Heliyon 10 (2024) e28853

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Comparative analysis of diets in Sioux Falls: Influence of sociodemographic characteristics, alignment to US national diet and healthy diet

Jacinda Netzer, Meghann Jarchow *

Department of Sustainability and Environment, University of South Dakota, 414 E Clark St., Vermillion, SD 57069, United States

A R T I C L E I N F O

Keywords:
dietary intake
dietary patterns
Sociodemographic characteristics
Survey

A B S T R A C T

Continuous examination of diets and factors that influence dietary patterns is vital to improve diet quality. The objectives of this study are to evaluate the average diet of adults in the Sioux Falls Metropolitan Statistical Area (SFMSA), USA, examining sociodemographic differences in dietary intake and compare the average diet in the SFMSA (SF Diet) to the U.S. national average and USDA healthy dietary guidelines. A cross-sectional population-based study was conducted and 127 individuals were surveyed from August 2020 to August 2021. Dietary intake was assessed using the self-reported single 24-h dietary recall method and sociodemographic questions. Main effects and first order interactions of participant sociodemographic characteristics were considered. Main findings show that men had higher intake of meat, poultry, and eggs ($p < 0.05$) and alcohol, particularly older men ($p < 0.05$), than women. Higher alcohol intake was found for participants with lower levels of income and education ($p < 0.01$). The intake of fish and seafood was higher for older adults with a high level of income ($p < 0.01$). Differences were found between the SF diet and the national average but both followed a similar trend (e.g., low in fruits and vegetables and high in solid fats) and did not meet dietary guidelines, particularly for nutrient-dense foods. The intake of total vegetables ($p < 0.001$) and dark green vegetables ($p < 0.001$) was higher in the SF Diet and the national average was higher in total grains ($p < 0.05$), refined grains ($p < 0.01$), oils and fats ($p < 0.001$), solid fats ($p < 0.001$), and added sugar ($p < 0.001$). By not meeting the dietary guidelines, the findings of this study raise public health concerns.

1. Introduction

Understanding the factors that influence diets and dietary trends is important to improve overall health. The USDA defines healthy dietary patterns as those that incorporate a variety of nutrient-dense foods[1] from all basic food groups in recommended amounts and calorie limits with limited intake of red and processed meats, refined grains, added sugars, and alcohol [1–3]. Including a variety of nutrient-dense foods increases food diversity and diet quality [1,2]. Nutrient-dense foods contain essential vitamins, minerals, healthy fats, lean protein, dietary fiber, and complex carbohydrates that promote optimal health and may prevent diet-related diseases [2,3].

* Corresponding author.
E-mail address: Meghann.Jarchow@usd.edu (M. Jarchow).

[1] These include whole grains, vegetables, fruits, low-fat or fat-free milk products, seafood, lean meats, eggs, peas, beans, and nuts.

https://doi.org/10.1016/j.heliyon.2024.e28853
Received 23 August 2022; Received in revised form 19 March 2024; Accepted 26 March 2024
Available online 2 April 2024

Monitoring dietary intake is one step toward improving nutritional and overall health.

Several studies have demonstrated the importance of evaluating dietary intake and examining sociodemographic differences. The National Health and Nutrition Examination Survey (NHANES) of U.S. citizens has shown the U.S. average diet has insufficient intake of fruits and vegetables and excess intake of refined grains, solid fats, alcohol, and added sugars [4–6]. Lower dietary quality and diversity were correlated with individuals of lower income in the NHANES. Individuals with lower income had less intake of fruits and vegetables and higher intake of less nutrient, more calorie-dense foods and beverages (e.g., sugar-sweetened drinks) than individuals with higher-income [7–11]. Lower dietary quality and food diversity has been correlated with men compared to women [12,13]. Age has been shown to have varying effects on dietary quality with higher quality shown for adults ages 20-59 than for adolescents and older adults (65+) [13,14]. Other studies have shown that individuals with a college degree or higher followed healthier dietary patterns [15–17] and diets of people with less than a high school degree were correlated with higher incidence of obesity [18]. Yet, more needs to be understood about what influences dietary intake, particularly in rural metropolitan areas.

This study addresses the gap in knowledge of dietary intake in rural metropolitan areas, particularly Sioux Falls, South Dakota. Rural metropolitan areas are important to consider since adults in rural communities are less likely to meet fruit and vegetable recommended intake. Yet, metropolitan areas tend to consume more fruits and vegetables than nonmetropolitan areas [19,20]. South Dakota including the Sioux Falls area still rank among the lowest in the nation for fruit and vegetable consumption, despite slight increases from 2015 to 2018 [21]. The findings will contribute to the existing knowledge of what influences dietary patterns in the U.S. and contextualize them to the Sioux Fall Metropolitan Statistical Area (SFMSA). The objectives of this study were twofold. The first was to evaluate the average dietary and energy intake in the SFMSA (hereafter SF Diet) and examined differences in the SF Diet by gender, age, level of education, and household income. The second was to compare the SF Diet to the U.S. national average diet and the 2020–2025 USDA Healthy Dietary Guidelines for Americans. Despite discrepancies in what constitutes a "healthy diet", this article uses the 2020–2025 USDA Healthy Dietary Guidelines for Americans as reference for healthy dietary patterns. This study builds upon previous literature that examined sociodemographic factors that influence dietary patterns as well as comparisons to the average U.S. national diet and recommended healthy diet. The findings from this study will give an initial understanding of SF Diet and consider the health implications that can be further evaluated in future studies.

2. Methods

2.1. Study site

The SFMSA was selected as the study site because it is the most populous, fast-growing urban center in the state of South Dakota, USA and can provide insight into urban diets in the Midwest. The SFMSA includes four counties containing and surrounding the city of Sioux Falls, namely Minnehaha, Lincoln, Turner and McCook counties. Nearly 70% of the SFMSA population lives in Sioux Falls [22].

2.2. Study design and population

A cross-sectional population-based survey was conducted on dietary intake and patterns in adults living in the SFMSA. Sample selection was carried out by convenience sampling, and snowball sampling when possible. Participants were recruited by posting the survey on local social media pages, promotion from the Sioux Falls Health Department, flyers hung at Sioux Falls businesses and main library, and handing out of flyers throughout Sioux Falls including downtown and at businesses and parks in different neighborhoods across the city. Efforts were made to obtain a diverse and representative sample by posting to social media pages of differing audiences (e.g., secondhand selling, event news, food-based pages, etc.), through outreach to low income and diverse populations by the Sioux Falls Health Department, and the distribution of handouts in different population centers of Sioux Falls. Eligibility criteria were individuals who were at least 18 years of age living in the SFMSA. Inclusion criteria were individuals who met the eligibility criteria, answered the sociodemographic questions, and completed a 24-h dietary recall (hereafter 24HR). Of the 358 individuals who began the survey, 161 participants started the 24HR and 127 participants met the eligibility and inclusion criteria. Despite efforts, a fully representative sample was not obtained with male and Hispanic or Latino populations as well as populations with a high school degree or less and income groups from $75,000-$149,999 being underrepresented. Further, populations with some college and higher were overrepresented and the sample median age was three years higher than the SFMSA median age. Out of the 127 participants, 90 were compensated a $10 gift card for completing the survey and 37 participants were recruited without compensation through posts to social media. The median duration to complete the survey was 22 min.

All participants agreed to an informed consent. The study protocol and all study procedures including the informed consent were approved by the University of South Dakota Office of Human Subjects Protection (IRB-20-25).

2.3. Data collection

A structured and self-administered online survey was administered using the Qualtrics XM platform. The survey was primarily deployed online due to the advantages [23–25]. A paper version of the survey was developed for populations with limited internet access. Two participants completed the paper survey and 125 participants electronically completed the online survey. The survey included three main sections. First, participants answered sociodemographic questions on age, gender, race and ethnicity, level of education, and household income. Second, participants were asked to record all food and beverages consumed over the past 24 h, including the quantity, preservation (e.g., frozen, cured), preparation (i.e., homemade, premade, not applicable), method of cooking, place of purchase, and whether it was organic, from breakfast through evening in a 24HR. Participants were instructed to record all food, drink, and food additives in common U.S. household measurements that they consumed from 12:00 a.m. to 11:59 p.m. the day before. As a guide, participants were shown an example of how to accurately record a morning meal and midday or evening meal. The 24HR was modeled after the USDA Automated Multiple-Pass Method (AMPM) by dividing the 24HR into three separate mealtimes (breakfast, lunch, dinner) [26]. As done in the AMPM, participants were asked between mealtimes and after the evening meal if they had any missed any food at the prior mealtime or if they had any food between mealtimes, providing examples of frequently missed foods, to help participants recall frequently missed foods and beverages, hereafter referred to as food(s),. If participants selected yes, they were asked to add any missed or additional foods they consumed. Each participant completed one 24HR. A single 24HR was selected because it can be used to represent the average intake of a group or population [27–29], which was the aim of this study. Third, participants were asked about their dietary patterns and to indicate whether they follow any particular diet(s) (e.g., vegan, vegetarian, lactose free). Because diets change over the year [30], the survey was deployed from August 2020 to August 2021 to collect data during all seasons.

