussion

Comparison with previous studies

Our study found that FPs in the NYS Capital Region typically distribute approximately 3.09 lbs. of vegetables and 2.97 lbs. of fruit to each client per month. Previous studies have shown that FPs contribute to increased daily FV consumption among low-income populations, but the amount of fresh produce distributed by FPs varies, largely depending on the sources [31, 32]. For instance, a study in central Texas [31] reported a higher monthly distribution of fruit (3.8 kg/person, equivalent to 8.38 lbs./person) but a slightly lower distribution of vegetables (1.2 kg/person, equivalent to 2.64 lbs./person) compared to the FPs in our study. Availability of fresh produce can be influenced by seasonal agricultural patterns, but counter-seasonal imports are used to assure constant availability of FVs in the retail sector [33, 34]. FPs in the Capital Region receive food primarily from regional food banks, where the majority of fresh produce are donated by the retail stores. In our seasonal pattern analysis, we observed no significant seasonal fluctuation in the amount of fresh FV donations at FPs. Therefore, it is reasonable to apply the no seasonal pattern assumption in our analysis.

"Double the donation, lower the risk"

After evaluating various scenarios, a clear and actionable finding emerged: "Double the donation, lower the risk." Specifically, a reduction of 6% in hypertension risk and 3% in diabetes risk requires an additional 6.09 lbs./(month*person) of produce, with additive assumption applied. This mirrors the monthly amount distributed to each FP user in the NYS Capital Region (6.07 lbs.), as shown in our dataset. Notably, this approach is associated with a negligible BMI increase (0.04 kg/m^2), assuming that FP users add the donated produce to their diets. Compared to the scenarios targeting a fixed risk reduction in both hypertension and diabetes, such as "5% reduction", the following communication messages are more straightforward and can mitigate the risk of increased BMI.

- Doubling the current produce donations at FPs in the NYS Capital Region may reduce the risk of hypertension and diabetes among FP users by 6% and 3%, respectively, assuming the number of FP users remains constant.
- FPs can safely increase current fruit and vegetable donations without changing the proportions they already provide. Similarly, FP users can enjoy the same fruit-to-vegetable balance in their meals without changing their fruit-to-vegetable ratio.

Strengths and limitations

Our study possesses notable strengths. To our knowledge, it is the first study to quantitatively evaluate the health impacts of increased FV consumption at the FP level. This approach includes the development of a calculator that integrates both FP and household food waste into the estimation of the health impacts of increased produce donations. This tool allows for a more accurate and comprehensive assessment of how increased produce donations at FPs could improve health outcomes among food insecure individuals. Furthermore, the findings can be relevant not only to the NYS Capital Region, but also to regions in the Northeastern US and beyond with similar climates and demographics. To apply the findings, the calculator can be adapted based on the local conditions in other regions. Another notable strength of our study is the relatively large sample size of the modeling data, allowing for significant discernment of the health impacts of increased FV consumption.

However, there are limitations. Our analysis employed assumptions which might not hold well in practice. For

instance, the additive assumption posits that FP users incorporate all received produce without replacement. However, some studies [22] indicate that supermarket purchases decrease after FP donations. Moreover, our study assumes that FP users are not selective and choose the donated products randomly, without preferences regarding the sources of the donations. In reality, many FPs operate under a client-choice model, where individuals select food based on personal or household preferences [35] and the quality of donated produce. Although client-choice model may help reduce household-level food waste [36], the produce donated to food pantries is often unsellable in markets due to its condition, leading to lower pickup rates among FP users [37]. This can further influence the effectiveness of such interventions. For future research, the questionnaires that prioritize FP clients should be expanded to include questions on FV replacement, preferred FV categories, and preferred distribution methods (client-choice or packaged). Questionnaires distributed to FP managers should collect detailed information on FP distribution patterns and the availability and content of on-site nutritional education programs. These added questions would enhance the accuracy of health outcome assessments, provide insights into client behaviors, waste management practices, and educational needs, and enhance the understanding of how FP operations affect client outcomes, thereby helping to inform the development of future FP interventions, including on-site education programs.

The information of food waste at household-level was collected in the end of 2021, when people's normal food-related behaviors were still disrupted by the COVID pandemic. However, our data indicated that overall food waste behavior was unchanged: 27% of people wasted less fresh produce compared to the pre-pandemic period, another 22% wasted more fresh produce, but 51% did not change their food waste behavior. When analyzing seasonal variation, only complete cases were included in our ANOVA test, with only eight FPs completing all surveys, potentially limiting our findings. Although our data showed consistent produce donations over seasons, there are seasonal patterns in the FV consumption and production in the literature [35, 36]. Furthermore, the FP dataset, which relies on self-reporting by operators or volunteers, is subject to individual recall and reporting biases. There was a smaller respondent pool in February 2018 (N=15) due to staffing shortages, which potentially increased the inaccuracy of the reported information. In contrast to structured programs such as SNAP, many FPs operate on a flexible "come and go" basis, which complicates participant counts [17]. Finally, our cross-sectional approach does not allow for causal analysis; the odds ratios merely represent associations between increased FV intake and chronic disease risks.

