Published in final edited form as:
Am J Clin Nutr. 2023 May ; 117(5): 946–954. doi:10.1016/j.ajcnut.2023.02.014.

Dietary Contributions of Food Outlets by Urbanization Level in the US Population 2 Years and Older, NHANES 2013–2018

Nicholas Ansai[1], **Edwina A. Wambogo**[1], **Kirsten A. Herrick**[2], **Meghan Zimmer**[2], **Jill Reedy**[2], **Craig M. Hales**[1], **Cynthia L. Ogden**[1]

[1]National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, MD

[2]National Cancer Institute, Rockville, MD

Abstract

Background: Differences in food access, availability, affordability, and dietary intake are influenced by the food environment, which includes outlets where foods are obtained. These differences between food outlets within rural and urban food environments in the US are not well understood.

Objective: The aim of this analysis was to describe the contribution of foods and beverages from six outlets – grocery stores, convenience stores, full-service restaurants, quick-service restaurants, schools, and other outlets – to total energy intake and Healthy Eating Index (HEI)-2015 scores in the US population, by urbanization level (non-metropolitan statistical areas (MSA), small to medium MSA, and large MSA).

Design: Data were from the National Health and Nutrition Examination Survey 2013–2018. Dietary intake from one 24-hour dietary recall was analyzed by the outlet where a food or beverage was obtained and by urbanization. Linear regression, adjusted for sex, age, race and Hispanic origin, and family income, was used to predict the contribution of each food outlet to total energy intake and HEI-2015 total and component scores by urbanization level.

Results: During 2013–2018, foods and beverages from grocery stores, quick-service, and full-service restaurants provided 62.1%, 15.1% and 8.5% of energy intake, respectively. The percent of energy intake from full- and quick-service restaurants increased with increasing urbanization level. HEI-2015 total scores increased with increasing urbanization level overall (48.1 non-MSAs, 49.2 small to medium MSAs, and 51.3 large MSAs), for grocery stores (46.7 non-MSAs, 48.0 small to medium MSAs, and 50.6 large MSAs), and for quick-service restaurants (35.8 non-MSAs, 36.3 small to medium MSAs, and 37.5 large MSAs).

Corresponding Author: Nicholas Ansai, MPH, National Center for Health Statistics/CDC, Hyattsville, MD 20782, qjk0@cdc.gov.

Data Share Statement: Data described in the manuscript and code book will be made available upon request.

Disclaimer: The findings and conclusions in this report are those of the authors and not necessarily the official position of the Centers for Disease Control and Prevention or the National Institutes of Health.

Conclusion: Grocery stores and restaurants were the largest contributors of energy intake in urban and rural areas. Diet quality improved with increasing urbanization overall and for grocery stores and quick-service restaurants.

Keywords

Energy intake; HEI-2015; Food outlets; Urbanization level; NHANES

INTRODUCTION

Differences in food access, availability, affordability (1), and intake of some foods and nutrients exist between rural and urban areas in the US (2). These differences may help to explain the higher prevalence of obesity among youth and adults living in rural versus urban settings (3, 4). In rural areas, available foods may be less healthful than in urban areas and accessing healthy foods may be more difficult due to poor spatial proximity to food sources (1, 5–9). Additionally, food may be less affordable due to higher food prices and lower wages (1, 8, 10), which may affect food purchasing and consumption practices. In urban areas, similar income disparities may affect food access and affordability, as lower income urban areas have been shown to have more expensive healthy foods than higher income urban areas, and the food security of low income urban residents may be more vulnerable to disruptions due to unemployment or inflation (11). Other barriers such as transportation costs and neighborhood safety may impact the accessibility and availability of foods in urban environments (11).

Adherence to the Dietary Guidelines for Americans (DGA) recommendations is low in the US population 2 years and older (12). Literature on dietary differences between rural and urban settings in the US is limited (13). Nevertheless, differences have been reported in prevalence and variety of fruit and vegetable intake, as well as differences in dairy intake, and in the consumption of fatty snack foods (13). Food purchasing and consumption practices are in part, a byproduct of the food environment, which includes the distribution of various food outlets. Because food environments may vary by level of urbanization, examining food outlets in which foods are sold and purchased may inform efforts to improve diet. Therefore, the objective of this study was to describe, using national data, the contribution of foods according to the food outlet where they were obtained to total energy consumption and diet quality as measured by Healthy Eating Index (HEI)-2015 scores in the US population during 2013–2018, by levels of urbanization.

METHODS

Study Design

Data from the National Health and Nutrition Examination Survey (NHANES) 2013–2018 were used for these analyses. NHANES is a cross-sectional survey of the US noninstitutionalized civilian population based on a complex, stratified, multistage probability sample design. NHANES collected data continuously from 1999 to 2018, with 2-year public data file releases. The survey combines an in-home interview and a standardized physical examination and dietary interview at a mobile examination center (MEC). Details of the NHANES study design, implementation, data sets, analytic considerations, and other documentation are available online (14). The sample design includes oversampling to obtain reliable estimates of health and nutritional measures for certain population subgroups. For the NHANES survey cycles included in this analysis, non-Hispanic Black, non-Hispanic Asian, and Hispanic persons, adults aged 80 years and older, and low income persons were oversampled (15, 16). The NHANES protocol was approved by the National Center for Health Statistics (NCHS) Ethics Review Board. For children and adolescents <18 years, written parental consent was obtained, and assent was also obtained from children and adolescents 7 to 17 years. Written informed consent was obtained for adults. Unweighted examination response rates for participants of all ages were 68.5% in 2013–14, 58.7% in 2015–16, and 48.8% in 2017–18 (17).

Dietary Intake

Two 24-hour dietary recall interviews were obtained from survey participants; the first recall was conducted in-person at the MEC, and the second was conducted by telephone approximately 10 days later (14, 18–20). These analyses used data from the first 24-hour dietary recall to obtain mean estimates of dietary intake on a given day. Data from one 24-hour dietary recall can be sufficient to estimate group mean intake on a given day (21). Trained interviewers, using a computer-assisted dietary interview system that included the USDA’s Automated Multiple-Pass Method (AMPM) with standardized probes (22), collected type, quantity, and source for all foods and beverages consumed during the previous 24 hours. In most cases, survey participants 12 years and older reported their own dietary intake; children 6 to 11 years old were assisted by an adult; and parents/guardians reported for children 5 years of age or younger. A detailed description of dietary data quality control criteria and methods are described elsewhere (20).