2.4. Data preparation and analysis

The foods reported in the 24HR and reported dietary patterns were used to calculate the SF Diet. The 2017–2018 USDA Food Pattern Equivalent Database (FPED; [31]) and Food and Nutrient Database for Dietary Studies (FNDDS; [32]) were used to convert

Table 1
SFMSA mean dietary intake and energy intake of food groups (left) and subgroups (right) for adults at least 18 years old.

Food Group		Unit	Mean ± SD	kcal
Grains	Total	oz. eq.	5.8 ± 4.0	481.4[h]
Whole grains		oz. eq.	1.0 ± 1.7	102.8
Refined grains		oz. eq.	4.8 ± 3.9	378.6
Vegetables	Total	c eq.	1.9 ± 1.4	144.3[h,i]
Dark green		c eq.	0.3 ± 0.6	5.3
Red, orange		c eq.	0.5 ± 0.7	17.9
Legumes		c eq.	0.1 ± 0.3	–
Starchy, root		c eq.	0.4 ± 0.8	88.9
Other		c eq.	0.7 ± 0.8	32.3
Fruit	Total[a]	c eq.	0.9 ± 1.3	104.2[h,i]
Citrus[b]		c eq.	0.3 ± 0.8	23.5
Non-citrus		c eq.	0.5 ± 1.0	70.3
Dairy	Total	c eq.	1.5 ± 1.5	183.4[3]
Fluid milk, yogurt[c]		c eq.	0.7 ± 1.3	82.5
Cheese		c eq.	0.8 ± 1.0	100.9
Proteins	Total	oz. eq.	6.5 ± 3.9	446.5[h,j,k]
Fish, seafood		oz. eq.	0.6 ± 1.8	26.1
Meat, poultry, eggs[d]		oz. eq.	4.3 ± 3.6	280.9
Red meat[e]		oz. eq.	2.2 ± 3.0	192.1
Poultry		oz. eq.	1.5 ± 2.6	52.5
Eggs		oz. eq.	0.5 ± 0.9	36.3
Legumes		oz. eq.	0.4 ± 1.0	28.6
Soy products, tofu		oz. eq.	0.2 ± 0.6	21.5
Nuts, seeds		oz. eq.	1.1 ± 2.0	89.3
Oils and fats	Total	g	55.4 ± 29.4	489.8[h,l]
Oils		g	27.9 ± 19.3	246.4
Solid fats		g	27.5 ± 21.1	243.4
Added sugar		tsp eq.	10.1 ± 11.3	164.3[j]
Beverages Stimulants[f]		oz. eq.	11.8 ± 16.3	na
Nonalcoholic[g]		oz. eq.	7.4 ± 13.0	95.9[h]
Alcoholic		drinks	0.4 ± 1.4	52.6[h]
Water		oz. eq.	30.9 ± 32.9	na

SD – standard deviation.
[a] also includes fruit from fruit juices.
[b] citrus, melons, and berries.
[c] includes soy milk.
[d] includes red meat, poultry, and eggs.
[e] beef, pork, lamb, and venison.
[f] includes coffee and tea.
[g] includes soft drinks, such as soda and carbonated water, energy drinks, and sports drinks.
[h] 24-h dietary recall.
[i] 2017–2018 NHANES.
[j] USDA Food Availability Database.
[k] National Marine Fisheries Service.
[l] Blasbalg et al. (2011).

foods into common household units and categorize them into food groups and subgroups (Table 1). Common household units were used for comparability to the USDA Healthy Dietary Guidelines for Americans. Reported quantity, preservation, and preparation in the 24HR and dietary patterns were used in selecting foods from the FPED and FNDDS to use in our calculations (e.g., vegetarian products). The mean intake for each food group and subgroup was used to determine the usual SF Diet.

The FNDDS Ingredient Nutrition Value dataset was used to convert food quantities into their kilocalories (kcal) equivalents. To calculate the mean kcal intake for each food group and subgroup, assumptions were made in the selection of foods from each food group based on participants' reported intake patterns, the 2017–2018 What We Eat in America (WWEIA) NHANES, USDA Food Availability Data System, Blasbalg et al. (2011 [33]), and National Marine Fisheries Service ([34] Table 1). The sum of food subgroups was used to calculate the kcal intake for each food group. Stimulants and water were assumed to not add any energy nutrient value.

The term proteins or protein foods were used in reference to fish, seafood, red meat, poultry, eggs, legumes, soy products, nuts, and seeds. Red meat, poultry, and eggs were subsequently combined in the subgroup meat, poultry, and eggs. Soy products and nuts and seeds were combined in the subgroup nuts, seeds, and soy products. These aggregations were used for comparison with the USDA Healthy Dietary Guidelines for Americans.

For the second objective, the SF Diet was compared to the U.S. national average diet (hereafter National Diet) and the 2020–2025 USDA Healthy Dietary Guidelines for Americans (hereafter Healthy Diet). The National Diet was calculated using dietary data from WWEIA, the 48-h dietary interview from the 2017–2018 NHANES. The NHANES is a nationally representative survey conducted annually to assess the health and nutritional status of the U.S. population by demographic and socioeconomic status [35]. The WWEIA estimates the types and amounts of food and beverages consumed using two 24HR [6,36]. The National Diet was calculated from the first 24HR (i.e., Day One) omitting all responses from individuals under 18 for comparability with the SF Diet. The Healthy Diet was based on 2020–2025 dietary guidelines for moderately active individuals. The dietary recommendations for each food group were averaged based on the age-gender distribution of the SFMSA adult population for comparison with the SF Diet. The Healthy Diet most closely aligns with the dietary recommendations following a 2200-kcal diet.

2.5. *Statistics*

Statistical analyses were done to test for sociodemographic differences in the reported intake of food groups and subgroups in the SF Diet and to compare the SF and National Diets. Summary statistics were calculated using central tendency (mean, standard deviation, standard error) and analyzed by gender, age, education, and household income. Four-way analysis of the variance (ANOVA) was used to test for differences in the SF Diet based on gender (men/women), age, level of education, and household income. Separate ANOVAs were run for each food group and subgroup (dependent variables). The main effects (e.g., gender) and first order interactions (e.g., gender*age) of sociodemographic variables (independent variables) were considered in the analysis. Participants were grouped into three age groups including younger adults (18-34), middle-aged adults (35-49), and older adults (50+) due to sample size. Four levels of education were used including high school degree or less, some college, college graduate, and graduate degree. Six levels of household income were also used in the analysis (Appendix, Table 1A). Race was excluded as an independent variable because 90% of the respondents identified as non-Hispanic and white. Tukey's method was used for post-hoc analysis to determine which sociodemographic groups differed when significant results were found. Due to sample size differences in the SF Diet ($n = 127$) and National Diet ($n = 5880$), the nonparametric Welch two-sample t-test was used to test for differences between the SF Diet and the National Diet. For the current study, 127 responses exceed the response threshold of 125 for a 95% confidence level with 8.76% error in responses. All analyses were conducted in R Studio Version 1.2.5033 or Excel.

3. Results and discussions

3.1. *SF diet*

The mean daily food reported by surveyed participants and energy intake in the SFMSA are presented in Table 1 (see Appendix Table 2A for international units). The median age of participants representing the mean daily food intake was 41 ranging from 18 to 73 years old with 73% of participants being women (Appendix Table 1A). The highest intake by ounce equivalents was total proteins (6.5 oz. eq.)[2] and total vegetables by cup equivalents (1.9 c eq.).[3] Participants reported the highest mean subgroup intake as refined grains (5.8 oz. eq.), other vegetables (0.7 c eq.), non-citrus fruit (0.5 c eq.), cheese (0.8 oz. eq.), and red meat (2.2 oz. eq.). Out of the eleven protein sources participants reported, beef had the highest mean intake (1.4 oz. eq.), followed by chicken (Appendix Table 2A). Participants reported a mean intake of 27.5 g (g) of solid fats, 10.1 teaspoon equivalents (tsp eq.)[4] of added sugar, 7.4 oz. eq.[5] of nonalcoholic beverages, and 0.4 alcoholic drinks.

Participants reported a mean energy intake of 2162 kcal per day, which is slightly higher than the recommended 2107 kcal for the SFMSA population [3,22]. Approximately two-thirds of the kcals consumed were from the food groups oils and fats (22.7%), grains (22.3%), and proteins (21.0%). Total fruit and vegetables contributed the fewest kcals to the mean daily energy intake (Table 1).

