The Journal of Nutrition, Health and Aging 28 (2024) 100379

Contents lists available at ScienceDirect

The Journal of Nutrition, Health and Aging

journal homepage: www.elsevier.com/locate/jnha

Original Article

Diet quality in U.S. adults eating in senior and community centers: NHANES 2009-2018

Maximilian Andreas Storz [a,*], Alvaro Luis Ronco [b,c]

[a] Department of Internal Medicine II, Centre for Complementary Medicine, Medical Center – University of Freiburg, Faculty of Medicine, University of Freiburg, Germany
[b] Unit of Oncology and Radiotherapy, Pereira Rossell Women's Hospital, Bvard. Artigas 1590, 11600 Montevideo, Uruguay
[c] Biomedical Sciences Center, University of Montevideo, Puntas de Santiago 1604, 11500 Montevideo, Uruguay

ARTICLE INFO

Keywords:
Community/Senior center
Nutrient intake
Diet quality
Meal program
NHANES

ABSTRACT

Background: With advancing age, the worsening of cognitive and physical disabilities may lead older adults to seek help in their daily living activities. Community/senior centers support older adults during aging, offering a wide variety of services, including meal programs. Using data from the National Health and Nutrition Examination Surveys (2009–2018), we aimed to examine whether community/senior center meal programs were associated with an improved nutritional exposure in U.S. adults aged 60 years or older.

Methods: Nutrient exposure and nutrient-based dietary indexes, including the Diet Quality Score (DQS) and the Food Nutrient Index (FNI) were compared between those eating meals at community/senior centers and the general population. Nutrient intakes were contrasted to the daily nutritional goals from the Dietary Guidelines for Americans.

Results: This study included 6261 participants aged ≥60 years, thereof $n = 421$ reporting community/senior center meals. The latter were predominantly female and almost 45% were widowed or divorced. Eating at community/senior centers did not result in a better diet quality in crude analyses. After adjustment for potential sociodemographic confounders as well as alcohol, smoking and energy intake, however, sex-specific differences emerged, revealing significantly higher FNI scores in males eating at community/senior centers (adjusted FNI predictions: 61.71 [CI:58.55–64.88] vs 57.64 [CI:56.86−58.41] points).

Conclusions: Eating at community/senior centers was associated with an improved nutrient exposure in older men, whereas no better diet quality was found in women. Community/senior centers may play a pivotal role when it comes to the diet quality of a particularly vulnerable group of the population.

1. Introduction

Poor diet quality is a major risk factor for numerous chronic diseases [1–3]. Older adults are at a particular risk for nutritional deficiencies [4,5], which have been shown to contribute to disability, frailty, and death among seniors [6].

In contrast, improvements in nutrition were associated with tangible benefits to older people, and many age-related conditions may be prevented or ameliorated by a proper diet [5]. In this context, healthier dietary habits were associated with cardiometabolic disease–free life expectancy between the ages of 50 and 85 [7].

Descriptive nutritional epidemiology has recently focused on the presence of suboptimal dietary intakes among free-living older U.S. Americans and their nutrient exposure [4,6]. Despite using different databases and data sources, these studies resulted in comparable conclusions: only a small fraction of the examined populations had a good quality diet, whereas the majority of older adults had diets considered poor or needing improvement [4,6].

With advancing age, the onset or worsening of cognitive and physical disabilities may lead older adults to seek help in their activities of daily living, such as meal preparation and cooking [8,9]. Several studies have recently investigated the food intake of older adults receiving home-

Abbreviations: AMDR, Acceptable Macronutrient Distribution Range; BMI, Body Mass Index; CI, Confidence Interval; CDRR, Chronic Disease Risk Reduction; DGA, Dietary Guidelines for Americans; DNG, Daily Nutritional Goal; DQS, Diet Quality Score; DRI, Dietary References Intakes; FNI, Food Nutrient Index; NCHS, National Center for Health Statistics; NHANES, National Health and Nutrition Examination Survey; RDA, Recommended Dietary Allowance; TNI, Total Nutrient Index.

* Corresponding author.
E-mail address: maximilian.storz@uniklinik-freiburg.de (M.A. Storz).

http://doi.org/10.1016/j.jnha.2024.100379
Received 4 June 2024; Received in revised form 19 September 2024; Accepted 22 September 2024
Available online xxx
1279-7707/

delivered meal services [8,10]. To this point, however, another important part of the population has received little attention: older adults who regularly eat meals at community/senior centers [11].

Located in cities nationwide, the approximately 11,000 senior centers in the United States play a pivotal role in supporting older adults during aging [12,13]. These centers serve more than 1 million older adults every day in their communities and neighborhoods, offering a wide variety of services, including meal and nutrition programs [13]. Whether these programs are associated with an improved nutritional status remains unknown, and has never been assessed using large epidemiological US-based survey datasets.

To address this gap in the literature, we compared nutrient intake data (and thereof calculated nutrient-based dietary indexes) between the non-institutionalized NHANES (National Health and Nutrition Examination Survey) general population aged 60 years or older and NHANES participants eating at senior/community centers. Nutrient intakes were also contrasted to the Dietary Guidelines for Americans (DGA) to identify potentially critical nutrients in those participants eating at senior/community centers [14].

2. Materials and methods

2.1. Study population and design

The NHANES is a nationally representative, cross-sectional epidemiological survey of the non-institutionalized, civilian US population, and employs a complex, stratified, multistage probability cluster sampling design [15–18]. This design ensures that sample populations are representative of the nation's non-institutionalized civilians, and allows for estimates of health-related statistics that would have been only obtained if the entire U.S. population had been surveyed [19,20]. NHANES data is collected from household interviews and from standardized medical examinations, including blood sample collections and anthropometric assessments performed in mobile examination centers. NHANES has been continuous since 1999 and involves a sample of approximately 5000 participants per annum [21]. Participants provided written informed consent, and study procedures were approved by the National Center for Health Statistics Research Ethics Review Board [22,23]. Considering the nature of the employed dataset and the outcomes of interest for this study, only NHANES participants aged 60 years or older were included for this analysis.

2.2. Primary outcome: nutrient exposure

The assessment of nutrient exposures is critical for evaluating population-level adherence to dietary recommendations, and to capture associations between health and diet [24]. The primary outcome of our study was the Food Nutrient Index (FNI) - a dietary supplement-free version of the Total Nutrient Index (TNI) developed by Cowan et al. [24]. The FNI was selected for its ability to assess micronutrient exposures of under-consumed micronutrients among US adults [24,25]. This score has been validated with NHANES data before, and includes a total of eight nutrients (calcium, magnesium, potassium, and choline as well as the vitamins A, C, D, and E). The FNI is scored from 0 to 100 and truncated at 100% of the respective standard [24,25]. Higher FNI scores indicate a better diet quality and closer adherence to the DGA in terms of critical nutrients.