Each food and beverage reported by participants was coded to corresponding foods and beverages in the USDA’s Food and Nutrient Database for Dietary Studies (FNDDS) and nutrient and food files were publicly released. The FNDDS food codes are accompanied by food descriptions, ingredient lists, gram weights, and nutrient and energy values. The FNDDS food codes linked to the USDA’s Food Patterns Equivalents Database (FPED) were used in determining diet quality in this study (23). The FPED disaggregates each food code into ounce-equivalents (oz.-eq), cup equivalents (c-eq), teaspoon equivalents (tsp-eq), or grams of 37 distinct food pattern components used to model the DGA food pattern recommendations.

Diet Quality

The HEI-2015 is a measure of overall diet quality, independent of quantity, that can be used to assess alignment with the DGA (24, 25). The HEI-2015 is composed of 13 components: nine assess dietary adequacy (Total Fruits, Whole Fruits, Total Vegetables, Greens and Beans, Whole Grains, Dairy, Total Protein Foods, Seafood and Plant Proteins, and Fatty Acids), while four assess components for which consumption in moderation is recommended (Refined Grains, Sodium, Added Sugars, and Saturated Fats) (25, 26). Component scores range from 0 to 5 or 0 to 10 and all component scores sum to yield a total score of 0 to 100, with higher scores indicating healthier dietary quality and better alignment with the DGA (24).

Food Outlets

Dietary intake was analyzed by the source where a food or beverage was reported as being obtained. As shown in Supplementary Table 1, the 26 food sources were grouped into six food outlet categories for this analysis: 1) grocery stores, 2) convenience stores, 3) full-service restaurants, 4) quick-service restaurants, 5) schools, and 6) other outlets.

Urbanization Level

The 2013 NCHS Urban-Rural classification scheme (27), a census-defined, county-level scheme, has six levels: four metropolitan (large central metro, large fringe metro, medium metro, and small metro) and two nonmetropolitan (micropolitan and noncore). For this study, the six levels were collapsed into three levels of urbanization to obtain stable estimates: non-MSA (micropolitan and noncore, i.e. rural), small to medium MSA (small metro and medium metro), and large MSA (large central metro and large fringe metro) (27). The dataset with geographic location data of NHANES participants is not publicly available and was accessed through the NCHS Research Data Center (28).

Demographics

Demographic data included sex, age, race and Hispanic origin, and family income. Age in years was categorized into youth 2–19 years and adults 20 years and older. Race and Hispanic origin were categorized as non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, Hispanic, and non-Hispanic other. Participants reporting "other" includes those reporting multiple races. Analyses were limited to the race and Hispanic origin groups for which data were statistically reliable. Family income was defined based on the Federal Poverty Level (FPL) as less than 130% and 130% or greater, based on the income to poverty ratio, a measure of the annual total family income divided by the US Department of Health and Human Services poverty guidelines, after accounting for inflation and family size (15). For context, the recommended cutoff point for eligibility for the Supplemental Nutrition Assistance Program (29) and the free and reduced price school lunch program is 130% of the poverty threshold (30).

Statistical Analysis

Individual-level HEI-2015 total and dietary component scores were estimated for each participant by food outlet using the Simple HEI Scoring Algorithm Per-Person method, based on Day 1 dietary recalls (31). This method first calculates the ratio of the HEI components to energy intake at the individual level, then the individual component scores are summed to calculate each total score. A sensitivity analysis was conducted excluding alcohol to further examine HEI-2015 scores, as some outlets may have a higher proportion of food and beverage sales from alcohol (32) and the HEI-2015, unlike previous versions, does not include a separate component for alcohol. The HEI-2015, however, accounts for alcohol within total energy (the denominator for most components) (25).

Predicted contributions of each food outlet to total energy intake and predicted HEI-2015 scores (total and component) for each food outlet by urbanization were estimated from linear regression models, adjusting for age, sex, race and Hispanic origin and family income. Linear and quadratic trends by urbanization level were evaluated using the Satterthwaite adjusted F-test in linear regression models. To visualize differences in the 13 HEI-2015 component scores by urbanization, the scores were scaled as a percentage of the maximum component score and then plotted on radar plots. Higher intakes of adequacy components and lower intakes of moderation components result in higher HEI scores that reflect better alignment with the DGA and healthier diet quality (24). On the radar plots, the center point of the graph represents a score of zero, and the outer point of each axis represents the maximum score for each component. Each HEI-2015 component forms an axis on the graph, and the plot connects the scores for each axis into a figure that, by its shape, suggests a pattern. A plot with all components at the outer point of the axis, for a total score of 100, indicates optimal alignment with the DGA, while a plot with many points closer to the center of the graph represents a food pattern that is not as aligned with the DGA (25).

NHANES survey design variables were used to account for the complex sample design and Day 1 dietary sample weights were used to account for differential probabilities of selection, nonresponse, noncoverage, and day of the week of the recall. Standard errors of the percentages were estimated using Taylor series linearization. All reported estimates were evaluated either using the NCHS data presentation standards for proportions (33) or relative standard error ≥30% for means. All significance levels for statistical testing were at the p less than 0.05 (34). Analyses of HEI-2015 component scores were exploratory and Bonferroni's method of correction was not used to adjust for multiple comparisons of component scores with urbanization level. Statistical analyses were performed using SAS (version 9.4, SAS Institute Inc, Cary, NC) (35) and SUDAAN version 11.0 (RTI International, Research Triangle Park, NC) (36).

RESULTS

Data for examined participants aged 2 years and older in 2013–14 (n=9,508), 2015–16 (n=9,282), and 2017–18 (n=8,663) were combined for a total of 27,453 participants (37). There were 1,238 participants who did not go to the MEC (2013–14 n=333; 2015–16 n=395; 2017–18 n=510) and participants were excluded if they did not provide a dietary recall (2013–14 n=990; 2015–16 n=869; 2017–18 n=939), their dietary recall was deemed unreliable (2013–14 n=112; 2015–16 n=95; 2017–18 n=84), or if they reported consuming breast milk (2013–14 n=6; 2015–16 n=5; 2017–18 n=8), though additional nonresponse among recalls were accounted for using Day 1 dietary sample weights (37). This resulted in a final analytic sample of 23,107 participants (2,055 were missing information on poverty and these participants were included in analyses that did not involve poverty; see Supplementary Figure 1).