Public health implications

The study delivers a clear message for FPs and the communities that support them: doubling produce donations can help to decrease the risk of chronic diseases among FP clients. While the aim of doubling donations may seem overly ambitious given the limited resources and logistical challenges faced by FPs. However, this aim was set to provide a clear benchmark for assessing the potential health benefits of increased FV availability and to offer a quantifiable goal for public health interventions.

Given the vast amounts of food wasted and sent to landfills, there is a potential for FPs in the NYS Capital Region to increase produce donations. One example is the Nourish NY Program [19], which redirects surplus produce from regional farms to those in need via New York's network of food banks, exemplifies a successful program of boosting donations to increase donations from regional growers and producers. Under this initiative, the state government furnishes incentives to farmers who donate their produce to food banks [19]. Furthermore, several strategies can contribute to "doubling the donation" and help to increase daily FV intake among FP users. Promoting client-choice model at FPs could help reduce food waste at household level and promote healthier diets among FP clients [36]. FP-based nutrition education interventions can also help to increase daily FV intakes among FP users [38, 39]. By providing cooking and nutrition education, food-use tips, and taste tests [40], FPs could provide their clients with both the ingredients and the knowledge to prepare healthier meals that incorporate more FV while reducing fat and salt content. Though evaluating the mediating effect of on-site nutrition education and its interaction with client-choice model was not one of our objectives, those would be important areas for future researchers to investigate further.

Supplementary material

Table S1.1, Table S1.2, Table S1. 3.1, Table S1. 3.2 and Figure S1 can be found at https://file.luminescience.cn/FNDS-379%20Supplemental%2BMaterials.pdf.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT to improve the readability of the text and to correct grammatical errors. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Authors' 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 data collections of the FAS-3 and the FP survey. M.T. participated in the FP survey data collection and management. T.O., B.F., C.T.B., M.T., T.M., and X.X.R. participated in the constructive criticism and co-wrote the article.

Acknowledgments

We extend our gratitude to the managers and staff at FPs in the NYS Capital Region for their support. Their dedication of time and effort in completing the surveys and providing essential data from the FPs was instrumental to this research.

Informed consent statement

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

Funding information

This research was funded by the Foundation for Food and Agriculture Research (FFAR; 557409), and the UAlbany President's COVID-19 MHD Engaged Researchers Seed Funding Program.

Conflict of interest

The authors declare no conflict of interest. The sponsor has no role in the design of the study, in the collection, analysis or interpretation of the data, in the writing of the manuscript or in the decision to publish the results.

References

[1] Zhang H, Zhou X-D, Shapiro MD, Lip GYH, Tilg H, Valenti L, et al. Global burden of metabolic diseases, 1990–2021. *Metabolism - Clinical and Experimental.* 2024;160. doi: 10.1016/j.metabol.2024.155999.

[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; 388:1659-724. doi: 10.1016/S0140-6736(16)31679-8.

[3] Quiñones AR, Botoseneanu A, Markwardt S, Nagel CL, Newsom JT, Dorr DA, et al. Racial/ethnic differences in multimorbidity development and chronic disease accumulation for middle-aged adults. *PLOS ONE*. 2019; 14:e0218462. doi: 10.1371/journal.pone.0218462.

[4] 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.

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

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

[9] 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; 20:2636-41. doi: 10.1017/S1368980016002081.

[10] 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; 28:353-9. doi: 10.1038/jhh.2013.115.

[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; 25:2709-18. doi: 10.1200/JCO.2007.10.7094.

[12] Pouliot N, Hamelin A-M. Disparities in fruit and vegetable supply: a potential health concern in the greater Québec City area. *Public Health Nutrition*. 2009; 12:2051-9. doi: 10.1017/S1368980009005369.

[13] Lee SH. Adults Meeting Fruit and Vegetable Intake Recommendations — United States, 2019. *Morbidity and Mortality Weekly Report.* 2022; 71. doi: 10.15585/mmwr.mm7101a1.

[14] Rabbitt MP, Reed-Jones M, Hales LJ, Burke MP. *Household food security in the United States in 2023*.

United States. Department of Agriculture. Economic Research Service. Report number: ERR-337. 2024. doi: 10.32747/2024.8583175.ers.

[15] Niles MT, Beavers AW, Clay LA, Dougan MM, Pignotti GA, Rogus S, et al. A Multi-Site Analysis of the Prevalence of Food Insecurity in the United States, before and during the COVID-19 Pandemic. *Current Developments in Nutrition*. 2021; 5:nzab135. doi: 10.1093/cdn/nzab135.

[16] Andrews M. *Household Food Security in the United States, 1999*. U.S. Department of Agriculture, Economic Research Service; 2000.

[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; 20:183–9. doi: 10.1017/S1368980016001786.