[2] Range of 28.35–50 g per ounce from peanuts and meats to whole egg [32].
[3] Range of 102–248 g per cup for dark green vegetables to fruit juice [32].
[4] Approximately 4.2 g [32].
[5] Approximately 218.8 mL [32].

Table 2
The *p*-values for the ANOVA analyses of the intake of food group and subgroups in the SF Diet based on gender, age, education, household income, and first order interactions. Bold asterisked values indicate significant findings ($p < 0.05$).

	Gender	Age	Education	Income		Gender	Age	Education	Income
Red, orange veg.					**Meat, poultry, egg**				
Gender	0.91				Gender	**0.01***			
Age	**0.03***	0.37			Age	0.27	0.87		
Education	**0.02***	0.42	0.35		Education	0.20	0.08	0.56	
Income	0.54	**0.03***	0.24	0.60	Income	0.09	0.23	0.07	0.68
Starchy, root veg.					**Red meat**				
Gender	0.42				Gender	0.79			
Age	0.67	0.67			Age	0.89	0.73		
Education	0.22	0.85	0.31		Education	0.45	0.07	0.28	
Income	0.24	**0.03***	0.19	0.47	Income	0.24	0.13	**0.04***	0.65
Milk, yogurt					**Poultry**				
Gender	0.19				Gender	**0.02***			
Age	**0.04***	0.68			Age	0.30	0.41		
Education	0.31	0.79	0.48		Education	0.20	0.32	0.62	
Income	0.24	0.91	0.74	0.27	Income	0.45	0.44	0.27	0.40
Fish, seafood					**Egg**				
Gender	0.91				Gender	**0.02***			
Age	0.95	0.80			Age	0.73	0.34		
Education	0.66	0.19	0.64		Education	0.08	0.41	0.20	
Income	0.93	**<0.01****	**0.03***	0.19	Income	**0.04***	0.06	0.40	0.28
Stimulants					**Alcoholic drinks**				
Gender	0.46				Gender	**0.03***			
Age	0.52	**<0.01****			Age	**0.01***	0.09		
Education	0.84	0.41	0.43		Education	**<0.01****	0.06	0.24	
Income	0.26	0.55	0.82	0.75	Income	**<0.01****	0.08	**<0.01****	0.18
Nonalcoholic drinks									
Gender	0.57								
Age	0.99	0.15							
Education	0.24	0.06	0.75						
Income	0.77	**0.02***	0.78	0.33					

*Note: Asterisks denote where the mean SF Diet is statistically different from the National Diet, where * $p < 0.05$, ** $p < 0.01$. Table with the p-values of insignificant sociodemographic variable effects can be found in Appendix Table 3A.

Discretionary calories, which include the solid fats, added sugars, nonalcoholic and alcoholic beverages subgroups [3], contributed approximately one-fourth (25.7% or 556.1 kcal) to participants' mean energy intake. Excluding nonalcoholic and alcoholic beverages, discretionary calories contributed 19% (407.7 kcal) of mean daily kcal intake with 11.3% and 7.6% from solid fats and added sugars, respectively. Within the food groups, refined grains contributed 378.6 kcal per day, the most of all food subgroups, followed by oils and red meat. Starchy root vegetables contributed 88.9 kcal per day, the highest vegetable subgroup in kcal but not volume. Cheese and citrus contributed the most kcal per day for dairy and fruits with 100.9 and 70.3 kcal, respectively. While participants reported a mean intake of 11.8 oz. eq. and 30.9 oz. eq. for stimulants and water, respectively, it is assumed they do not add to the mean daily kcal intake.

Differences in dietary intake reported by SFMSA residents were found based on gender, age, level of education, and household income (Table 2). Men consumed more meat, poultry, and eggs than women ($p < 0.05$), including the subgroups poultry ($p < 0.05$) and eggs ($p < 0.05$). No gender specific differences were found in the intake of red meat or nutrient-dense plant-based proteins such as legumes and nuts and seeds.

Higher intake of proteins reported by men in this study aligns with other findings. Various studies have found that men tend to consume more meat and meat products than women (see for example [12,37]). Higher income households have also been associated with greater intake of animal-based protein [12,38]. This study found differences in fish and seafood intake with the interaction of income and age ($p < 0.01$). Participants 50 years and older with an income of $100–149,999 ate more fish and seafood than other age or income groups. Fish and seafood and red meat intake differed by the interaction of income and education ($p < 0.05$), but no significant pairwise comparisons were found. Egg intake was higher for men than women and differences were found with the interaction between income and gender ($p < 0.05$). Men with a household income of $100–149,999 ate more than women with a household income of $150,000 or more ($p < 0.05$).

No significant difference was found for total vegetables, but differences were found in the intake of red and orange vegetables with interactions between gender and age ($p < 0.05$), gender and education level ($p < 0.05$), and age and income ($p < 0.05$) (Table 2). Men with a college degree ate more red and orange vegetables than men with some college education ($p < 0.05$). These findings could suggest dietary quality of the SF Diet increased with higher levels of education for men. Others have found that dietary quality was associated with higher vegetable intake as education and income levels increased [15–17]. No significant pairwise comparisons were found for the interaction between gender and age or age and income. However, middle-aged adults tended to consume more red and orange vegetables as income increased, but no consistent patterns were found across the full age range. Older men tended to eat more and women tended to eat less red and orange vegetables than younger adults. Similarly, Beck et al. (2018) found a positive association in the intake of red and orange vegetables with men and age in the New Zealander traditional dietary pattern [39].

For dairy, the intake of milk and yogurt differed with the interaction of gender and age ($p < 0.05$). No significant pairwise comparisons were found, but mean intake of milk and yogurt was highest for younger men (1.79 c eq.) and lowest for younger women (0.33 c eq.). Intake decreased by age group for men (0.51 and 0.45c eq.) and intake increased for middle-aged women (0.78 c eq.) but decreased for older women (0.53 c eq.). Previously reported trends for yogurt and milk have shown that most consumers that decreased intake with age were women or younger [40–42].

In general, older adults drank more beverages than younger adults including stimulants ($p < 0.01$), primarily coffee. The results from this study also show that the interaction of age and income affected the mean intake of nonalcoholic drinks ($p < 0.05$), primarily soft drinks, where the highest mean intakes (16.7–24.2 oz. eq.) were reported by older adults with household incomes of less than $50,000 and ranging from $75–99,999 (not significant). The number of alcoholic drinks differed by gender ($p < 0.05$) and interactions between gender and age ($p < 0.05$), gender and education ($p < 0.01$), gender and income ($p < 0.01$), and education and income ($p < 0.01$). Men drank more alcohol than women ($p < 0.05$). Older men drank more than women of all age groups and middle-aged men ($p < 0.05$). Men with a high school degree or less drank more than men and women with higher levels of education ($p < 0.01$).

The results on the intake of alcohol from this study align with other findings. Men have been found to drink more alcohol than women [43,44]. Additionally, people with higher levels of education have been found to drink lower quantities of alcohol at greater frequency and people with lower levels of education were found to "binge drink" more but drank less often [44–46]. This study shows that the intake of alcohol with education was moderated by the participants' household income ($p < 0.01$; Table 2). Participants with the lowest education and income levels drank more alcohol (3.3 drinks) than participants with more education or income. Similarly, Kanny et al. (2018) found the prevalence of binge drinking and total drinks consumed annually for current drinkers decreased with level of education and household income [44].

Overall, the results of this study have implications for trends in dietary quality based on the sociodemographic characteristics of participants. Other findings suggest men may not differ in diet quality when compared to women [13], variability in dietary quality based on age [15–17], and improved dietary quality with higher levels of income and level of education [15–17]. This study suggests variability in dietary quality based on gender and age. For example, no significant difference between men and women was found for total fruit and vegetable consumption, which are linked to healthy diets [1,2], and red meat consumption. Variability was also found in the consumption of red and orange vegetables and milk and yogurt based on age and gender. Additionally, men had higher mean intake of meat, poultry, and eggs and alcohol than women. The finding that higher alcohol intake was reported by participants with the lower levels of education and household, fish and seafood intake was higher for older adults with a household income of $100–149, 999, and red and orange vegetables intake was higher for men with a college degree than men with some college education suggest improved dietary quality and diversity with higher levels of income and education.