Table 1 shows the sample sizes and weighted demographic characteristics of the study population. Nearly half were from large MSAs (47.8%), while just over three quarters (76.0%) were adults ages 20 years and older and 25.1% had family income <130% FPL.

Table 2 shows the unadjusted and adjusted predicted mean percent of total energy intake from each of the selected food outlets and trends by urbanization level. Adjusted results were similar to the unadjusted results. The adjusted mean percent of total energy intake was similar by urbanization for grocery stores (63.3% in non-MSAs, 61.8% in small to medium MSAs, and 61.6% in large MSAs) and for other outlets (9.1% in non-MSAs, 8.0% in small to medium MSAs, and 7.2% in large MSAs). The adjusted mean percent of total energy intake from convenience store foods decreased with increasing urbanization level (6.2% in non-MSAs, 5.1% in small to medium MSAs, and 4.1% in large MSAs), while the adjusted percent of energy intake from both full and quick-service restaurants increased with increasing urbanization level (6.5% and 12.3% in non-MSAs, 8.1% and 15.0% in small to medium MSAs, and 9.5% and 16.4% in large MSAs). Decreasing trends in predicted mean percent of total energy intake was also observed with increasing urbanization level for schools.

Adjusted and unadjusted HEI-2015 total scores and trends by urbanization level were similar (Table 3). Adjusted total scores increased with increasing urbanization level (48.1 for non-MSAs, 49.2 for small to medium MSAs, and 51.3 for large MSAs). Adjusted scores for grocery stores also increased with increasing urbanization level (46.7 for non-MSAs, to 48.0 for small to medium MSAs, and 50.6 for large MSAs). No significant trends by urbanization level were observed for convenience store foods (34.9 for non-MSAs, 35.6 for small to medium MSAs, and 35.6 for large MSAs) or for full-service restaurants (40.6 for non-MSAs, 41.8 for small to medium MSAs, and 42.4 for large MSAs). The adjusted total scores for quick-service restaurants (35.8 for non-MSAs, 36.3 for small to medium MSAs, and 37.5 for large MSAs) increased with increasing urbanization. Schools had a HEI-2015 total score of 50.8, but no significant trends by urbanization level. Scores for other outlets decreased with increasing urbanization (24.0 for non-MSAs, 20.1 for small to medium MSAs, and 19.0 for large MSAs).

Figure 1 shows predicted HEI-2015 component scores by urbanization level, adjusted for age, sex, race and Hispanic origin, and family income. Component scores for Total Fruits, Whole Fruits, Total Vegetables, Greens and Beans, Seafood and Plant Proteins, and Added Sugars improved with increasing urbanization.

HEI-2015 component scores for each food outlet are shown in Figure 2 and Supplementary Table 2. Trends in HEI-2015 component scores with urbanization were found primarily for grocery stores (increasing scores with increasing urbanization for eight components) and other outlets (decreasing scores with increasing urbanization for six components). No significant trends in component scores by level of urbanization existed for convenience stores. Full-service restaurant scores for Greens and Beans and Added Sugars also improved with urbanization. Quick-service restaurant scores for Greens and Beans and Seafood and Plant Proteins rose with increasing urbanization level. Scores for Refined Grains from school foods decreased with increasing urbanization level.

In a sensitivity analysis excluding alcohol from foods and beverage (Supplementary Tables 3 and 4), predicted HEI-2015 component scores and trends by urbanization were similar to those in the main analysis. The most notable differences were for convenience stores where total HEI-2015 decreased from 35.5 to 34.0 and component scores for Refined Grains, Sodium, Added Sugars, and Saturated Fat all decreased.

DISCUSSION

During 2013–2018, grocery stores were the largest contributors to energy intake in urban and rural areas, providing about 62% of total energy. Together, full- and quick-service restaurants contributed around one fourth of energy intake overall, with increasing contributions from these sources with increasing urbanization level. In addition, overall diet quality and diet quality for foods consumed from grocery stores and quick-service restaurants, based on HEI-2015 scores, increased with increasing urbanization level.

These findings are consistent with previous studies that showed that grocery store and restaurant foods are the largest contributors to energy intake but the foods consumed from these sources, particularly restaurants, do not fully align with dietary guidance as measured by HEI-2015 scores and other measures such as the American Heart Association diet score (12, 38–44). To aid in the interpretation of HEI-2015 scores, a graded approach can be used in which most scores across all food outlets presented in these analyses would receive a poor score of an "F", that is, they have overall scores of 0 to 59, or component scores that are 0% to 59% of maximum score (25). Notably, Vinyard et al., (38) found similar patterns of total energy intake contributions and HEI-2015 scores for similar categories of food outlets and concluded that the US population has not been consuming foods that meet dietary guidance from the DGA.

This study builds on those findings by showing that the foods consumed from outlets that contributed most to intake overall (grocery stores and quick-service restaurants) had lower HEI-2015 scores in rural areas than the same types of food outlets in urban areas. Other studies have suggested that rural areas may experience poorer diet quality compared to urban areas in the US (7, 9, 45, 46). For instance, McCullough et al., (9) found that rural residents were at higher risk of experiencing poor diet quality compared to urban residents, even after controlling for education. The difference in nutritional quality of foods offered in rural versus urban food outlets is not well understood but could be related to socioeconomic factors that cause healthy foods to be less accessible or affordable in rural areas (45, 46).

Our results help to expand the understanding of differences in dietary intake between rural and urban areas. For example, overall component scores for Total Fruits, Whole Fruits, Total Vegetables, and Greens and Beans improved with urbanization, which supports the findings of another study that showed youth in rural areas may consume less fruits and vegetables than those in urban areas (2). Additionally, convenience store components for Refined Grains, Sodium, and Saturated Fats (moderation components) achieved scores relatively close to the maximum. This is contrary to previous findings that showed convenience store foods and beverages are less healthful than those in other food outlets, like grocery stores (6, 42). Further investigation is needed to understand the convenience store component scores.