[19] *Nourish New York*. Agriculture and Markets n.d. https://agriculture.ny.gov/NourishNY. [Accessed October 5, 2022].

[20] Azagba S, Sharaf MF. Disparities in the frequency of fruit and vegetable consumption by socio-demographic and lifestyle characteristics in Canada. *Nutrition Journal*. 2011; 10:118. doi: 10.1186/1475-2891-10-118.

[21] Chen J, Hosler AS, O'Grady TJ, Romeiko XX, Feingold B. Evaluating the association between fruit and vegetable consumption and chronic disease prevalence among food pantry users in the northeastern United States. *Journal of Food, Nutrition and Diet Science*. 2024:122-9. doi: 10.55976/fnds.220241267122-129.

[22] Clancy KL, Bowering J, Poppendieck J. Characteristics of a random sample of emergency food program users in New York: I. Food pantries. *American Journal of Public Health*. 1991; 81:911-4. doi: 10.2105/AJPH.81.7.911.

[23] 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): 310-323. doi: 10.1080/19320248.2013.786663.

[24] 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; 116:1613-20. doi: 10.1016/j.jand.2016.03.014.

[25] Gustavsson J, Cederberg C, Sonesson U, van Otterdijk R, Meybeck A, editors. *Global food losses and food waste: extent, causes and prevention*. Rome: FAO; n.d.

[26] Buzby JC, Farah-Wells H, Hyman J. The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States. *USDA-ERS Economic Information Bulletin Number 121*. 2014. doi: 10.2139/ssrn.2501659.

[27] Grizzetti B, Pretato U, Lassaletta L, Billen G, Garnier J. The contribution of food waste to global and European nitrogen pollution. *Environmental Science & Policy*. 2013; 33:186-95. doi: 10.1016/j.envsci.2013.05.013.

[28] Hosler AS, Chen J, Arroyo MT, Neff RA, Bozlak CT, Romeiko XX, et al. Fruit and Vegetable Consumption, Food Acquisition Behavior, and Food Insecurity Before and After the COVID-19 Vaccine Rollout. *Journal of Public Health Management and Practice*. 2024; 30:550. doi: 10.1097/PHH.0000000000001946.

[29] Mu T, Feingold B, Hosler A, Bozlak C, Chen J, Neff R, et al. Comparing life cycle environmental impacts of food access and consumption pre- and during COVID 19 in New York State's Capital Region. *Science of The Total Environment*. 2024; 949:175037. doi: 10.1016/j.scitotenv.2024.175037.

[30] 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.

[31] Mousa TY, Freeland-Graves JH. Impact of food pantry donations on diet of a low-income population. *International Journal of Food Sciences and Nutrition*. 2019; 70:78-87. doi: 10.1080/09637486.2018.1466271.

[32] Bryant M, Sahota P, Santorelli G, Hill A. An exploration and comparison of food and drink availability in homes in a sample of families of White and Pakistani origin within the UK. *Public Health Nutrition*. 2015; 18:1197-205. doi: 10.1017/S1368980014000147.

[33] Johnson R. *The US trade situation for fruit and vegetable products*. Congressional Research Service Washington, DC; 2014.

[34] Stanton JV. Habits in Fresh Produce Consumption: Are Seasonal Increases in Marketing Efforts Necessary? *Journal of Food Products Marketing*. 2007; 13:1-18. doi: 10.1300/J038v13n01_01.

[35] Wilson NLW, Just DR, Swigert J, Wansink B. Food pantry selection solutions: a randomized controlled trial in client-choice food pantries to nudge clients to targeted foods. *Journal of Public Health*. 2016: fdw043. doi:10.1093/pubmed/fdw043.

[36] Pruden B, Poirier L, Gunen B, Park R, Hinman S, Daniel L, et al. Client Choice Distribution Model Is Associated with Less Leftover Food in Urban Food Pantries. *Current Developments in Nutrition*. 2020; 4:nzaa043_117. doi: 10.1093/cdn/nzaa043_117.

[37] Long CR, Bailey MM, Cascante D, Purvis R, Rowland B, Faitak B, et al. Food Pantry Clients'

Needs, Preferences, and Recommendations for Food Pantries: A Qualitative Study. *Journal of Hunger & Environmental Nutrition*. 2023;18:245-60. doi: 10.1080/19320248.2022.2058334.

[38] Clarke P, Evans SH. How Do Cooks Actually Cook Vegetables? A Field Experiment With Low-Income Households. *Health Promotion Practice*. 2016; 17:80-7. doi: 10.1177/1524839915597898.

[39] Martin KS, Colantonio AG, Picho K, Boyle KE. Self-efficacy is associated with increased food security in novel food pantry program. *SSM - Population Health*. 2016; 2:62-7. doi: 10.1016/j.ssmph.2016.01.005.

[40] *Taste Good Series*. Capital Roots 2020. https://www.capitalroots.org/taste-good-series/ [accessed December 4, 2024].