As done earlier, we used the FNI in conjunction with the Diet Quality Score (DQS) by Fitzgerald, Dewar, and Veugelers [26,27]. The DQS is not confined to under-consumed nutrients but aggregates a total of 17 nutrients (carbohydrate, fat, saturated fat, protein, thiamin, riboflavin, niacin, phosphorus, magnesium, iron, zinc, selenium, and vitamins A, B6, B12, C, and E) into an overall summary measure. Designed to assess an individual's compliance with the Dietary References Intakes (DRI) for the aforementioned nutrients, a value of 1 is given for each age- and gender-specific nutrient recommendation met (see Supplementary Table S1) [26,28]. A value of 0 is assigned for each nutrient intake recommendation that was not met. The values are then summed, resulting in an overall score ranging from 0 to 17 points [26].

Nutrient intakes to compute the DQS and FNI were obtained from the NHANES dietary module, which is based on two 24-h dietary recalls employing a computer-assisted dietary interview software program [29,30]. In order to obtain a more complete picture of the usual dietary intake of the U.S. population, a second dietary interview for all participants who complete the in-person recall was added to the NHANES. The second dietary recall administered by telephone was not considered for this particular analysis in order to maintain an adequate sample size in the "participants eating at senior centers" group. While potentially losing some precision [31], a single 24-h recall has been considered sufficient to describe mean dietary intakes and is considered adequate for descriptive epidemiologic purposes [27,29]. No modelling techniques were employed to estimate usual intakes over time. Finally, we only considered participants with a reliable dietary recall status. For this, a special NHANES variable ("dr1drstz ") indicating the quality and completeness of a survey participant's response to the dietary recall section was used.

2.3. Secondary outcome: nutrient intake in relation to the DGA

Following an approach described earlier [32,33], we contrasted nutrient intake profiles of participants eating at senior/community centers with the daily nutritional goals (DNG) specified in the current 2020–2025 DGA [14].

All nutrients displayed in the DNG Tables A1-A2 in the 2020–2025 DGA were considered for this analysis [14]. The DGA is the cornerstone of the US Federal nutrition policy designed to provide food-based dietary recommendations for the US population [34]. Published jointly by the US Department of Health and Human Services and the US Department of Agriculture, the DGA are released every 5 years [34]. In the appendix, the DGA include age and sex-specific nutritional goals in a multi-page table format. This format was applied here, and color-coded descriptive comparisons were performed (red: goal not met; green: goal met). The DNG in the 2020–2025 DGA stem from various sources and concepts (including Adequate Intake (AI), Acceptable Macronutrient Distribution Range (AMDR), Chronic Disease Risk Reduction (CDRR), and the Recommended Dietary Allowance (RDA)), and have been discussed elsewhere in detail [32].

2.4. Covariates

Covariates included sociodemographic and anthropometric factors known to be associated with an impaired nutrient intake. Demographic data included: sex (male, female; categorical), age (continuous), race/ethnicity (Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other Race; categorical), marital status (married/living with partner, widowed/divorced/separated, never married; categorical), household income (less or $\geq$ 20000 US$ per annum; categorical), education level (less than 9th grade, 9−11th grade, high school graduate, some college or associate degree, college graduate or above; categorical) and body mass index (BMI; continuous). Alcohol intake was assessed by the question "In any one year, have you had at least 12 drinks of any type of alcoholic beverage?" whereas smoking history was assessed with the question "Have you smoked at least 100 cigarettes in your entire life?".

The question "in the past 12 months, did you go to a community program or senior center to eat prepared meals?" was used to determine whether participants ate at community/senior centers. Of note, this question also included adult day care and was posed to all male and females NHANES participants aged 60 years or older. For this reasons, participants who were younger than 60 years could not be considered in this analysis. While the plural in the question ("meals") implies regularity, NHANES did not provide us with an exact frequency variable.

2.5. Statistical analysis

The statistical analysis was performed with STATA 14 statistical software (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP). After merging multiple NHANES modules (Supplementary Table S2), and after appending five consecutive cycles (2009–2010 through 2017–2018), we constructed a 10-year weight for dietary data in accordance with the NHANES weighting module and the analytic guidelines. Weighted survey analyses were performed using Stata's "svyset" and "svy" commands. Only participants without missing data on any of the included variables were considered. Data distribution was examined via histograms and subpopulation summary statistics. Normally distributed data was described with the mean and corresponding 95%-confidence interval, whereas categorical variables were described with their weighted proportions and 95%-confidence interval.

All weighted proportions were checked for reliability based on the 2017 NCHS (National Center for Health Statistics) data presentation standards for proportions [35]. These standards require the investigator to glance at the Korn-Graubard confidence interval (CI), along with CI widths, the sample size, and the degrees of freedom when assessing the reliability of a proportion [36]. For practical purposes, we employed Ward's post-estimation command "kg_nchs" in Stata, and flagged unreliable proportions with a "**" symbol.

Table 1
Sample characteristics of the examined study population (NHANES, 2009–2018): general population vs. participants eating at community/senior centers.