Demographic confounders did not explain differences in energy intake or HEI scores by urbanization. Additionally, sensitivity analyses excluding alcohol from HEI-2015 score calculations showed only marginal changes in HEI scores for each outlet, with the most noticeable changes among the HEI-2015 total scores for convenience store foods. However, there were still no trends in convenience store diet quality by urbanization level.

School foods had a HEI-2015 total score of 50.8 and there was no trend in diet quality by urbanization level. The absence of differences in diet quality of school foods across different urbanization levels may be due to guidance about the nutritional quality of school meals that is standardized by federal legislation and federal school nutrition programs (38–40). This may underscore the importance of school foods in achieving recommended intakes of several food groups, regardless of urbanization level.

Statistically significant differences may not always reflect meaningful differences in dietary quality. Others have suggested that differences in HEI scores of 5–6 points between independent groups have the potential to be meaningful (24). In our analyses of differences in HEI-2015 scores by urbanization, except for the difference by urbanization in adjusted HEI-2015 total scores for other outlets, statistically significant differences were all less than 5 points. Some of the larger statistically significant differences were between 3 and 4 points, specifically the differences between non-MSAs and large MSAs in the overall adjusted HEI-2015 total score of 3.2 points and for grocery stores of 3.9 points.

Limitations of this study include the use of self-reported (proxy reported for children and adolescents) dietary data, which is subject to misreporting due to reliance on memory and allows for bias in under or over reporting of foods and nutrients (47–49). Additionally, this analysis combined three two-year cycles of NHANES (2013–2014, 2015–2016 and 2017–2018) to ensure sufficient sample size to stratify by food outlet category. However, it is generally recommended that the version of the HEI used correspond to the dietary guidelines in place at the time of data collection (50); for the NHANES 2013–2014 this would be HEI-2010. Furthermore, NHANES surveys, like other national surveys, have seen ongoing decreases in overall response rates, however non-response bias investigations have shown that errors in representation were minimized with weighting adjustments (51). Also, some groups may have been too underpowered to detect significant differences in HEI scores by urbanization. Sample size limitations also preclude the ability to examine HEI scores by subgroups like age or race and Hispanic origin. Residual confounding may be present due to the use of only two age groups and family income levels for adjustment in regression models. Another limitation is the use of the Simple HEI Scoring Algorithm Per-Person method, based on Day 1 recalls. Although this method allows for adjustment by covariates, it has been shown to be susceptible to bias (52). This bias could account for the lower estimates of HEI-2015 total and component scores in this current analysis, compared to those presented by Vinyard et al. (38). The population ratio method is recommended when only one 24-hour recall is used; however, as mentioned above this method isn't flexible enough to allow for adjustment by covariates. The Multivariate Markov Chain Monte Carlo (MCMC method) is recommended (53) for HEI, although the programming is currently under development (31).

Strengths of this study include using nationally representative data, which provides a high degree of generalizability. The results presented are, to our knowledge, the first nationally representative estimates of diet quality for foods obtained and consumed from different food outlets by urbanization level. Also, this study examined groups of foods that were consumed on a given day from outlets as opposed to foods that were purchased. This may contribute to better characterization of diet as it doesn't include food lost to waste. This study also used definitions of food outlets that separated grocery stores and convenience stores, which have not been well explored in the context of diet quality.

CONCLUSION

Grocery stores and restaurants were the largest contributors of energy intake. Additionally, diet quality, based on HEI-2015 scores, increased with urbanization overall and for foods consumed from grocery stores and quick-service restaurants.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

N.A., E.A.W. C.L.O., and C.H. conceived the study; N.A., and E.A.W. analyzed the data; N.A., E.A.W. C.L.O., C.H., M.Z., K.A.H., and J.R. interpreted the data, and made critical revisions of the manuscript; N.A., and C.L.O., had primary responsibility for the final content. All authors read and approved the final manuscript. None of the authors had a personal or financial conflict of interest.

Funding Support:

No external funding supported this research

List of Abbreviations:

NCHS	National Center for Health Statistics
AMPM	Automated Multiple-Pass Method
DGA	Dietary Guidelines for Americans
FPED	Food Patterns Equivalents Database
MEC	mobile examination center
NHANES	National Health and Nutrition Examination Survey
WWEIA	What We Eat in America

REFERNCES

1. Ko LK, Enzler C, Perry CK, Rodriguez E, Mariscal N, Linde S, Duggan C. Food availability and food access in rural agricultural communities: use of mixed methods. BMC Public Health 2018;18(1):634. doi: 10.1186/s12889-018-5547-x. [PubMed: 29769045]
2. Euler R, Jimenez EY, Sanders S, Kuhlemeier A, Van Horn ML, Cohen D, Gonzales-Pacheco D, Kong AS. Rural-Urban Differences in Baseline Dietary Intake and Physical Activity Levels of Adolescents. Prev Chronic Dis 2019;16:E01. doi: 10.5888/pcd16.180200. [PubMed: 30605423]

3. Ogden CL, Fryar CD, Hales CM, Carroll MD, Aoki Y, Freedman DS. Differences in Obesity Prevalence by Demographics and Urbanization in US Children and Adolescents, 2013–2016. Jama 2018;319(23):2410–8. doi: 10.1001/jama.2018.5158. [PubMed: 29922826]

4. Hales CM, Fryar CD, Carroll MD, Freedman DS, Aoki Y, Ogden CL. Differences in Obesity Prevalence by Demographic Characteristics and Urbanization Level Among Adults in the United States, 2013–2016. Jama 2018;319(23):2419–29. doi: 10.1001/jama.2018.7270. [PubMed: 29922829]

5. Hubley TA. Assessing the proximity of healthy food options and food deserts in a rural area in Maine. Applied Geography 2011;31(4):1224–31. doi: 10.1016/j.apgeog.2010.09.004.

6. Liese AD, Weis KE, Pluto D, Smith E, Lawson A. Food store types, availability, and cost of foods in a rural environment. J Am Diet Assoc 2007;107(11):1916–23. doi: 10.1016/j.jada.2007.08.012. [PubMed: 17964311]

7. Vilaro MJ BT. The Rural Food Environment: A Survey of Food Price, Availability, and Quality in a Rural Florida Community. Food and Public Health 2013;3(3):111–8. doi: 10.5923/j.fph.20130303.01.