3.2. *Comparison of the SF, national, and healthy diets*

Similarities and differences in dietary intake were found between the SF, National, and Healthy Diets (Figs. 1 and 2). As seen in

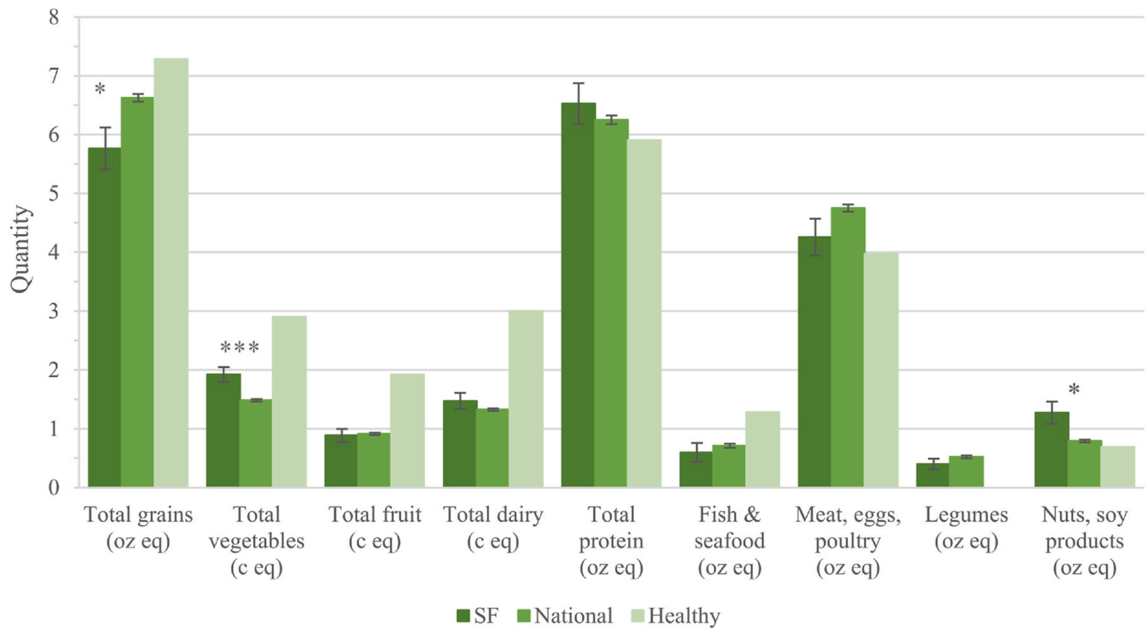

Fig. 1. Comparison of the intake of major food groups and protein subgroups for the SF Diet, National Diet, and Healthy Diet. Error bars show the standard error. Asterisks denote where the mean SF Diet is statistically different from the National Diet, where * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Note: all p-values of tested food groups and subgroups are found in Appendix Table 4A.

Fig. 1, the SFMSA residents ate fewer total grains than the National Diet ($p < 0.05$; also see Appendix Table 4A), which was lower than the Healthy Diet. Total reported vegetable intake was higher in the SF Diet than the National Diet ($p < 0.001$) but was approximately a cup equivalent lower than the Healthy Diet (Appendix Table 5A). Total fruit, total dairy, and fish and seafood in the SF and National Diets were lower than Healthy Diet. Total proteins including meat, poultry, eggs; legumes; and nuts and soy products in the SF and National Diets exceeded the Healthy Diet but nuts and soy products were higher in the SF Diet than the National Diet ($p < 0.05$). Additionally, Fig. 2 shows that the total oil and fats, solid fats, and added sugar from the SF Diet were lower than the National Diet ($p < 0.001$), but total oil and fats in both diets exceeded the Healthy Diet.[6]

The SF Diet followed similar trends as the National Diet in comparison to the Healthy Diet, but additional differences were found. The SF Diet contained less refined grains ($p < 0.05$) but higher dark green ($p < 0.001$) and red and orange vegetables ($p < 0.05$); nuts and seeds ($p < 0.05$); and soy products ($p < 0.05$) than the National Diet (Appendix Table 4A). Higher intake of vegetables, soy, nuts, and seeds along with lower intake of total grains, refined grains, solid fats, and sugar in the SF Diet suggests variability in dietary quality between the SF Diet and the National Diet. No significant difference between the SF Diet and the National Diet was found for dairy, non-citrus fruit, and red meat (Fig. 1 and Appendix Table 4A). However, neither diet met the Healthy Diet.

The SF Diet did not meet additional recommendations for food subgroups in the Healthy Diet, including many of the nutrient-dense food guidelines (Appendix Table 5A). The SFMSA participants reported eating more refined grains than is recommended in the Healthy Diet but did not meet the recommended total or whole grains intake. SFMSA participants reported greater intake of dark green vegetables than the Healthy Diet but did not meet the Healthy Diet guidelines for the remaining vegetables, including total vegetables. Total proteins including meat, poultry, eggs and soy and nuts and seeds subgroups in the SF Diet exceeded the Healthy Diet (Appendix Table 5A). The most consumed meat product, red meat and more specifically beef, is often not considered a lean protein. The SF Diet exceeded the allowable discretionary calories (<10% of kcal) based the intake of solid fat and added sugar, including and excluding nonalcoholic and alcoholic beverages. Major drivers of poor health in the SFMSA have been associated with unhealthy dietary behaviors such as low intake of fruits and vegetables as well as high intake of sugar-sweetened beverages [47]. All of these findings suggest that the dietary quality of the SF diet is negatively impacted.

Based on the dietary composition of the SF Diet, adjustments should be made to meet the 2020–2025 USDA Healthy Dietary Guidelines for Americans. Eating more nutrient-dense foods such as vegetables and fruits and replacing refined grains with whole grains could increase the intake of essential vitamins and minerals as well as reduce the impacts of poor diet quality and its effects on the onset of diet-related chronic diseases [3]. The dietary guidelines recommend at least half of grain intake should be whole grains with limited intake of refined grains [3]. For the SF Diet, whole and refined grains were lower and higher, respectively, than recommended by the Healthy Diet. While the SF Diet met the guidelines for dark green vegetables, the Healthy Diet recommends eating more vegetables. Additionally, the SF Diet fruit intake did not meet the recommendations. While lower than recommended, cheese which is often found with higher amounts of sodium and saturated fats [48,49] was the most reported dairy product consumed in the SF Diet. By not meeting the recommended intake of whole grains, vegetables, fruits, and dairy the SF Diet likely resulted in deficiencies in certain nutrients such dietary fiber and calcium, for example [3].

For proteins, shifts are needed to add more variety in the intake of other protein food subgroups [48,49]. The intake of fish and seafood were lower in the SF Diet than Healthy Diet. Substituting land-based animal proteins, specifically fatty cuts of meat such as beef, with fish and seafood could reduce the consumption of saturated fats, and potentially sodium [50,51] as well as increase the intake of vitamin D [52]. Similarly, substituting animal-based proteins with legumes, 0.2 c eq. lower in the SF Diet than Healthy Diet, could help lower the intake of saturated fat and increase dietary fiber intake. Additionally, nuts and seeds could be substituted with other low-fat protein food subgroups to reduce the intake of saturated fat. Saturated fats in nutrient-dense foods in the Healthy Diet (e.g., lean meat, poultry, eggs; nuts and seeds; and saturated fat in fatty acids of oils) contribute approximately five percent of total calories, leaving little room for additional saturated fats in a healthy dietary pattern [3].

3.3. Limitations

It is known that cross-sectional and dietary studies have limitations. While cross-sectional studies do not allow for causality, which was not the goal of this study, associations could be made between the food group intake and sociodemographic characteristics. For example, it is possible that food additives at the table and while cooking (e.g., butter) were underreported in this study due to the nature of an online 24HR, despite the survey design including prompts about missed food and beverages after each mealtime. Similar to other dietary assessments, 24HR are susceptible to over- and under-estimation since they rely on the ability of participants to recall previous food consumption, which can be difficult for participants to accurately estimate [53–55]. The accuracy of the dietary data could be affected by the use of a single 24HR and participant recall biases. The use of a single 24HR may not accurately estimate usual dietary intake since individual diets can vary day to day, but it is believed that the average of the participants' 24HRs can be used to represent the average diet for the SFMSA (see 27–29). Recall bias and underreporting of food intake has been associated with higher body fat percentage, feminine gender, and social desirability [56]. Women were more likely to respond to our survey (73% of participants) which could skew the dietary intake data for this study. Hence, portion sizes of desirable foods could have been overestimated and undesirable foods could have been underestimated. The 24HR completion rate (78.9% of participants that started the 24HR) and inclusion criteria could have led to selection bias. Selection bias could have occurred for populations with no or limited

[6] There is no specific quantity for solid fats or added sugars provided in the healthy dietary guidelines. They are accounted for in the Limit on Calories for Other Uses (kcal/day) based on a percent of overall calorie intake for each calorie level found in the healthy dietary guidelines.