	General population $n = 5840$	Community/Senior center eaters $n = 421$	p-value
Sex			$p = 0.001$ [b]
Males	46.43% [45.03–47.83]	35.22% [29.89–40.94] *	
Females	53.57% [52.17–54.97]	64.78% [59.06–70.11] *	
Age (years)	69.40 [69.11–69.69]	73.28 [72.26–74.31]	$p < 0.001$ [c]
Race/ethnicity			$p = 0.261$ [b]
Mexican American	4.31% [3.03–6.10]	2.99 % [1.60–5.51]	
Other Hispanic	3.53% [2.63–4.72]	2.02 % [1.19–3.41] *	
Non-Hispanic White	78.31% [75.19–81.14]	77.17 % [68.11–84.25]	
Non-Hispanic Black	8.47% [6.98–10.25]	9.69% [6.52–14.15]	
Other Race [a]	5.38% [4.39–6.57]	8.13% [3.65–17.15] **	
Marital status			$p < 0.001$ [b]
Married/living with partner	65.98 % [63.82–68.07]	45.47 % [38.48–52.64] *	
Widowed/divorced/separated	29.93 % [28.02–31.90]	46.41 % [38.79–54.20] *	
Never married	4.10 % [3.45–4.86]	8.12 % [5.76–11.34] *	
Annual household income			$p < 0.001$ [b]
<20000 US$	16.07% [14.14–18.21]	38.51% [31.91–45.56] *	
≥20000 US$	83.93% [81.79–85.86]	61.49% [54.44–68.09] *	
Alcohol intake (≥12 drinks/yr)			$p < 0.001$ [b]
No	29.01% [26.67–31.45]	42.29% [36.16–48.66] *	
Yes	70.99% [68.55–73.31]	57.71% [51.34–63.84] *	
At least 100 cigarettes in life			$p = 0.064$ [b]
Yes	50.79% [48.94–52.63]	44.89% [39.02–50.90]	
No	49.21% [47.37–51.06]	55.11% [49.10–60.98]	
Educational level			$p < 0.001$ [b]
Less than 9th grade	7.19% [6.07–8.50]	10.13% [7.12–14.23]	
9–11th grade	10.39% [9.02–11.94]	13.11% [8.33–20.04]	
High school graduate/GED [d]	22.40% [20.72–24.17]	29.33% [24.66–34.49] *	
Some college or AA degree	31.16% [29.05–33.36]	32.09% [27.70–36.83]	
College graduate or above	28.86% [25.97–31.93]	15.33% [10.49–21.85] *	
Body mass index (kg/m^2)	29.31 [29.02–29.61]	28.92 [27.90–29.95]	$p = 0.430$ [c]

Weighted proportions. Total number of unweighted observations: $n = 6{,}261$. Continuous variables shown as mean [95%-confidence interval]. Categorical variables shown as weighted proportions [95%-confidence interval]. a = includes multi-racial; b = based on Stata's design-adjusted Rao–Scott test; c = based on regression analyses followed by adjusted Wald tests; d = General Education Diploma or equivalent, * = indicates significant differences in weighted proportions; ** = weighted proportions cannot be considered reliable, as per the recent National Center for Health Statistics Guidelines [35].

To test for potential differences between the general population and NHANES participants eating at senior centers/community centers, we used multivariate linear regression analyses (followed by adjusted Wald tests) and Stata's Rao–Scott test [37]. In an additional analysis, we also used regression analyses followed by adjusted Wald tests to compare crude nutrient intakes between males and females eating at senior centers/community centers. The comparison of crude nutrient intakes to the DGA was performed in a descriptive way, without calculating p-values.

In a last step, we constructed multivariate linear regression models for the FNI and negative binomial regression models for the DQS. Models were constructed for males and females separately, although the same covariates were included in both models. All models were built based on the recommendations of West, Berglund, and Heeringa for regression models in applied survey data analysis [38]. This procedure included exploratory bivariate analyses to identify potential candidate predictors with a significant relationship with the FNI. Only predictor variables of scientific relevance and with a bivariate relationship of significance < 0.25 with the response variable in the initial model were used. Using *t*-tests for individual coefficients and Wald tests for multiple coefficients, we then verified the importance of the included variables and assessed potential changes in all predictor variables in the multivariate model [37]. Following linear regression, we used Stata's marginsplots function to graph statistics from the fitted models. A *p*-value < 0.05 was used as a cutoff for statistical significance.

3. Results

The final sample comprised 6261 participants (see Supplementary Fig. S1). Thereof, 421 participants eating at community/senior centers were included, which may be extrapolated to represent 2,686,683 U.S. Americans.

Participants who reported consuming community/senior center meals were predominantly female and significantly older when compared to the general NHANES population. More than 45% were widowed, divorced or separated and approximately 39% reported an annual household income <$20000. Additional sociodemographic data characterizing the sample may be obtained from Table 1.

Substantial and significant differences were found in terms of macronutrient-, fiber- and total energy intake between the general population and those eating at community/senior centers (Table 2). Mean energy intake was significantly lower in those eating at community/senior centers and this also applied to fiber and protein intake. At the same time, significant differences were also found for those nutrients when comparing males and females within the community/senior center meals group, with significantly lower intakes for almost all nutrients in females.

Comparable patterns were found for many micronutrients and vitamins, with a significantly lower intake of calcium, magnesium, phosphorus, potassium, sodium, riboflavin and niacin as well as choline in those eating at community/senior centers (Table 3). Again, numerous sex-specific differences were found for many of these micronutrients, with lower intakes in females.

In a subsequent step, we performed energy-adjusted analyses (nutrient intakes/1000 kcal). Results may be obtained from Supplementary Table S3, suggesting that differences persisted for only a handful of nutrients, including total protein and total carbohydrate intake. Supplementary Table S3 thus points a pivotal role for total energy intake, which may serve as a conceivable explanation for most intergroup nutrient intake differences.

When comparing mean nutrient intakes to the daily nutritional goals specified in the DGA (Tables 2 and 3), both males and females failed to meet the majority of recommendations. The most evident discrepancies were found for fiber, saturated fatty acid intake, and numerous micronutrients, including calcium, magnesium, potassium and sodium. Likewise, the mean intakes of vitamins A, E and D in both sexes was below the recommended daily intake.

Nutrient based diet quality metrics were then calculated for individuals eating at community/senior centers and contrasted to the

Table 2
Macronutrient and fiber intake in community/senior center eaters in comparison to the general population and in comparison to the Dietary Guidelines for Americans (2020–2025).