8. National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) Internet: https://www.cdc.gov/chronicdisease/pdf/factsheets/Rural-Health-Overview-H.pdf (accessed June 16 2021).

9. McCullough ML, Chantaprasopsuk S, Islami F, Rees-Punia E, Um CY, Wang Y, Leach CR, Sullivan KR, Patel AV. Association of Socioeconomic and Geographic Factors With Diet Quality in US Adults. JAMA Network Open 2022;5(6):e2216406-e. doi: 10.1001/jamanetworkopen.2022.16406. [PubMed: 35679041]

10. Cafer A, Mann G, Ramachandran S, Kaiser M. National Food Affordability: A County-Level Analysis. Prev Chronic Dis 2018;15:E115. doi: 10.5888/pcd15.180079. [PubMed: 30240570]

11. Vilar-Compte M, Burrola-Méndez S, Lozano-Marrufo A, Ferré-Eguiluz I, Flores D, Gaitán-Rossi P, Teruel G, Pérez-Escamilla R. Urban poverty and nutrition challenges associated with accessibility to a healthy diet: a global systematic literature review. International Journal for Equity in Health 2021;20(1):40. doi: 10.1186/s12939-020-01330-0. [PubMed: 33472636]

12. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025 9th Edition. December 2020., 2020.

13. McCormack LA, Meendering J. Diet and Physical Activity in Rural vs Urban Children and Adolescents in the United States: A Narrative Review. J Acad Nutr Diet 2016;116(3):467–80. doi: 10.1016/j.jand.2015.10.024. [PubMed: 26685123]

14. Ahluwalia N, Dwyer J, Terry A, Moshfegh A, Johnson C. Update on NHANES Dietary Data: Focus on Collection, Release, Analytical Considerations, and Uses to Inform Public Policy. Advances in nutrition (Bethesda, Md) 2016;7(1):121–34. doi: 10.3945/an.115.009258. [PubMed: 26773020]

15. Chen TC, Clark J, Riddles MK, Mohadjer LK, Fakhouri THI. National Health and Nutrition Examination Survey, 2015–2018: Sample design and estimation procedures. National Center for Health Statistics. Vital Health Stat 2(184) 2020.

16. Johnson CL, Dohrmann SM, Burt VL, Mohadjer LK. National Health and Nutrition Examination Survey: Sample design, 2011–2014. Vital Health Stat National Center for Health Statistics, 2014.

17. National Center for Health Statistics. Internet: https://wwwn.cdc.gov/nchs/nhanes/responserates.aspx#response-rates (accessed Jan 6 2021).

18. Agricultural Research Service. Internet: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/wweianhanes-overview/.

19. Rhodes DG, Adler ME, Clemens JC, Moshfegh AJ. What we eat in America food categories and changes between survey cycles. J Food Comp and Analysis 2017. doi: 10.1016/j.jfca.2017.07.018.

20. Centers for Disease Control and Prevention. Internet: https://wwwn.cdc.gov/nchs/nhanes/AnalyticGuidelines.aspx.

21. Kirkpatrick SI, Guenther PM, Subar AF, Krebs-Smith SM, Herrick KA, Freedman LS, Dodd KW. Using Short-Term Dietary Intake Data to Address Research Questions Related to Usual Dietary Intake among Populations and Subpopulations: Assumptions, Statistical Techniques,

and Considerations. Journal of the Academy of Nutrition and Dietetics 2022. doi: 10.1016/j.jand.2022.03.010.

22. Moshfegh AJ, Rhodes DG, Baer DJ, Murayi T, Clemens JC, Rumpler WV, Paul DR, Sebastian RS, Kuczynski KJ, Ingwersen LA, et al. The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. The American Journal of Clinical Nutrition 2008;88(2):324–32. doi: 10.1093/ajcn/88.2.324. [PubMed: 18689367]
23. US Department of Agriculture ARS. Internet: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fped-overview/ (accessed Sep 14 2022).
24. Kirkpatrick SI, Reedy J, Krebs-Smith SM, Pannucci TE, Subar AF, Wilson MM, Lerman JL, Tooze JA. Applications of the Healthy Eating Index for Surveillance, Epidemiology, and Intervention Research: Considerations and Caveats. J Acad Nutr Diet 2018;118(9):1603–21. doi: 10.1016/j.jand.2018.05.020. [PubMed: 30146072]
25. Krebs-Smith SM, Pannucci TE, Subar AF, Kirkpatrick SI, Lerman JL, Tooze JA, Wilson MM, Reedy J. Update of the Healthy Eating Index: HEI-2015. J Acad Nutr Diet 2018;118(9):1591–602. doi: 10.1016/j.jand.2018.05.021. [PubMed: 30146071]
26. Reedy J, Lerman JL, Krebs-Smith SM, Kirkpatrick SI, Pannucci TE, Wilson MM, Subar AF, Kahle LL, Tooze JA. Evaluation of the Healthy Eating Index-2015. J Acad Nutr Diet 2018;118(9):1622–33. doi: 10.1016/j.jand.2018.05.019. [PubMed: 30146073]
27. Ingram D, Franco S. 2013 NCHS urban–rural classification scheme for counties. Vital Health Stat: National Center for Health Statistics, 2014.
28. National Center for Health Statistics. Internet: https://www.cdc.gov/rdc/.
29. US Department of Agriculture Food and Nutrition Service. Internet: https://www.fns.usda.gov/snap/recipient/eligibility (accessed Jan 6 2021).
30. US Department of Agriculture Food and Nutrition Service. Internet: https://www.govinfo.gov/content/pkg/FR-2019-03-20/pdf/2019-05183.pdf (accessed Jan 6 2021).
31. National Cancer Institute. Internet: https://epi.grants.cancer.gov/hei/.
32. Centers for Disease Control and Prevention. Guide for Measuring Alcohol Outlet Density 2017.
33. Parker JD, Talih M, Malec DJ, et al. National Center for Health Statistics Data Presentation Standards for Proportions. National Center for Health Statistics Vital Health Stat 2017(175).
34. Klein RJ SC. Age adjustment using the 2000 projected U.S. population. Healthy People 2010 Statistical Notes Hyattsville, MD: National Center for Health Statistics, 2001.
35. SAS Institute Inc. SAS [computer program] Version 9.4. Cary, NC: SAS Institute Inc., 2013.
36. SUDAAN. Release 11.0,. . Research Triangle Park (NC), 2012.
37. National Center for Health Statistics. Internet: https://wwwn.cdc.gov/nchs/nhanes/default.aspx.
38. Vinyard M, Zimmer M, Herrick KA, Story M, Juan W, Reedy J. Healthy Eating Index-2015 Scores Vary by Types of Food Outlets in the United States. Nutrients 2021;13(8):2717. doi: 10.3390/nu13082717. [PubMed: 34444877]
39. Liu J, Micha R, Li Y, Mozaffarian D. Trends in Food Sources and Diet Quality Among US Children and Adults, 2003–2018. JAMA network open 2021;4(4):e215262-e. doi: 10.1001/jamanetworkopen.2021.5262. [PubMed: 33844000]
40. Liu J, Rehm CD, Micha R, Mozaffarian D. Quality of Meals Consumed by US Adults at Full-Service and Fast-Food Restaurants, 2003–2016: Persistent Low Quality and Widening Disparities. J Nutr 2020;150(4):873–83. doi: 10.1093/jn/nxz299. [PubMed: 31995199]
41. Neckerman KM, Lovasi L, Yousefzadeh P, Sheehan D, Milinkovic K, Baecker A, Bader MDM, Weiss C, Lovasi GS, Rundle A. Comparing Nutrition Environments in Bodegas and Fast-Food Restaurants. Journal of the Academy of Nutrition and Dietetics 2014;114(4):595–602. doi: 10.1016/j.jand.2013.07.007. [PubMed: 24035459]
42. Thomson JL, Goodman MH, Landry AS. Measurement of Nutrition Environments in Grocery Stores, Convenience Stores, and Restaurants in the Lower Mississippi Delta. Preventing chronic disease 2020;17:E24-E. doi: 10.5888/pcd17.190293. [PubMed: 32163354]