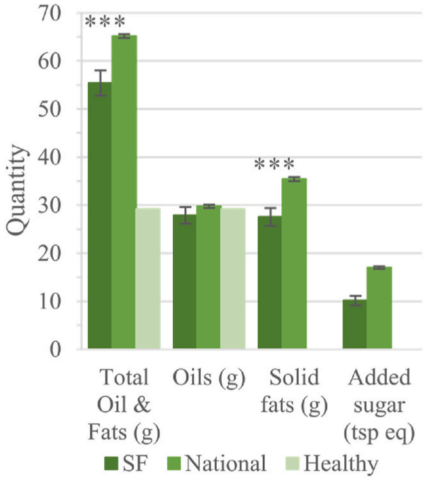

Fig. 2. Comparison of the intake of total oil and fats, oils, solid fats, and added sugar for the SF Diet, National Diet, and Healthy Diet. Error bars show the standard error. Asterisks denote where the mean SF Diet is statistically different from the National Diet, where * $p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Note: all p-values of tested food groups and subgroups are found in Appendix Table 4A.

electronic access that do not receive services from the Sioux Falls Health Department. 24HR(s) that may have been representative of participant(s)'s food intake may not have met the inclusion criteria.

Additionally, assumptions had to be made in the conversion of food products into their constituent parts and food groups. For example, the type of granola bars consumed were often not specified, and soy is an ingredient in "not further specified" granola bars in the FPED database. The difference in soy products and nuts and seeds between the National Diet and SF Diet could be influenced by the conversion of granola bars into food groups. Underestimations could be one reason why the mean intake of food groups, particularly oils and solid fats, in SF Diet are significantly different than the National Diet. These differences could also be partially explained by the demographic of this study in comparison to the National Diet. The National Diet is country wide, encompassing a broader demography whereas the sample that represents the SF Diet is from a rural metropolitan area, and metropolitan and rural areas have been shown to have different diets [57,58]. Since the SF Diet is based on diets in the SFMSA, the findings from this study may not be generalizable to other metropolitan areas in U.S. but to other rural metropolitan areas in the Midwest U.S. Finally, the small sample size from our study may not fully represent the diets of the SFMSA. However, the number of participants surveyed allows this study a 95% confidence level with 8.76% error in the dietary data.

3.4. Implications

The findings from this study have several public health and practical implications. The SF Diet raises concern for the incidence of several diet-related diseases without dietary changes. Red meat, and beef in particular, was the highest consumed protein. This is of concern because red meat intake has been linked to several types of cancers and higher mortality rates [59,60]. Higher intake of saturated or solid fats, red meat, added sugar, and refined grains have been associated with obesity, heart disease, and diabetes [3,61,62]. Low intake of foods such as fruit, vegetables, whole grains, dairy and fish and seafood can lead to deficient intake of dietary fiber, calcium, and vitamin D, for example, which are important for stimulating the homeostasis of gut bacteria as well as immune and brain function [63,64] and could contribute to suboptimal bone heath and increased risk of osteoporosis [52].

These findings suggest dietary changes and programs that promote a healthy lifestyle and diversified diets are needed in the SFMSA. A more nuanced approach in the development of programs that address health needs of individuals with different socio-demographic backgrounds is suggested. For example, unhealthy eating behaviors can be identified through well-designed health-surveillance programs and can inform political initiatives toward nutritional health [65,66]. Understanding dietary choices and health implications allows individuals to have a better awareness of their own health and gives them the ability to change their individual habits and dietary intake. Once a population's dietary intake is determined then initiatives can be designed to improve nutritional health based on current dietary data.

4. Conclusions

The purpose of this study was to evaluate the average dietary and energy intake in the SFMSA, assessing for sociodemographic differences, and to compare the SF Diet to the National Diet and Healthy Diet. Results from this study indicate that healthier dietary intake was associated with higher levels of education and income, whereas differences based on age and gender were less consistent in their alignment with the dietary guidelines. The SF Diet deviated from the National Diet and Healthy Diet in several food groups, but the average energy intake for the SF Diet was comparable to the USDA 2020–2025 Healthy Dietary Guidelines for Americans. Ultimately, the SF Diet and National Diet had similar trends compared to the Healthy Diet but neither diet followed the Healthy Diet. The results from this study suggest that the SF Diet and National Diet could be nutrient deficient with below recommended intake of certain nutrient-dense food groups including fruit, vegetables, (whole) grains, dairy, fish and seafood, and legumes.

Overall, findings from this study provide more insight into how sociodemographic characteristics influence dietary intake, particularly in urban areas in Midwest, USA, that can be evaluated in future studies. Comparing the SF Diet with the National Diet and Healthy Diet also shows the regionality of diets and reaffirms U.S. dietary patterns do not adhere to dietary guidelines. These findings raise concerns for public health. The implications from this study suggest that without changes, the SF Diet could lead to a higher probability of diet-related diseases. Programs that promote a healthy lifestyle and diverse, nutrient dense foods while addressing the different sociodemographic dietary trends and health needs are suggested. It is recommended these findings be used to help inform political initiatives and programs that promote a healthy lifestyle to improve overall dietary quality and nutritional health.

5. Ethics Statement

This study was submitted to the Institutional Review Board (IRB) at the University of South Dakota and was granted review exempt on April 2, 2020, with the approval number: IRB-20-25. Two IRB amendments were submitted and approved. The IRB was closed on December 13, 2021. All participants provided informed consent prior to initiating to participate in the study.

6. Data availability statement

The following is the Supplementary data to this article. De-identified data will be made available on request to the corresponding author.

CRediT authorship contribution statement

Jacinda Netzer: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Meghann Jarchow:** Conceptualization, Methodology, Validation, Funding acquisition, Project administration, Supervision, Resources, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Meghann Jarchow reports financial support was provided by National Science Foundation. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e28853.

Appendix. 6

Appendix Table 1A shows the sociodemographic descriptive statistics of the SFMSA sample that were calculated based on what participants reported.

Table 1A
Descriptive statistics of the sociodemographic characteristics of SFMSA sample.

Characteristics	Category	Number (n = 127)	Percentage, SD
Gender			
	Men	34	26.8%
	Women	93	73.2%
Age			
	18–34	39	30.7%
	35–49	47	37.0%
	50+	41	32.3%
	Median	41	
	Mean	43	±14.2
Race			
	White/Caucasian	114	89.8%
	Black/African American	3	2.4%
	American Indian/Alaska Native	3	2.4%

(continued on next page)

Table 1A (*continued*)

Characteristics	Category	Number ($n = 127$)	Percentage, SD
	Nonwhite Hispanic/Latino	3	2.4%
	Asian	1	0.8%
	Multiply Ethnicity	3	2.4%
Education			1.6%
	HS degree or less	17	13.4%
	Some college	34	26.8%
	College degree	53	41.7%
	Graduate degree	23	18.1%
Household income			
	<$24,999	17	13.4%
	$25,000–49,999	23	18.1%
	$50,000–74,999	27	21.3%
	$75,000–99,999	17	13.4%
	$100,000–149,999	24	18.9%
	$150,000+	19	14.9%
Household size			
	Mean	2.6	±1.3
Housing location			
	Urban	87	68.5%
	Suburban	15	11.8%
	Small city	12	9.4%
	Rural	13	10.2%
County			
	Lincoln	24	18.9%
	McCook	2	1.6%
	Minnehaha	98	77.2%
	Turner	3	2.4%

Notes: all values may not add up to 100% due to rounding error.

Appendix Table 2A shows all the different reported food groups, food subgroups, and all types of protein foods that participants reported eating. Juice was aggregated into total fruit and soy milk was aggregated into total dairy. Beef, pork, venison, and lamb were aggregated into red meat, and chicken and turkey were aggregated into poultry. Red meat and poultry were subsequently combined in the subgroup meat, poultry, and eggs for comparison with the USDA Healthy Dietary Guidelines for Americans.

Table 2A
The mean daily intake of all reported dietary food groups and subgroups among adults 18 years old and over in the SF Diet.

Food Group		Unit	Mean
Grains	**Total**	g	**164.77**
Whole grains		g	28.66
Refined grains		g	135.67
Vegetables	**Total**	g	**303.91**
Dark green		g	33.02
Red, orange		g	112.95
Legumes		g	17.65
Starchy, root		g	48.42
Other		g	91.87
Fruit	**Total**	g	**149.83**
Citrus[a]		g	48.59
Non-citrus		g	79.44
Juice		g	21.8
Dairy	**Total**	g	**258.87**
Fluid milk, yogurt		g	163.42
Cheese		g	89.92
Soy milk		g	5.53
Proteins	**Total**	g	**205.88**
Fish, seafood		g	17.16
Beef		g	38.52
Pork		g	20.77
Poultry		g	44.31
Other meat[b]		g	2.12
Eggs		g	24.28
Soy products, tofu		g	8.74
Nuts, seeds		g	30.40
Oil and fats	**Total**	g	**55.40**
Oils		g	27.87

(*continued on next page*)

Table 2A (*continued*)

Food Group	Unit	Mean
Solid Fats	g	27.53
Added sugar	g	**42.98**
Beverages Stimulants[c]	g	346.17
Nonalcoholic[d]	g	231.59
Alcoholic	g	12.67
Water	g	931.06

[a] includes citrus, melons, and berries.
[b] includes lamb and venison.
[c] includes coffee and tea.
[d] includes soft drinks, such as soda and carbonated water, energy drinks, and sports drinks.