Nutrient	General population *n = 5840*	Community/Senior center eaters *n = 421*	*p**	Community/Senior center: males *n = 182*	Source of Goal	DGA M 51+	DNG met?	Community/Senior center: females *n = 239*	DGA F 51+	DNG met?	*p***
Energy intake (kcal/d)	1872.61 [1841.16-1904.05]	1733.14 [1652.37-1813.92]	**0.004**	1915.73 [1785.95-2045.51]		2000	↓	1633.89 [1530.30-1737.49]	1600	↑	**<0.001**
Protein (% kcal)	16.00 [15.77-16.23]	15.29 [14.75-15.84]	**0.021**	15.54 [14.56-16.53]	AMDR	10-35		15.16 [14.40-15.92]	10-35		0.571
Protein (g)	73.13 [71.81-74.46]	65.05 [61.73-68.37]	**<0.001**	73.27 [66.78-79.76]	RDA	56	↑	60.59 [55.64-65.53]	46	↑	**0.008**
Carbohydrate (% kcal)	48.34 [47.85-48.84]	50.76 [49.62-51.89]	**<0.001**	48.58 [46.04-51.13]	AMDR	45-65		51.94 [50.52-53.35]	45-65		**0.041**
Carbohydrate (g)	223.92 [219.40-228.44]	216.59 [205.72-227.46]	0.248	227.30 [211.96-242.65]	RDA	130	↑	210.77 [197.57-223.97]	130	↑	0.069
Fiber (g)	17.05 [16.58-17.51]	15.42 [14.15-16.70]	**0.019**	17.02 [14.40-19.64]	14g/1000 kcal	28	↓	14.56 [13.32-15.79]	22	↓	**0.008**
Total lipid (% kcal)	34.69 [34.32-35.06]	34.51 [33.49-35.53]	0.701	35.66 [33.49-37.84]	AMDR	20-35	↑	33.88 [32.81-34.96]	20-35		0.160
Saturated Fatty Acids (% kcal)	11.19 [11.04-11.34]	11.21 [10.73-11.69]	0.942	11.74 [11.08-12.41]	DGA	<10	↑	10.92 [10.26-11.59]	<10	↑	0.103
18:2 Linoleic acid (g)	15.24 [14.80-15.69]	14.24 [13.00-15.48]	0.169	15.78 [13.62-17.95]	AI	14	↑	13.40 [11.97-14.83]	11	↑	0.059
18:3 Linolenic acid (g)	1.67 [1.60-1.74]	1.62 [1.44-1.80]	0.596	1.99 [1.54- 2.44]	AI	1.6	↑	1.42 [1.28-1.56]	1.1	↑	**0.019**

Data presented as means [95% confidence interval]; significant p-values in bold. p* = indicates differences between the general population and NHANES participants eating at community/senior centers; p** = indicates differences between male and female NHANES participants eating at community/senior centers. AMDR = Acceptable Macronutrient Distribution Range, RDA: Recommended Dietary Allowance, AI = Adequate Intake (based on the Dietary Guidelines for Americans [14]). DNG = Daily Nutritional Goals. %kcal refers to the percentage of total energy intake.

Table 3
Micronutrient and vitamin intake in community/senior center eaters in comparison to the general population and to the Dietary Guidelines for Americans (2020–2025).

Nutrient	General population *n = 5840*	Community/Senior center eaters *n = 421*	*p**	Community/Senior center: males *n = 182*	Source of Goal	DGA M 51+	DNG met?	Community/Senior center: females *n = 239*	DGA F 51+	DNG met?	*p***
Calcium (mg)	877.87 [852.81-902.93]	820.19 [773.33-867.06]	**0.042**	904.88 [818.48-991.29]	RDA	1000	↓	774.15 [710.32-837.99]	1200	↓	**0.030**
Iron (mg)	14.12 [13.73-14.50]	13.82 [12.79-14.86]	0.566	16.23 [13.97-18.48]	RDA	8	↑	12.51 [11.34-13.69]	8	↑	**0.007**
Magnesium (mg)	288.08 [281.52-294.63]	256.65 [242.91-270.39]	**<0.001**	286.43 [257.79-315.06]	RDA	420	↓	240.47 [225.71-255.22]	320	↓	**0.005**
Phosphorus (mg)	1254.64 [1230.12-1279.16]	1147.97 [1098.21-1197.72]	**0.001**	1285.18 [1193.10-1377.27]	RDA	700	↑	1073.38 [1001.52-1145.24]	700	↑	**0.002**
Potassium (mg)	2639.28 [2588.17-2690.39]	2418.53 [2323.50-2513.56]	**<0.001**	2689.59 [2526.59-2852.59]	AI	3400	↓	2271.19 [2154.88-2387.50]	2600	↓	**<0.001**
Sodium (mg)	3123.33 [3064.83-3181.82]	2887.45 [2682.65-3092.26]	**0.030**	3254.77 [2909.12-3600.43]	CDRR	2300	↑	2687.79 [2467.09-2908.50]	2300	↑	**0.004**
Zinc (mg)	10.44 [10.22-10.66]	10.14 [9.33-10.96]	0.479	12.52 [10.55-14.49]	RDA	11	↑	8.85 [8.07-9.63]	8	↑	**0.001**
Vitamin A (mcg RAEd)	677.27 [611.32-743.23]	666.48 [596.80-736.16]	0.818	801.56 [649.16-953.97]	RDA	900	↓	593.05 [514.09-672.01]	700	↓	**0.024**
Vitamin E (mg ATd)	8.26 [7.97-8.54]	8.27 [7.28-9.25]	0.983	10.43 [8.54-12.32]	RDA	15	↓	7.10 [6.26-7.93]	15	↓	**<0.001**
Vitamin D (IUDd)	190.36 [182.13-198.60]	192.77 [170.29-215.24]	0.860	218.14 [183.35-252.92]	RDA	600	↓	178.98 [151.52-206.43]	600	↓	0.072
Vitamin C (mg)	82.39 [78.37-86.41]	80.08 [69.66-90.49]	0.665	93.80 [77.80-109.80]	RDA	90	↑	72.62 [63.02-82.21]	75	↓	**0.003**
Thiamin (mg)	1.51 [1.47-1.55]	1.45 [1.37-1.54]	0.210	1.70 [1.54-1.86]	RDA	1.2	↑	1.32 [1.21-1.43]	1.1	↑	**<0.001**
Riboflavin (mg)	2.05 [1.99-2.11]	1.9 [1.80-2.03]	**0.043**	2.31 [2.12-2.51]	RDA	1.3	↑	1.70 [1.59-1.80]	1.1	↑	**<0.001**
Niacin (mg)	22.52 [21.96-23.09]	20.51 [19.20-21.81]	**0.003**	24.60 [22.43-26.77]	RDA	16	↑	18.28 [16.59-19.98]	14	↑	**<0.001**
Vitamin B-6 (mg)	1.88 [1.83-1.93]	1.76 [1.64-1.88]	0.051	2.19 [1.95-2.43]	RDA	1.7	↑	1.53 [1.41-1.65]	1.5	↑	**<0.001**
Vitamin B-12 (mcg)	4.91 [4.41-5.40]	4.46 [4.09-4.83]	0.167	5.48 [4.68-6.27]	RDA	2.4	↑	3.91 [3.53-4.28]	2.4	↑	**<0.001**
Choline (mg)	311.32 [304.57-318.07]	282.43 [266.89-297.96]	**0.002**	325.75 [295.98-355.52]	AI	550	↓	258.88 [240.23-277.53]	425	↓	**<0.001**
Vitamin K (mcg)	126.08 [108.96-143.20]	105.74 [88.65-122.83]	0.087	128.19 [91.15-165.24]	AI	120	↑	93.53 [76.53-110.54]	90	↑	0.097
Folate mcg DFEd	169.57 [161.88-177.26]	164.25 [145.31-183.20]	0.578	200.64 [163.92-237.35]	RDA	400	↓	144.48 [125.29-163.66]	400	↓	**0.006**

Data presented as means + [95% confidence interval]; significant p-values in bold. p* = indicates differences between the general population and NHANES participants eating at community/senior centers; p** = indicates differences between male and female NHANES participants eating at community/senior centers. CDRR = Chronic Disease Risk Reduction, RDA: Recommended Dietary Allowance, AI = Adequate Intake (based on the Dietary Guidelines for Americans [14]). DNG = Daily Nutritional Goals.

general population. A crude (not energy-adjusted) analysis suggested no significant differences between both groups (Table 4). Overall, diet quality in NHANES participants aged 60 or older appeared pale with regard to the average FNI results (approximately 60/100 total points).