43. Wellard-Cole L, Davies A, Allman-Farinelli M. Contribution of foods prepared away from home to intakes of energy and nutrients of public health concern in adults: a systematic review. Critical Reviews in Food Science and Nutrition 2021:1–12. doi: 10.1080/10408398.2021.1887075.
44. Saksena MJ, Okrent AM, Anekwe TD, Cho C, Dicken C, Effland A, Elitzak H, Guthrie J, Hamrick KS, Hyman J, et al. America's Eating Habits: Food Away From Home In: AMO Michelle Saksena, and Hamrick Karen S., ed. EIB-196 ed: U.S. Department of Agriculture, Economic Research Service, 2018.
45. Darmon N, Drewnowski A. Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis. Nutrition Reviews 2015;73(10):643–60. doi: 10.1093/nutrit/nuv027. [PubMed: 26307238]
46. Hardin-Fanning F, Rayens MK. Food Cost Disparities in Rural Communities. Health Promotion Practice 2014;16(3):383–91. doi: 10.1177/1524839914554454. [PubMed: 25305093]
47. Subar AF, Freedman LS, Tooze JA, Kirkpatrick SI, Boushey C, Neuhouser ML, Thompson FE, Potischman N, Guenther PM, Tarasuk V, et al. Addressing Current Criticism Regarding the Value of Self-Report Dietary Data. J Nutr 2015;145(12):2639–45. doi: 10.3945/jn.115.219634. [PubMed: 26468491]
48. Church S Sixth International Conference on Dietary Assessment Methods. Nutrition Bulletin 2016;31:262–7.
49. Shim JS, Oh K, Kim HC. Dietary assessment methods in epidemiologic studies. Epidemiology and health 2014;36:e2014009. doi: 10.4178/epih/e2014009. [PubMed: 25078382]
50. National Cancer Institute. Internet: https://epi.grants.cancer.gov/hei/comparing.html (accessed Sep 14 2022).
51. Fakhouri THI MC, Chen TC, Akinbami LJ, Ogden CL, Paulose-Ram R, et al. . An investigation of nonresponse bias and survey location variability in the 2017−2018 National Health and Nutrition Examination Survey. Vital Health Stat National Center for Health Statistics, 2020.
52. Freedman LS, Guenther PM, Krebs-Smith SM, Kott PS. A population's mean Healthy Eating Index-2005 scores are best estimated by the score of the population ratio when one 24-hour recall is available. J Nutr 2008;138(9):1725–9. doi: 10.1093/jn/138.9.1725. [PubMed: 18716176]
53. National Cancer Institute. Internet: https://prevention.cancer.gov/research-groups/biometry/measurement-error-impact/software-measurement-error (accessed Sep 14 2022).