Appendix Table 3A shows the four-way ANOVA *p*-values for the food groups and subgroups that had nonsignificant main and interactions effects based on the sample sociodemographic variables.

Table 3A
Nonsignificant ANOVA results in the analyses of differences in the intake of food group and subgroups in the SF Diet based on gender, age, education, household income, and first order interactions.

	Gender	Age	Education	Income		Gender	Age	Education	Income
Total grains					Total dairy				
Gender	0.92				Gender	0.86			
Age	0.26	0.17			Age	0.09	0.14		
Education	0.49	0.90	0.89		Education	0.44	0.78	0.54	
Income	0.78	0.48	0.46	0.09	Income	0.29	0.85	0.68	0.69
Whole grains					Cheese				
Gender	0.48				Gender	0.12			
Age	0.48	0.38			Age	0.79	0.08		
Education	0.34	0.95	0.79		Education	0.98	0.30	0.49	
Income	0.39	0.64	0.94	0.30	Income	0.41	0.20	0.57	0.58
Refined grains					Total protein				
Gender	0.77				Gender	0.07			
Age	0.55	0.05			Age	0.54	0.50		
Education	0.88	0.78	0.95		Education	0.45	0.75	0.53	
Income	0.66	0.56	0.55	0.29	Income	0.38	0.34	0.16	0.53
Total vegetables					Legume protein				
Gender	0.62				Gender	0.90			
Age	0.32	0.35			Age	0.60	0.22		
Education	0.11	0.93	0.49		Education	0.26	0.34	0.36	
Income	0.12	0.40	0.21	0.22	Income	0.95	0.77	0.46	0.44
Dark green veg.					Soy, nuts, seeds				
Gender	0.13				Gender	0.47			
Age	0.59	0.29			Age	0.65	0.22		
Education	0.49	0.56	0.95		Education	0.39	0.31	0.09	
Income	0.39	0.40	0.64	0.11	Income	0.98	0.53	0.89	0.12
Legume veg.					Soy products, tofu				
Gender	0.86				Gender	0.52			
Age	0.61	0.25			Age	0.45	0.57		
Education	0.22	0.34	0.24		Education	0.74	0.71	0.12	
Income	0.96	0.76	0.48	0.52	Income	0.07	0.66	0.98	0.27
Other veg.					Nuts, seeds				
Gender	0.60				Gender	0.33			
Age	0.12	0.16			Age	0.76	0.30		
Education	0.67	0.94	0.65		Education	0.30	0.33	0.15	
Income	0.80	0.69	0.56	0.29	Income	0.87	0.65	0.89	0.09
Total fruit					Total oils and solid fats				
Gender	0.73				Gender	0.15			
Age	0.34	0.58			Age	0.74	0.11		
Education	0.42	0.57	0.32		Education	0.68	0.83	0.71	
Income	0.69	0.96	0.36	0.49	Income	0.98	0.60	0.13	0.10
Citrus fruit					Oils				
Gender	0.59				Gender	0.44			
Age	0.37	0.93			Age	0.18	0.26		
Education	0.83	0.79	0.69		Education	0.82	0.85	0.18	
Income	0.57	0.94	0.72	0.51	Income	0.97	0.50	0.44	0.12
Non-citrus fruit					Solid fats				
Gender	0.97				Gender	0.22			

(*continued on next page*)

Table 3A (*continued*)

	Gender	Age	Education	Income		Gender	Age	Education	Income
Age	0.75	0.29			Age	0.69	0.32		
Education	0.08	0.87	0.27		Education	0.70	0.70	0.36	
Income	0.64	0.87	0.49	0.08	Income	0.90	0.29	0.25	0.40
Sugar					Water	0.22			
Gender	0.53				Gender	0.52			
Age	0.24	0.40			Age	0.35	0.76		
Education	0.78	0.15	0.68		Education	0.37	0.64	0.66	
Income	0.33	0.42	0.75	0.10	Income	0.12	0.06	0.84	0.94

Appendix Table 4A shows the mean for each food group and subgroup in SF Diet and National Diet. The *p*-values from the Welch's *t*-test on the differences for the food group and subgroups means between the SF Diet and National Diet. Significant findings have asterisks next to them.

Table 4A
Welch's *t*-test results of the difference between the SF Diet and National Diet for all food groups and subgroups.

			Units	SF Diet	National Diet	p-value[1]
Grains		Total	oz. eq.	5.8	6.6	0.019*
Whole grains			oz. eq.	1.0	0.8	0.172
Refined grains			oz. eq.	4.8	5.8	0.003**
Vegetables	Total		c eq.	1.9	1.5	<0.001***
Dark green			c eq.	0.3	0.2	<0.001***
Red, orange			c eq.	0.5	0.4	0.049*
Legumes			c eq.	0.1	0.1	0.170
Starchy, root			c eq.	0.4	0.5	0.265
Other			c eq.	0.7	0.5	0.061
Fruit	Total		c eq.	0.9	0.9	0.825
Citrus			c eq.	0.3	0.2	0.594
Other			c eq.	0.5	0.5	0.398
Juice			c eq.	0.1	0.2	<0.001***
Dairy	Total		c eq.	1.5	1.3	0.285
Fluid milk, yogurt			c eq.	0.7	0.6	0.865
Cheese, other			c eq.	0.8	0.7	0.142
Proteins		Total	oz. eq.	6.5	6.3	0.441
Fish, seafood			oz. eq.	0.6	0.7	0.491
Meat, poultry, eggs			oz. eq.	4.3	4.8	0.127
Red meat			oz. eq.	2.2	2.5	0.415
Poultry			oz. eq.	1.5	1.7	0.609
Eggs			oz. eq.	0.5	0.6	0.056
Legumes			oz. eq.	0.4	0.5	0.194
Nuts, seeds, soy prod.			oz. eq.	1.3	0.8	0.013*
Soy products			oz. eq.	0.2	0.1	0.027*
Nuts, seeds			oz. eq.	1.1	0.7	0.048*
Oils and fats		Total	g	55.4	65.2	<0.001***
Oils			g	27.9	29.8	0.278
Solid fats			g	27.5	35.4	<0.001***
Added sugar			tsp eq.	10.1	17.0	<0.001***
Alcoholic beverages			drinks	0.4	0.7	0.087

1 Asterisks denote where the mean SF Diet is statistically different from the National Diet, where * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Appendix Table 5A shows the numerical comparison of food groups and subgroups for the SF Diet, National Diet, and Healthy Diet. Asterisks indicate where the SF Diet and National Diet meet or exceed the Healthy Diet.

Table 5A
Comparison of the SF Diet and National Diet with the Healthy Diet.

		SF	National	Healthy
Grains (oz. eq.)	Total	5.8	6.6	7.3
	Whole grains	1.0	0.8	3.6
	Refined grains	4.8*	5.8*	3.6
Vegetables (c eq.)	Total	1.9	1.6	2.9
	Dark green	0.3*	0.2	0.3
	Red, orange	0.5	0.4	0.9
	Legumes	0.1	0.1	0.3
	Starchy, root	0.4	0.5	0.8
	Other	0.7*	0.6	0.7

(*continued on next page*)

Table 5A (*continued*)

		SF	National	Healthy
Fruit (c eq.)	Total	0.9	0.9	1.9
Dairy (c eq.)	Total	1.5	1.4	3.0
Proteins (oz. eq.)	Total	6.5*	6.3*	5.9
	Fish, seafood	0.6	0.6	1.3
	Meat, poultry, eggs	4.3*	4.8*	4.0
	Legumes	0.4	0.5	–
	Nuts, soy products	1.3*	0.9*	0.7
Oils and fats (g)	Total	55.4*	67.5*	29.2
	Oils	27.9	30.5*	29.2
	Solid fats	27.5	37.0	–
Added sugar (tsp eq.)	Total	10.1	17.0	–

References

[1] W.C. Willett, M.J. Stampfer, Current Evidence on healthy eating, Annu Rev Public Health [Internet] 34 (1) (2013) 77–95. Available from: https://www.annualreviews.org/doi/abs/10.1146/annurev-publhealth-031811-124646.

[2] M. Franquesa, G. Pujol-Busquets, E. García-Fernández, L. Rico, L. Shamirian-Pulido, A. Aguilar-Martínez, et al., Mediterranean diet and Cardiodiabesity: a systematic review through Evidence-based Answers to Key Clinical questions, Nutrients 11 (3) (2019), 2019/03/21.