In light of the substantial between group differences in many sociodemographic aspects and total energy intake, we also ran a sex-specific multivariate regression model for the FNI, adjusting for race/ethnicity, education, income, marital status, alcohol intake, smoking status and total energy intake. Predictive margins (adjusted sex-specific predictions) for the FNI in males and females based on these models are shown in Fig. 1. Eating at community/senior centers was associated with a significantly higher predicted FNI in males (ΔFNI: +4.08 [CI: 0.87–7.29], p = 0.014), whereas no significant differences were found for females. The lowest predicted values were found for Non-Hispanic Black

Table 4
Diet Quality Score (DQS) and Food Nutrient Index (FNI) in community/senior center eaters by sex.

Nutrient Index	Male general population *n = 2906*	Male community/senior center eaters *n = 182*	*p**
DQS	10.63 [10.45–10.82]	10.16 [9.68–10.65]	0.056
FNI	62.36 [61.37–63.34]	62.14 [58.83–65.45]	0.898

Nutrient Index	Female general population *n = 2934*	Female community/senior center eaters *n = 239*	*p**
DQS	9.87 [9.61–10.12]	9.92 [9.45–10.40]	0.840
FNI	60.21 [59.07–61.35]	59.35 [56.79–61.92]	0.599

Data presented as means [95% confidence interval]; significant *p*-values in bold. *p** = indicates differences between the general population and NHANES participants eating at community/senior centers.

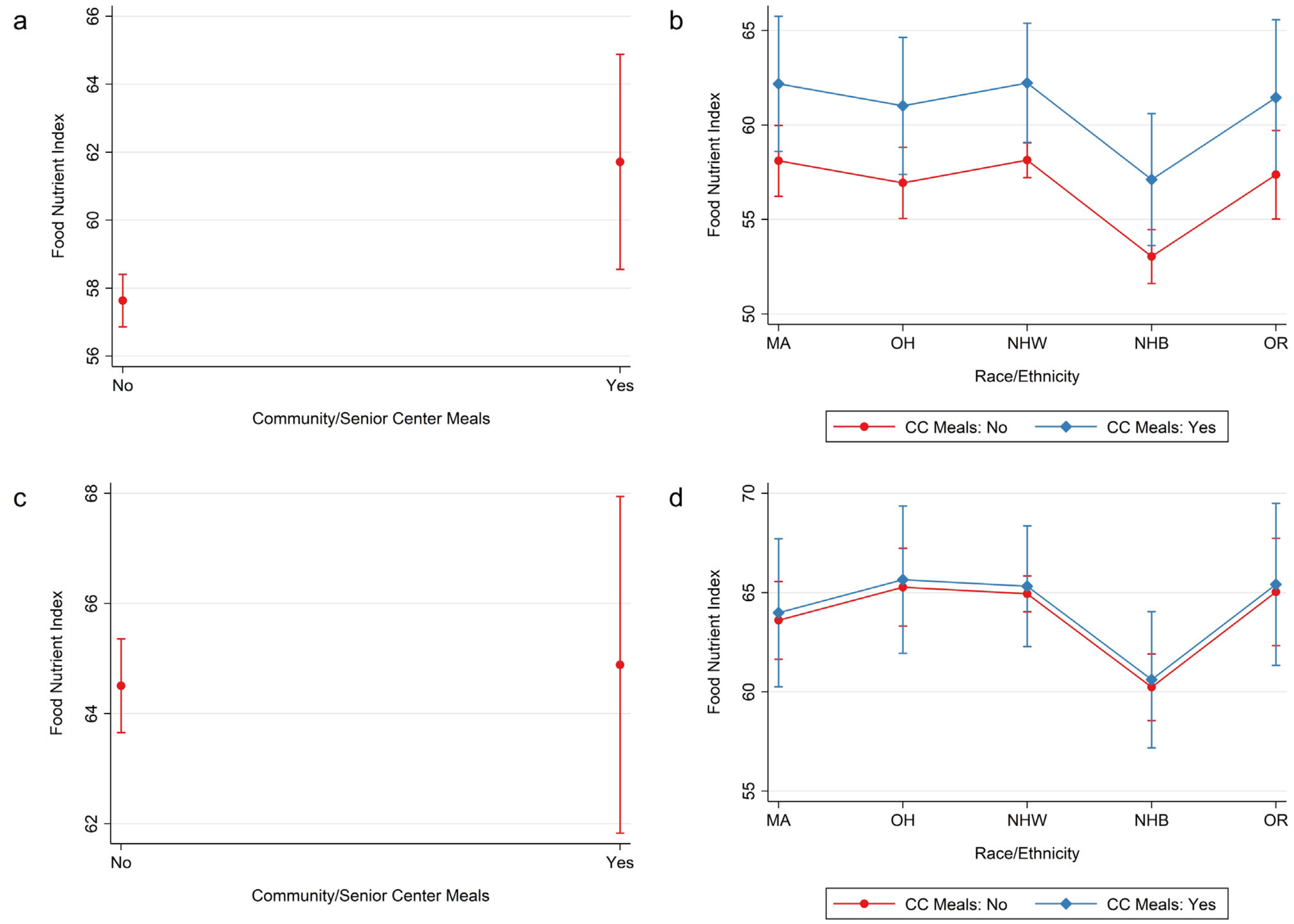

Fig. 1. Marginsplots: Predictive margins for the food nutrient index in males (top row) and females (bottom row).
Plot of marginal predicted values based on multivariable regression model adjusting for race/ethnicity (categorical), education (categorical), income (categorical), marital status (categorical), alcohol intake (categorical), smoking status (categorical) and total energy intake (continuous). a = predictive margins by community center/senior center meal category (no/yes) in males. b = plot of marginal predicted values, illustrating differences in the relationship of the FNI and community center/senior center meal category (no/yes), depending on race/ethnicity in males. c = predictive margins by community center/senior center meal category (no/yes) in females. d = plot of marginal predicted values, illustrating differences in the relationship of the FNI and community center/senior center meal category (no/yes), depending on race/ethnicity in females.

males, who had a significantly lower FNI when compared to Non-Hispanic Whites (Fig. 1). Comparable figures for the DQS are presented in Supplementary Figure S2.