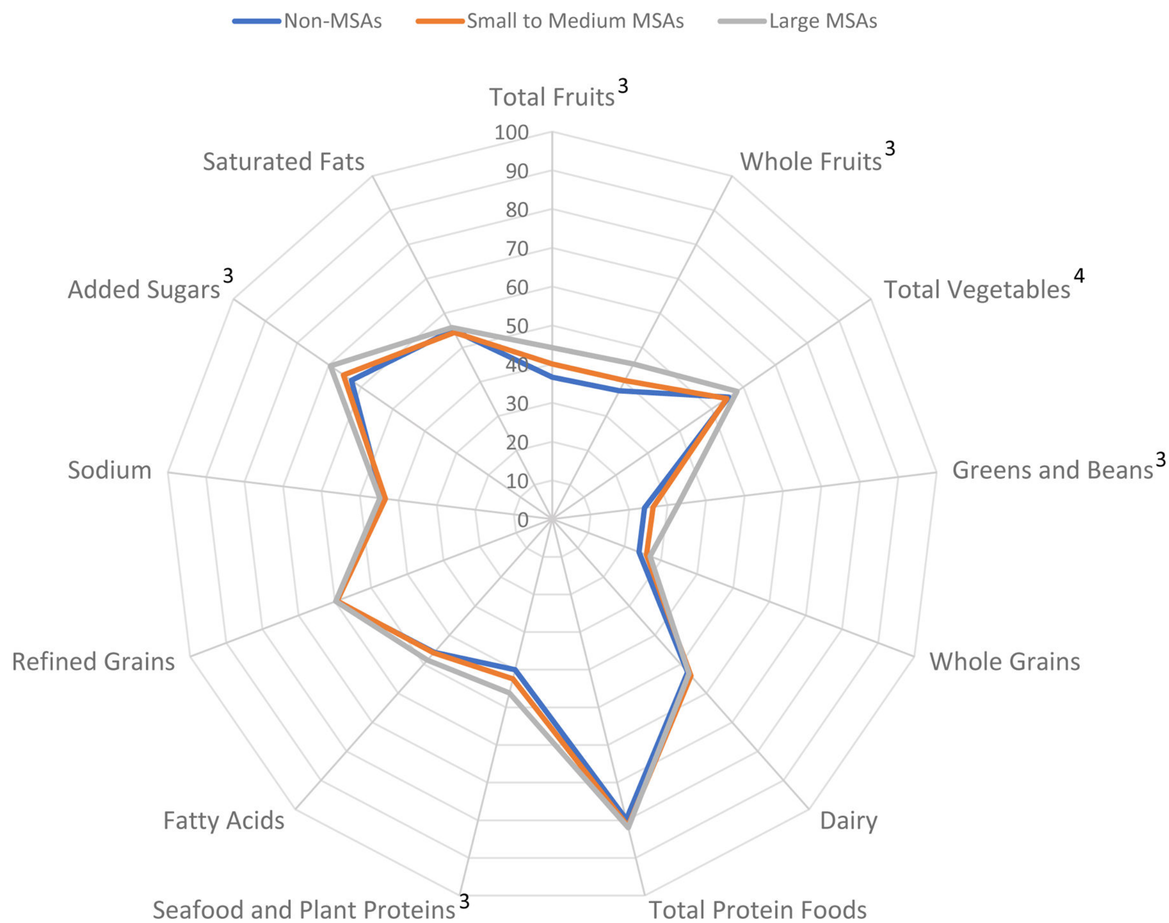

Figure 1.

HEI-2015 Component Score by urbanization levels, study population aged 2 years and older, 2013–2018[1,2]

[1] Data from the National Health and Nutrition Examination Survey 2013–2018; MSA - Metropolitan statistical area.

[2] HEI-2015 scores are adjusted for age, sex, race and Hispanic origin and family income

[3] Significant linear trend with increasing urbanization level (p<0.01)

[4] Significant linear trend with increasing urbanization level (p<0.05)

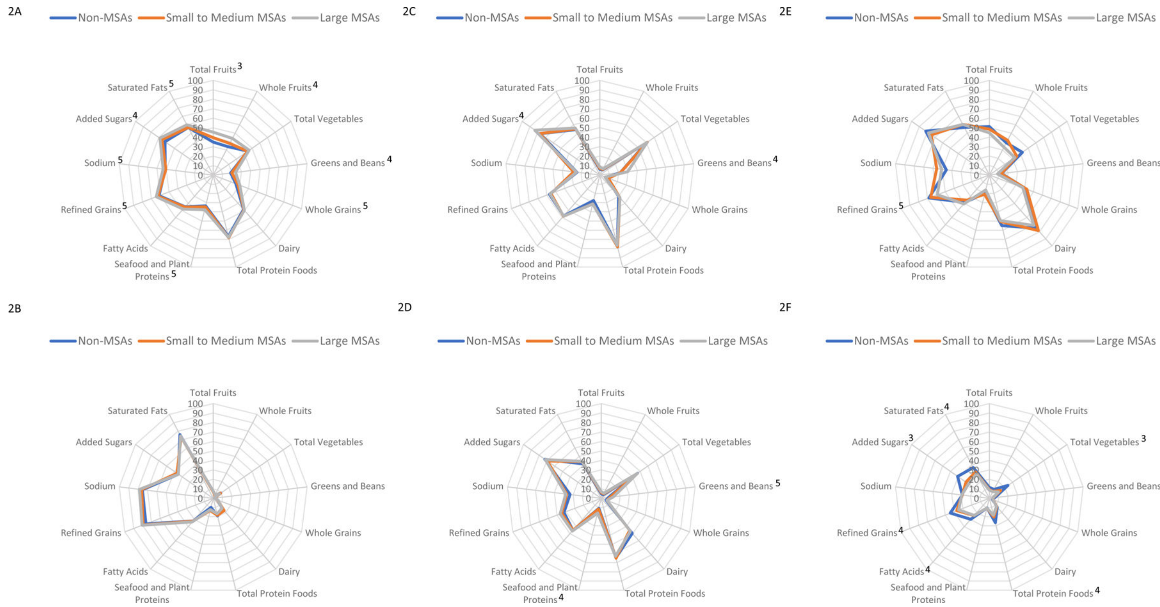

Figure 2.

HEI-2015 component scores by urbanization levels and food outlet, study population aged 2 years and older, 2013–2018[1,2], (2A) grocery stores, (2B) convenience stores, (2C) full-service restaurants, (2D) quick service restaurants, (2E) schools, (2F) other

[1] Data from the National Health and Nutrition Examination Survey 2013–2018; MSA - Metropolitan statistical area.

[2] HEI-2015 scores are adjusted for age, sex, race and Hispanic origin and family income

[3] Significant linear trend with increasing urbanization level ($p<0.001$)

[4] Significant linear trend with increasing urbanization level ($p<0.01$)

[5] Significant linear trend with increasing urbanization level ($p<0.05$)

Table 1.

Characteristics of study population 2 years and older, 2013–2018 [1]

Characteristics	Unweighted Sample Size	Weighted %	SE[3]
Urbanization Level[2]			
Non-MSAs	3274	15.2	3.8
Small to Medium MSAs	7658	37.0	5.9
Large MSAs	12175	47.8	4.8
Age (years)			
2–19	8301	24.0	0.6
20 and older	14806	76.0	0.6
Sex			
Male	11292	48.9	0.4
Female	11815	51.1	0.4
Race and Hispanic Origin			
Non-Hispanic White	8077	61.0	2.1
Non-Hispanic Black	5136	11.9	1.1
Non-Hispanic Asian	2399	5.4	0.6
Non-Hispanic Other	1207	4.4	0.3
Hispanic	6288	17.4	1.5
Family Income			
< 130% Federal poverty level	7507	25.1	1.2
≥ 130% Federal poverty level	13545	75.0	1.2

[1]Data from the National Health and Nutrition Examination Survey 2013–2018

[2]MSA - metropolitan statistical areas; Non-MSAs - Counties in or not within micropolitan statistical areas; Small to medium MSAs - Counties within MSAs of 50,000–999,999 population; Large MSAs - counties of MSAs of 1 million or more population.