[3] U.S. Department of Agriculture, U.S. Department of Health and Human Services, Dietary Guidelines for Americans, 2020-2025 [Internet]. 9th ed. 2020 [cited 2021 Feb 15]. Available from: DietaryGuidelines.gov.

[4] P.M. Guenther, K.O. Casavale, S.I. Kirkpatrick, J. Reedy, H.a.BB. Hiza, K.J. Kuczynski, et al., Diet quality of Americans in 2001-02 and 2007-08 as measured by the healthy eating index-2010: nutrition insight 51, J. Acad. Nutr. Diet. 113 (4) (2013).

[5] Centers for Nutrition Polly and Promotion (CNPP), U.S. Department of Agriculture (USDA), HEI-2010 total and Component Scores for Children, Adults, and Older Adults During 2011-2012 [Internet] (2016) [cited 2022 Apr 4]. Available from: http://www.cnpp.usda.gov.

[6] Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS), National health and nutrition examination survey: 2017–2018 data Documentation, Codebook, and Frequencies: dietary interview: individual foods, First Day (DR1IFF_J) [Internet] (2020) [cited 2021 Jan 13]. Available from: https://wwwn.cdc.gov/NCHS/nhanes/2017-2018/DR1IFF_J.htm.

[7] [Internet], U.S. Department of Agriculture, U.S. Department of Health and Human Services. Healthy People 2030, 2020 [cited 2022 May 9]. Available from: https://health.gov/healthypeople.

[8] S.I.P.R.D. Kirkpatrick, K.W.P. Dodd, J.P.R.D. Reedy, S.M.P.R.D. Krebs-Smith, Income and race/ethnicity are associated with adherence to food-based dietary guidance among US adults and Children, J. Acad. Nutr. Diet. 112 (5) (2012) 624–635.e6.

[9] E. Condon, S. Drilea, K. Jowers, C. Lichtenstein, J. Mabli, E. Madden, et al., Diet Quality of American by SNAP Participation Status: Data from the National Health and Nutrition Examination Survey, 2007-2010, 2015. Nutritional Assistance Program Report.

[10] R. Pechey, P. Monsivais, Socioeconomic inequalities in the healthiness of food choices: Exploring the contributions of food expenditures, Prev Med (Baltim) [Internet] 88 (2016) 203–209. Available from: https://www.sciencedirect.com/science/article/pii/S0091743516300676.

[11] S.A. French, C.C. Tangney, M.M. Crane, Y. Wang, B.M. Appelhans, Nutrition quality of food purchases varies by household income: the SHoPPER study, BMC Public Health [Internet] 19 (1) (2019) 231, https://doi.org/10.1186/s12889-019-6546-2. Available from:.

[12] M. Lombardo, G. Aulisa, E. Padua, G. Annino, F. Iellamo, A. Pratesi, et al., Gender differences in taste and foods habits, Nutr. Food Sci. 50 (1) (2020) 229–239.

[13] J. Ahn, N.S. Kim, B.K. Lee, Kim S. Park, Trends in the intake of fatty acids and their food source According to obese status among Korean adult population using KNHANES 2007-2017, Food Nutr Bull [Internet] 41 (1) (2020) 77–88. Available from: https://journals.sagepub.com/doi/abs/10.1177/0379572119898323.

[14] S.C. de Andrade, Á.N. Previdelli, C.L.G. Cesar, D.M.L. Marchioni, R.M. Fisberg, Trends in diet quality among adolescents, adults and older adults: a population-based study, Prev Med Rep 4 (2016).

[15] S. Boylan, T. Lallukka, E. Lahelma, H. Pikhart, S. Malyutina, A. Pajak, et al., Socio-economic circumstances and food habits in Eastern, Central and Western European populations, 2010/09/15, Public Health Nutr [Internet] 14 (4) (2011) 678–687. Available from: https://www.cambridge.org/core/article/socioeconomic-circumstances-and-food-habits-in-eastern-central-and-western-european-populations/BEEE912A1717FA52258A8B180659EDC8.

[16] K. Vlismas, V. Stavrinos, D.B. Panagiotakos, Socio-economic status, dietary habits and health-related outcomes in various parts of the world: a review, Cent Eur J Public Health 17 (2) (2009) 55–63, 2009/08/11.

[17] K. Backholer, E. Spencer, E. Gearon, D.J. Magliano, S.A. McNaughton, J.E. Shaw, et al., The association between socio-economic position and diet quality in Australian adults [Internet]. 2015/05/20, Public Health Nutr 19 (3) (2016) 477–485. Available from: https://www.cambridge.org/core/article/association-between-socioeconomic-position-and-diet-quality-in-australian-adults/48106AB58906A3D5A4B3534D670A9F4A.

[18] E. Gearon, K. Backholer, A. Hodge, A. Peeters, The mediating role of dietary factors and leisure time physical activity on socioeconomic inequalities in body mass index among Australian adults, BMC Publ. Health 13 (2013) 1214, 2013/12/24.

[19] A. Michimi, M.C. Wimberly, Associations of supermarket accessibility with obesity and fruit and vegetable consumption in the conterminous United States, Int. J. Health Geogr. 9 (1) (2010) 49.

[20] M.N. Lutfiyya, L.F. Chang, M.S. Lipsky, A cross-sectional study of US rural adults' consumption of fruits and vegetables: do they consume at least five servings daily? BMC Publ. Health 12 (1) (2012 Dec 1) 280.

[21] Sanford Avera, Live Well Sioux Falls, 2019 Community Health Status Report, Sioux Falls, 2019.

[22] U.S. Census Bureau. Census Redistricting data [internet] [cited 2021 Jan 14]. Available from: https://data.census.gov/cedsci/table?q=Sioux%20Falls&t=Counts,%20Estimates,%20and%20Projections&g=310XX00US43620&y=2020, 2020.

[23] H. Taylor, Does internet research work? Comparing online survey results with telephone survey, Int. J. Mark. Res. 42 (1999).

[24] G.W. Yun, C.W. Trumbg, Comparative response to a survey executed by post, e-mail, & web form, J. Computer-Mediated Commun. 6 (2000).

[25] K.B. Wright, Researching internet-based populations: advantages and disadvantages of online survey research, online questionnaire authoring software packages, and web survey services, J. Computer-Mediated Commun. 10 (3) (2005).

[26] C.A. Blanton, A.J. Moshfegh, D.J. Baer, M.J. Kretsch, The USDA automated multiple-pass method accurately estimates group total energy and nutrient intake, J. Nutr. 136 (10) (2006).

[27] G. Biró, K.F.A.M. Hulshof, L. Ovesen, J.A. Amorim Cruz, Selection of methodology to assess food intake, Eur. J. Clin. Nutr. 56 (2002).

[28] J. Brussaard, M. Löwik, L. Steingrímsdóttir, A. Møller, J. Kearney, Henauw S. De, et al., A European food consumption survey method–conclusions and recommendations, Eur. J. Clin. Nutr. 56 (S2) (2002 May 1) S89–S94.

[29] F.E. Thompson, A.F. Subar, Dietary assessment methodology, in: A.M. Coulston, C.J. Boushey, M.G. Ferruzzi, L.M. Delahanty (Eds.), Nutrition in the Prevention and Treatment of Disease, fourth ed., Elsevier, 2017, pp. 5–48.