The marginal predictive values presented in Fig. 1 thus suggest sex-specific differences when it comes to the potentially beneficial effects of community/senior center meals, which apparently have a more pronounced and significant effect in males.

4. Discussion

Using NHANES data from $n = 6261$ participants, we investigated whether eating at community/senior centers was associated with an improved nutritional status in comparison to the general population.

Our results suggest that eating at community/senior centers does not necessarily result in a better diet quality when compared to the general population. Very few between group differences were found after adjustments for energy intake, with limited clinical relevance. When adjusting for other potentially relevant covariates, however, we identified sex-specific differences when it comes to the potentially beneficial effects of community/senior center meals. The latter apparently had a significant effect in males, who yielded higher FNI scores when compared to males from the general population. Of note, this effect was not observed in women.

Due to the cross-sectional nature of our study, one may only speculate about the reasons for this observed phenomenon. As summarized by Keller et al., men are less likely to cook a range of meals and more likely to choose foods that are generally easy to prepare when compared to women of the same age group [39,40]. In general, the majority of food shopping and cooking duties in the United States is still performed by women, and older men in particular may simply not possess the skills and practical knowledge to prepare meals [41–43]. It is thus not inconceivable that they benefit from community/senior center meals in a different way than women, who have the routine to prepare home-cooked meals on a daily basis.

Apart from cooking and food shopping, annual household income and financial resources in older adults could also play a role [44,45]. The number of participants with an annual household income < $20000 was substantially higher in those eating at community/senior centers in our study, and it is also possible that these individuals may simply not be able to afford nutrient-dense meals on a daily basis. Food insecurity is a topic of public health concern in older adults in the US, and community/senior center meals may alleviate some of the daily burden imposed on affected individuals [45]. Notably, food insecurity in older adults in the U.S. was shown to affect women disproportionally, and may thus not explain the sex-specific differences encountered here [46,47].

The reasons for the potential sex-specific differences are likely more complex and multifactorial. A cross-sectional (exploratory) study might not be suitable to answer this question, which goes beyond the scope of this analysis. The fact that no differences were found between the female general population and those eating at community/senior centers does explicitly *not* imply that senior/community meals are of little value to older women.

To the contrary, we examined only a single outcome dimension in this article (nutrient exposure). Senior/community centers serve numerous other important purposes not considered here, such as psychological well-being, lower levels of depression and supportive friendships associated with senior/community centers [13,48,49].

Thus, our preliminary conclusion on benefits of community/senior center meals confined to older men applies only for the nutrition dimension. It is likely that community/senior center meals may have favorable (socio-psychological) effects on older women, as well, which may go beyond nutrient exposure. Future studies will be necessary to examine this.

To the best of our knowledge, we are the first group to examine nutrient exposure associated with community/senior center meals using US population-based survey data. For this analysis, the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline was followed and is available as a supplementary file (Supplementary Table S4) [50].

This analysis also has several limitations worth mentioning. Cross-sectional in nature, our study does not allow for any causal inferences. Dietary data may be subject to recall and reporting bias. Eating at community/senior centers was self-reported, and thus also subject to bias. Finally, the most important limitation may be that NHANES provided no "frequency variable" on the number of community/senior center meals consumed per week. We transparently acknowledge this important aspect, which would have greatly enhanced this analysis. While the question is framed to imply a certain regularity, it is hypothetically possible that participants who tried community center meals a few times (e.g., due to curiosity) were captured with this variable, as well. As the question included adult day care, as well, we considered it to imply a rather regular phenomenon. In this regard, the study must be viewed with caution and confirmatory studies will certainly be required. In general, the combination of the aforementioned community center meals variable with the 24-h-dietary recalls is not indicative of the diet quality of the meals received at community centers. Then again, our approach appeared to be the most feasible one with regard to the NHANES data structure, and the observed adjusted predictions are generally in line with several aspects of the literature as discussed earlier. The fact that individuals had to be excluded for missing data (mostly alcohol intake data) is another weakness of this study and may compromise its representativeness, however, we still deem the sample size large enough to compute reliable weighted proportions. As such, we believe that our study adds to the literature and lays the basis for future confirmatory studies. For future studies, it will be very important to consider clinical outcomes in the context of community center meals. For example, it would be important to investigate whether the sex differences observed in our study correlate with other established and widely used nutritional screening and assessment tools. One example could be the Mini Nutritional Assessment (MNA) [51]. Here, it would be interesting to see whether lower diet quality scores translate into lower MNA scores in the context of our study. Regrettably, the complete set of variables necessary to complete the MNA were not available in the NHANES; thus we were unable to include said outcome here.

5. Conclusions

Community/senior centers play a pivotal role in supporting older adults as they age, and frequently offer meal and nutrition programs. Our analysis suggests that eating at community/senior centers was associated with an improved nutrient exposure in older men, whereas no better diet quality was found in women (when compared to the general population). Confined to the dimension of nutrient exposure, our study did not consider other (beneficial) dimensions of community/senior center services and programs. Future studies are required to confirm our results.

Authors' contributions

Conceptualization: M.A.S. and A.L.R.; Data curation: M.A.S.; Formal analysis: M.A.S.; Funding acquisition: M.A.S.; Investigation: M.A.S. and A.L.R.; Methodology: M.A.S.; Project administration: M.A.S. and A.L.R.; Resources: M.A.S. and A.L.R.; Software: M.A.S. and A.L.R.; Supervision: A.L.R.; Validation: M.A.S. and A.L.R.; Visualization: M.A.S.; Writing – original draft: M.A.S.; Writing - review & editing: M.A.S. and A.L.R.

Funding

The authors received no financial support/funding. Open access publishing enabled by Project DEAL.

Declarations

This work has not been published before; it is not under consideration for publication anywhere else. This work been approved by all co-authors.