[3]SE – Standard Error

Table 2.

Unadjusted and adjusted predicted mean percentage of total energy intake of foods obtained from selected food outlets by urbanization level, study population aged 2 years and older, 2013–2018[1]

Food Outlet	Unadjusted								Adjusted[2]							
			Urbanization Level								Urbanization Level					
	Total		Non-MSAs		Small to Medium MSAs		Large MSAs		Total		Non-MSAs		Small to Medium MSAs		Large MSAs	
	%	95% CI[3]	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Grocery Stores	62.1	(61.1–63.1)	63.1	(59.8–66.5)	62.0	(60.4–63.6)	61.9	(60.6–63.1)	61.9	(60.8–63.0)	63.3	(60.2–66.5)	61.8	(60.3–63.4)	61.6	(60.3–62.8)
Convenience Stores	4.8	(4.4–5.3)	6.7[4]	(5.2–8.1)	5.1	(4.5–5.6)	4.0	(3.6–4.5)	4.8	(4.4–5.2)	6.2[4]	(5.1–7.3)	5.1	(4.5–5.7)	4.1	(3.6–4.6)
Full-Service Restaurants	8.5	(7.9–9.0)	6.4[4]	(4.8–7.9)	8.2	(7.6–8.8)	9.3	(8.6–10.1)	8.5	(8.0–9.1)	6.5[4]	(4.7–8.3)	8.1	(7.6–8.7)	9.5	(8.6–10.4)
Quick-Service Restaurants	15.1	(14.4–15.8)	12.2[5]	(10.9–13.5)	14.8	(13.5–16.1)	16.3	(15.5–17.0)	15.2	(14.6–15.9)	12.3[5]	(11.0–13.6)	15.0	(13.7–16.3)	16.4	(15.6–17.1)
Schools	1.7	(1.5–2.0)	2.5[4]	(1.7–3.2)	2.0	(1.5–2.4)	1.3	(1.0–1.5)	1.7	(1.5–2.0)	2.5[5]	(1.9–3.2)	2.0	(1.6–2.4)	1.3	(1.0–1.5)
Other Outlets[6]	7.8	(7.3–8.3)	9.2[7]	(7.8–10.5)	8.0	(7.1–8.8)	7.2	(6.6–7.8)	7.8	(7.3–8.3)	9.1	(7.6–10.6)	8.0	(7.2–8.9)	7.2	(6.6–7.9)

[1] Data from the National Health and Nutrition Examination Survey 2013–2018; MSA - Metropolitan statistical area.

[2] Mean percentages are adjusted for age, sex, race and Hispanic origin, and family income

[3] 95% CI – 95% Confidence Interval

[4] Significant linear trend ($p<0.01$)

[5] Significant linear trend ($p<0.001$)

[6] See Supplementary Table 1 for list of food sources

[7] Significant linear trend ($p<0.05$)

Table 3.

Unadjusted and adjusted predicted HEI-2015 total scores of foods obtained from selected food outlets by urbanization level, study population aged 2 years and older, 2013–2018[1]

Food Outlet	Unadjusted								Adjusted[2]							
			Urbanization Level								Urbanization Level					
	Total		Non-MSAs		Small to Medium MSAs		Large MSAs		Total		Non-MSAs		Small to Medium MSAs		Large MSAs	
	HEI	95% CI	HEI	95% CI	HEI	95% CI	HEI	95% CI	HEI	95% CI	HEI	95% CI	HEI	95% CI	HEI	95% CI
Overall	50.1	(49.4–50.7)	47.6[3]	(45.9–49.2)	49.1	(48.1–50.2)	51.5	(50.8–52.3)	50.0	(49.4–50.7)	48.1[3]	(46.7–49.6)	49.2	(48.1–50.2)	51.3	(50.4–52.2)
Grocery Stores	49.1	(48.3–49.8)	46.2[3]	(44.3–48.1)	48.0	(46.9–49.2)	50.8	(49.9–51.6)	49.1	(48.3–49.8)	46.7[3]	(45.0–48.3)	48.0	(46.9–49.1)	50.6	(49.7–51.6)
Convenience Stores	35.5	(34.9–36.0)	35.0	(34.0–35.9)	35.6	(34.6–36.5)	35.6	(34.8–36.4)	35.5	(35.0–36.0)	34.9	(34.0–35.8)	35.6	(34.7–36.5)	35.6	(34.8–36.4)
Full-Service Restaurants	42.0	(41.4–42.7)	40.7	(39.2–42.3)	41.8	(40.7–42.9)	42.4	(41.6–43.3)	42.0	(41.3–42.7)	40.6	(39.2–42.1)	41.8	(40.7–43.0)	42.4	(41.4–43.4)
Quick Service Restaurants	36.8	(36.4–37.3)	35.7[3]	(34.5–37.0)	36.1	(35.4–36.9)	37.5	(37.0–38.1)	36.8	(36.4–37.3)	35.8[5]	(34.6–37.1)	36.3	(35.5–37.1)	37.5	(36.9–38.1)
Schools	50.8	(49.8–51.9)	51.8	(49.4–54.1)	51.5	(50.0–53.1)	49.5	(47.8–51.2)	50.8	(49.7–51.9)	51.8	(49.2–54.5)	51.8	(50.2–53.4)	49.0	(47.2–50.9)
Other Outlets[6]	20.2	(19.3–21.0)	23.5[4]	(21.4–25.7)	20.0	(18.4–21.6)	19.4	(18.4–20.3)	20.1	(19.3–21.0)	24.0[4]	(22.0–26.1)	20.1	(18.5–21.7)	19.0	(18.1–19.9)

[1] Data from the National Health and Nutrition Examination Survey 2013–2018; MSA - Metropolitan statistical area.

[2] HEI-2015 scores are adjusted for age, sex, race and Hispanic origin, and family income

[3] Significant linear trend (p<0.001)

[4] Significant linear trend (p<0.01)

[5] Significant linear trend (p<0.05)

[6] See Supplementary Table 1 for list of food sources