[30] D.R. Shahar, N. Yerushalmi, F. Lubin, P. Froom, A. Shahar, E. Kristal-Boneh, Seasonal Variations in dietary intake Affect the consistency of dietary assessment, Eur. J. Epidemiol. 17 (2) (2001) 129–133.
[31] S.A. Bowman, J.C. Clemens, J.E. Friday, K.L. Lynch, A.J. Moshfegh, Food Patterns Equivalents Database 2017-2018: Methodology and User Guide [Internet], Maryland, Beltsville, 2020 [cited 2021 Mar 23]. Available from: http://www.ars.usda.gov/nea/bhnrc/fsrg.
[32] U.S. Department of Agriculture ARS, USDA Food and Nutrient Database for Dietary Studies 2017-2018 [Internet], 2020 [cited 2021 Mar 23]. Available from: http://www.ars.usda.gov/nea/bhnrc/fsrg.
[33] T.L. Blasbalg, J.R. Hibbeln, C.E. Ramsden, S.F. Majchrzak, R.R. Rawlings, Changes in consumption of omega-3 and omega-6 fatty acids in the United States during the 20th century, Am. J. Clin. Nutr. 93 (5) (2011 May 1) 950–962.
[34] National Marine Fisheries Service, Fisheries of the United States, 2018 [internet] [cited 2022 Jan 10]. Available from: https://www.fisheries.noaa.gov/national/commercial-fishing/fisheries-united-states-2018, 2020.
[35] G. Zipf, M. Chiappa, K.S. Porter, B.G. Lewis, Y. Ostchega, J. Dostal, National Health and Nutrition Examination Survey: Plan and Operations, 1999-2010. Vital and Health Statistics, Series 1: Programs and Collection Procedures, 2013, 56.
[36] N. Ahluwalia, J. Dwyer, A. Terry, A. Moshfegh, C. Johnson, Update on NHANES dietary data: Focus on collection, Release, Analytical Considerations, and Uses to inform public policy, Adv. Nutr. 7 (1) (2016 Jan 1) 121–134.
[37] R. Prättälä, L. Paalanen, D. Grinberga, V. Helasoja, A. Kasmel, J. Petkeviciene, Gender differences in the consumption of meat, fruit and vegetables are similar in Finland and the Baltic countries, Eur J Public Health [Internet] 17 (5) (2006) 520–525, https://doi.org/10.1093/eurpub/ckl265. Available from:.
[38] A. Aggarwal, A. Drewnowski, Plant- and animal-protein diets in relation to sociodemographic drivers, quality, and cost: findings from the Seattle Obesity Study, Am J Clin Nutr [Internet] 110 (2) (2019) 451–460, https://doi.org/10.1093/ajcn/nqz064. Available from:.
[39] K.L. Beck, B. Jones, I. Ullah, S.A. McNaughton, S.J. Haslett, W. Stonehouse, Associations between dietary patterns, socio-demographic factors and anthropometric measurements in adult New Zealanders: an analysis of data from the 2008/09 New Zealand Adult Nutrition Survey, Eur J Nutr [Internet] 57 (4) (2018) 1421–1433, https://doi.org/10.1007/s00394-017-1421-3. Available from:.
[40] A.P.D. Samara, B.P.D. Herbeth, N.C.P.D. Ndiaye, F.P.D. Fumeron, S.M.S. Billod, G.P.D. Siest, et al., Dairy product consumption, calcium intakes, and metabolic syndrome–related factors over 5 years in the STANISLAS study, Nutrition 29 (3) (2013) 519–524.
[41] M. Fisberg, R. Machado, History of yogurt and current patterns of consumption, Nutr. Rev. 73 (Suppl 1) (2015) 4–7, 2015/07/16.
[42] I. Kovalskys, A. Rigotti, B. Koletzko, M. Fisberg, G. Gómez, M. Herrera-Cuenca, et al., Latin American consumption of major food groups: results from the ELANS study, PLoS One [Internet] 14 (12) (2019) e0225101, https://doi.org/10.1371/journal.pone.0225101. Available from:.
[43] T. Huckle, R.Q. You, S. Casswell, Socio-economic status predicts drinking patterns but not alcohol-related consequences independently, Addiction [Internet] 105 (7) (2010) 1192–1202. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1360-0443.2010.02931.x.
[44] D. Kanny, T.S. Naimi, Y. Liu, H. Lu, R.D. Brewer, Annual total binge drinks consumed by U.S. Adults, 2015, Am J Prev Med. 2018/03/21 54 (4) (2018) 486–496.
[45] F. Lê, J. Ahern, S. Galea, Neighborhood education inequality and drinking behavior, Drug Alcohol Depend [Internet]. 2010/06/11 112 (1–2) (2010) 18–26. Available from: https://pubmed.ncbi.nlm.nih.gov/20541875.
[46] C.K. Lui, W.C. Kerr, N. Mulia, Y. Ye, Educational differences in alcohol consumption and heavy drinking: an age-period-cohort perspective, Drug Alcohol Depend. 186 (2018) 36–43, 2018/03/16.
[47] Centers for Disease Control and Prevention, BRFSS Prevalence & Trends Data [Internet], 2019 [cited 2021 Jul 18]. Available from: https://www.cdc.gov/brfss/brfssprevalence/.
[48] S.L. Drake, K. Lopetcharat, M.A. Drake, Salty taste in dairy foods: can we reduce the salt? J Dairy Sci. 2011/01/25 94 (2) (2011) 636–645.
[49] E. Yu, F.B. Hu, Dairy products, dairy fatty acids, and the prevention of Cardiometabolic disease: a review of recent Evidence, Curr Atheroscler Rep [Internet] 20 (5) (2018) 24. Available from: https://pubmed.ncbi.nlm.nih.gov/29564646.
[50] R.H. Eckel, J.M. Jakicic, J.D. Ard, JM de Jesus, N.H. Miller, V.S. Hubbard, et al., 2013 AHA/ACC guideline on lifestyle Management to reduce Cardiovascular risk, J Am Coll Cardiol [Internet] 63 (25_Part_B) (2014) 2960–2984. Available from: https://www.jacc.org/doi/abs/10.1016/j.jacc.2013.11.003.
[51] S. Bronzato, A. Durante, A Contemporary review of the relationship between red meat consumption and Cardiovascular risk, Int J Prev Med [Internet] 8 (2017) 40. Available from: https://pubmed.ncbi.nlm.nih.gov/28656096.
[52] I.R. Reid, M.J. Bolland, Calcium and/or vitamin D Supplementation for the prevention of Fragility Fractures: who needs it? Nutrients [Internet] 12 (4) (2020) 1011. Available from: https://pubmed.ncbi.nlm.nih.gov/32272593.
[53] A.L. Carriquiry, Estimation of usual intake distributions of nutrients and foods, J. Nutr. 133 (2) (2003) 601S–608S.
[54] K. Poslusna, J. Ruprich, J.H.M. de Vries, M. Jakubikova, P. van't Veer, Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice, Br. J. Nutr. 101 (S2) (2009) S73–S85.
[55] K.L. Rennie, A. Coward, S.A. Jebb, Estimating under-reporting of energy intake in dietary surveys using an individualised method, Br. J. Nutr. 97 (6) (2007) 1169–1176.
[56] C.L. Serban, A. Chirita-Emandi, I.T. Perva, A. Sima, N. Andreescu, S. Putnoky, et al., Intake differences between subsequent 24-h dietary recalls Create significant reporting bias in adults with obesity, Applied Sciences [Internet] 12 (5) (2022). Available from: https://www.mdpi.com/2076-3417/12/5/2728.
[57] J. Kearney, Food consumption trends and drivers, Phil. Trans. Biol. Sci. 365 (1554) (2010 Sep 27) 2793–2807.
[58] F. Imamura, R. Micha, S. Khatibzadeh, S. Fahimi, P. Shi, J. Powles, et al., Dietary quality among men and women in 187 countries in 1990 and 2010: a systematic assessment, Lancet Glob Health 3 (3) (2015 Mar) e132–e142.
[59] V. Bouvard, D. Loomis, K.Z. Guyton, Y. Grosse, F El Ghissassi, L. Benbrahim-Tallaa, et al., Carcinogenicity of consumption of red and processed meat, Lancet Oncol [Internet] 16 (16) (2015) 1599–1600. Available from: https://www.sciencedirect.com/science/article/pii/S1470204515004441.
[60] Y. Zheng, Y. Li, A. Satija, A. Pan, M. Sotos-Prieto, E. Rimm, et al., Association of changes in red meat consumption with total and cause specific mortality among US women and men: two prospective cohort studies, BMJ [Internet] 365 (2019) l2110. Available from: https://www.bmj.com/content/bmj/365/bmj.l2110.full.pdf.
[61] C.J.L. Murray, J. Abraham, M.K. Ali, M. Alvarado, C. Atkinson, L.M. Baddour, et al., The State of US health, 1990-2010: Burden of diseases, injuries, and risk factors, JAMA 310 (6) (2013 Aug 14) 591–608.
[62] D.D. Wang, C.W. Leung, Y. Li, E.L. Ding, S.E. Chiuve, F.B. Hu, et al., Trends in dietary quality among adults in the United States, 1999 through 2010, JAMA Intern. Med. 174 (10) (2014).
[63] Y. Cai, J. Folkerts, G. Folkerts, M. Maurer, S. Braber, Microbiota-dependent and -independent effects of dietary fibre on human health, Br. J. Pharmacol. 177 (2020).
[64] I.R. Reid, M.J. Bolland, Calcium and/or vitamin D Supplementation for the prevention of Fragility Fractures: who needs it? Nutrients [Internet] 12 (4) (2020) 1011. Available from: https://pubmed.ncbi.nlm.nih.gov/32272593.
[65] R. Ballard-Barbash, Designing surveillance Systems to address Emerging Issues in diet and health, J. Nutr. 131 (2) (2001 Feb 1) 437S–439S.
[66] C.A. Monteiro, M.H.D. Benicio, W.L. Conde, S. Konno, A.L. Lovadino, A.J.D. Barros, et al., Narrowing socioeconomic inequality in child stunting: the Brazilian experience, 1974-2007, Bull. World Health Organ. 88 (4) (2010) 305–311.