Ethics approval and consent to participate

NHANES was approved by the National Centre for Health Statistics research ethics review board https://www.cdc.gov/nchs/nhanes/irba98.htm) and informed consent was obtained for all participants.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Written and oral consent was obtained from all NHANES participants.

Availability of data and materials

Data is publicly available online (https://wwwn.cdc.gov/nchs/nhanes/Default.aspx). The datasets used and analyzed for the current analysis are available from the corresponding author on reasonable request.

Acknowledgements

n/a.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jnha.2024.100379.

References

[1] Shang X, Liu J, Zhu Z, Zhang X, Huang Y, Liu S, et al. Healthy dietary patterns and the risk of individual chronic diseases in community-dwelling adults. Nat Commun. 2023;14(1):6704, doi:http://dx.doi.org/10.1038/s41467-023-42523-9.

[2] McCullough ML, Chantaprasopsuk S, Islami F, Rees-Punia E, Um CY, Wang Y, et al. Association of socioeconomic and geographic factors with diet quality in US adults. JAMA Network Open. 2022;5(6):e2216406, doi:http://dx.doi.org/10.1001/jamanetworkopen.2022.16406.

[3] O'Connell ML, Coppinger T, Lacey S, Arsenic T, McCarthy AL. The nutritional status and dietary intake of free-living seniors: a cross-sectional study. Clin Nutr ESPEN. 2021;43:478–86, doi:http://dx.doi.org/10.1016/j.clnesp.2021.02.020.

[4] Choi YJ, Crimmins EM, Kim JK, Ailshire JA. Food and nutrient intake and diet quality among older Americans. Public Health Nutr. 2021;24(7):1638–47, doi:http://dx.doi.org/10.1017/S1368980021000586.

[5] Clegg ME, Williams EA. Optimizing nutrition in older people. Maturitas. 2018;112:34–8, doi:http://dx.doi.org/10.1016/j.maturitas.2018.04.001.

[6] Long T, Zhang K, Chen Y, Wu C. Trends in diet quality among older US adults from 2001 to 2018. JAMA Netw Open 2022;5(3):e221880, doi:http://dx.doi.org/10.1001/jamanetworkopen.2022.1880.

[7] Lagström H, Stenholm S, Akbaraly T, Pentti J, Vahtera J, Kivimäki M, et al. Diet quality as a predictor of cardiometabolic disease–free life expectancy: the Whitehall II cohort study. Am J Clin Nutr. 2020;111(4):787–94, doi:http://dx.doi.org/10.1093/ajcn/nqz329.
[8] Fleury S, Van Wymelbeke-Delannoy V, Lesourd B, Tronchon P, Maître I, Sulmont-Rossé C. Home-delivered meals: characterization of food intake in elderly beneficiaries. Nutrients. 2021;13(6):2064, doi:http://dx.doi.org/10.3390/nu13062064.
[9] Miller MJ, Cenzer I, Barnes DE, Covinsky KE. Physical inactivity in older adults with cognitive impairment without dementia: room for improvement. Aging Clin Exp Res. 2022;34(4):837–45, doi:http://dx.doi.org/10.1007/s40520-021-01999-5.
[10] Sakr-Ashour FA, Wambogo E, Song HJ, Sahyoun NR. Home-delivered meal programme participants may be at greater risk of malnutrition without the meal programme. Public Health Nutr. 2021;25(7):1–8, doi:http://dx.doi.org/10.1017/S1368980021004274.
[11] Song HJ, Simon JR, Patel DU. Food preferences of older adults in senior nutrition programs. J Nutr Gerontol Geriatrics. 2014;33(1):55–67, doi:http://dx.doi.org/10.1080/21551197.2013.875502.
[12] What Are Senior Centers? Forbes Health. Published December 12, 2023. Accessed March 28, 2024. https://www.forbes.com/health/healthy-aging/senior-centers/.
[13] Senior Center Facts. Accessed March 28, 2024. https://www.ncoa.org/article/get-the-facts-on-senior-centers.
[14] U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025. 9th edition . . (accessed March 2024) https://www.dietaryguidelines.gov.
[15] Bailey RL, Pac SG, Fulgoni VL, Reidy KC, Catalano PM. Estimation of total usual dietary intakes of pregnant women in the United States. JAMA Netw Open. 2019;2(6):e195967, doi:http://dx.doi.org/10.1001/jamanetworkopen.2019.5967.
[16] Venkatraman S, Echouffo-Tcheugui JB, Selvin E, Fang M. Trends and disparities in glycemic control and severe hyperglycemia among US adults with diabetes using insulin, 1988-2020. JAMA Network Open. 2022;5(12):e2247656, doi:http://dx.doi.org/10.1001/jamanetworkopen.2022.47656.
[17] Myers CA, Mire EF, Katzmarzyk PT. Trends in adiposity and food insecurity among US adults. JAMA Network Open. 2020;3(8):e2012767, doi:http://dx.doi.org/10.1001/jamanetworkopen.2020.12767.
[18] NHANES - National Health and Nutrition Examination Survey Homepage. Published January 29, 2024. Accessed March 28, 2024. https://www.cdc.gov/nchs/nhanes/index.htm.
[19] Chen TC, Clark J, Riddles MK, Mohadjer LK, Fakhouri THI. National health and nutrition examination survey, 2015-2018: sample design and estimation procedures. Vital Health Stat 2 2020;(184):1–35.
[20] Pan J, Zhou Y, Pang N, Yang L. Dietary niacin intake and mortality among individuals with nonalcoholic fatty liver disease. JAMA Network Open. 2024;7(2):e2354277.
[21] Zidar DA, Al-Kindi SG, Liu Y, Krieger NI, Perzynski AT, Osnard M, et al. Association of lymphopenia with risk of mortality among adults in the US general population. JAMA Network Open. 2019;2(12):e1916526.
[22] NHANES - NCHS Research Ethics Review Board Approval [Internet]. 2022 [cited 2024 Apr 4]. Available from: https://www.cdc.gov/nchs/nhanes/irba98.htm.
[23] Li Y, Xia PF, Geng TT, Tu ZZ, Zhang YB, Yu HC, et al. Trends in self-reported adherence to healthy lifestyle behaviors among US adults, 1999 to March 2020. JAMA Network Open 2023;6(7):e2323584.
[24] Cowan AE, Bailey RL, Jun S, Dodd KW, Gahche JJ, Eicher-Miller HA, et al. The total nutrient index is a useful measure for assessing total micronutrient exposures among US adults. J Nutr. 2021;152(3):863–71, doi:http://dx.doi.org/10.1093/jn/nxab428.
[25] Cowan AE, Jun S, Tooze JA, Dodd KW, Gahche JJ, Eicher-Miller HA, et al. A narrative review of nutrient based indexes to assess diet quality and the proposed total nutrient index that reflects total dietary exposures. Crit Rev Food Sci Nutr. 2023;63(12):1722–32, doi:http://dx.doi.org/10.1080/10408398.2021.1967872.
[26] Fitzgerald AL, Dewar RA, Veugelers PJ. Diet quality and cancer incidence in Nova Scotia, Canada. Nutr Cancer. 2002;43(2):127–32, doi:http://dx.doi.org/10.1207/S15327914NC432_2.
[27] Storz MA. Does self-perceived diet quality align with nutrient intake? A cross-sectional study using the food nutrient index and diet quality score. Nutrients. 2023;15(12):2720, doi:http://dx.doi.org/10.3390/nu15122720.
[28] Institute of Medicine (US) Subcommittee on Interpretation and Uses of Dietary Reference Intakes, Institute of Medicine (US) Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. DRI Dietary Reference Intakes: Applications in Dietary Assessment [Internet]. Washington (DC): National Academies Press (US); 2000 (accessed March 2024). Available from: http://www.ncbi.nlm.nih.gov/books/NBK222890/.
[29] 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. Adv Nutr. 2016;7(1):121–34, doi:http://dx.doi.org/10.3945/an.115.009258.
[30] NHANES - Measuring Guides. Published May 8, 2019. Accessed March 28, 2024. https://www.cdc.gov/nchs/nhanes/measuring_guides_dri/measuringguides.htm.
[31] Knüppel S, Norman K, Boeing H. Is a single 24-hour dietary recall per person sufficient to estimate the population distribution of usual dietary intake? J Nutr. 2019;149(9):1491–2, doi:http://dx.doi.org/10.1093/jn/nxz118.
[32] Storz MA, Ronco AL. Nutrient intake in low-carbohydrate diets in comparison to the 2020–2025 Dietary Guidelines for Americans: a cross-sectional study. Br J Nutr 2022;1–14, doi:http://dx.doi.org/10.1017/S0007114522001908.
[33] Storz MA, Ronco AL. How well do Low-PRAL diets fare in comparison to the 2020–2025 dietary guidelines for Americans? Healthcare (Basel). 2023;11(2):180, doi:http://dx.doi.org/10.3390/healthcare11020180.
[34] Dietary Guidelines for Americans Most Popular Questions. https://www.dietaryguidelines.gov/most-popular-questions (accessed March 2024).
[35] Parker JD, Talih M, Malec DJ, Beresovsky V, Carroll M, Gonzalez JF, et al. National center for health statistics data presentation standards for proportions. Vital Health Stat 2 2017;(175):1–22.
[36] Ward BW. kg_nchs: a command for Korn-Graubard confidence intervals and National Center for Health Statistics' Data Presentation Standards for Proportions. Stata J. 2019;19(3):510–22, doi:http://dx.doi.org/10.1177/1536867X19874221.
[37] Storz MA. Health inequities in the USA: a role for dietary acid load? Results from the National Health and Nutrition Examination Surveys. J Racial Ethn Health Disparities. 2023;10(6):2851–60, doi:http://dx.doi.org/10.1007/s40615-022-01462-9.
[38] Heeringa SG, West BT, Berglund PA. Applied Survey Data Analysis. 2nd ed. Chapman and Hall/CRC; 2017, doi:http://dx.doi.org/10.1201/9781315153278.
[39] Keller HH, Gibbs A, Wong S, Vanderkooy P, Hedley M. Men can cook!: Development, implementation, and evaluation of a senior men's cooking group. J Nutr Elder. 2004;24(1):71–87.
[40] Donkin AJ, Johnson AE, Morgan K, Neale RJ, Page RM, Silburn RL. Gender and living alone as determinants of fruit and vegetable consumption among the elderly living at home in urban Nottingham. Appetite. 1998;30(1):39–51.
[41] Storz MA, Beckschulte K, Brommer M, Lombardo M. Current sex distribution of cooking and food shopping responsibilities in the United States: a cross-sectional study. Foods. 2022;11(18):2840, doi:http://dx.doi.org/10.3390/foods11182840.
[42] Taillie LS. Who's cooking? Trends in US home food preparation by gender, education, and race/ethnicity from 2003 to 2016. Nutr J 2018;17(1):41, doi:http://dx.doi.org/10.1186/s12937-018-0347-9.
[43] Wolfson JA, Ishikawa Y, Hosokawa C, Janisch K, Massa J, Eisenberg DM. Gender differences in global estimates of cooking frequency prior to COVID-19. Appetite. 2021;161:105117, doi:http://dx.doi.org/10.1016/j.appet.2021.105117.
[44] USDA ERS - Food Spending Depends on Age and Income. Accessed April 3, 2024. https://www.ers.usda.gov/amber-waves/2007/september/food-spending-depends-on-age-and-income/.
[45] Pak TY, Kim G. Association of food insecurity with allostatic load among older adults in the US. JAMA Network Open. 2021;4(12):e2137503, doi:http://dx.doi.org/10.1001/jamanetworkopen.2021.37503.
[46] Aljahdali AA, Na M, Leung CW. Food insecurity and health-related quality of life among a nationally representative sample of older adults: cross-sectional analysis. BMC Geriatr. 2024;24(1):1–9, doi:http://dx.doi.org/10.1186/s12877-024-04716-9.
[47] Koller EC, Egede LE, Garacci E, Williams JS. Gender differences in the relationship between food insecurity and body mass index among adults in the USA. J Gen Intern Med. 2022;37(16):4202–8, doi:http://dx.doi.org/10.1007/s11606-022-07714-y.
[48] Fitzpatrick TR, McCabe J, Gitelson R, Andereck K. Factors that influence perceived social and health benefits of attendance at senior centers. Act Adapt Aging. 2006;30(1):23–45, doi:http://dx.doi.org/10.1300/J016v30n01_02.
[49] Farone DW, Fitzpatrick TR, Tran TV. Use of senior centers as a moderator of stress related distress among Latino elders. J Gerontol Soc Work. 2005;46(1):65–83, doi:http://dx.doi.org/10.1300/J083v46n01_05.
[50] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for Reporting Observational Studies. Prev Med. 2007;45(4):247–51, doi:http://dx.doi.org/10.1016/j.ypmed.2007.08.012.
[51] Cereda E. Mini nutritional assessment. Curr Opin Clin Nutr Metab Care. 2012;15(1):29–41.