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Associations between social isolation and diet quality among US adults with disability participating in the National Health and Nutrition Examination Survey, 2013–2018

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A B S T R A C T

Social isolation and disability are established risk factors for poor nutrition. We aimed to assess whether social isolation is associated with diet quality specifically among adults with disabilities.

This cross-sectional analysis used data from the National Health and Nutrition Examination Survey, 2013–2018. Adults with a disability, who were not pregnant, breastfeeding, or missing dietary intake data were included (n = 5,167). Disability was defined as a physical functioning limitation based on difficulty with any activities of daily living, instrumental activities of daily living, lower extremity mobility activities, or general physical activities. The Healthy Eating Index (HEI)-2015 measured diet quality; higher scores correspond to higher diet quality. We computed a social isolation index by summing single status, living alone, and two social engagement difficulty measures (one point for each component met; maximum 4 points). Multivariable linear regression, controlling for demographic and health covariates, estimated differences in HEI scores for dietary intake data, by social isolation score.

Over half of HEI scores were < 51, corresponding to "poor" diet quality. Higher social isolation score was associated with lower vegetable and seafood/plant proteins intake. Single status and one of two social engagement measures were associated with lower scores on certain adequacy components. Differences were modest. There was little evidence of effect modification by age or gender.

Adults with disabilities are not meeting national dietary standards; improving diet quality is a priority. Whether social isolation is associated with specific dietary components in this population requires further investigation. Further research is also needed among younger adults.

1. Introduction

Disability affects one in four (61 million) US adults (Okoro et al., 2019) and is a well-established risk factor for social isolation (Macdonald et al., 2018; Emerson et al., 2020) and inadequate nutrition (An et al., 2015; Xu et al., 2012; Kim et al., 2013; Sugiura et al., 2016). Improving the health of people living with disabilities and improving Americans' nutrition status are Healthy People 2030 goals (U.S. Department of Health and Human Services, 2020). Improving diet quality is important for chronic disease prevention and management and for preserving the functional status and cognition of older adults (Zhao and Andreyeva, 2022; Fan et al., 2021), especially relevant for adults who already have a disability.

Studies globally have revealed significant associations between disability and nutrition status, considering diet quality based on reported intake only (An et al., 2015; Xu et al., 2012) or overall nutritional risk accounting for environmental, food insecurity, and health factors (Kim et al., 2013; Sugiura et al., 2016). Two studies using US nationally representative National Health and Nutrition Examination Survey (NHANES) data found an inverse association between better nutrition

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and odds of disability (An et al., 2015; Xu et al., 2012).

Social isolation, the objective lack of interactions with others or lack of a social network, is distinct from loneliness, the subjective perception of absence of social interaction (Leigh-Hunt et al., 2017). Social isolation and loneliness are consistently associated with poor mental health, cardiovascular outcomes, and mortality, and may be as important as traditional clinical risk factors in predicting mortality (Leigh-Hunt et al., 2017; Pantell et al., 2013). In older adults, social isolation and loneliness have been independently associated with poor nutrition (Boulos et al., 2017; Sahyoun and Zhang, 2005). In a study among middle-aged and older US adults using NHANES 2007–2008 data, greater social support was associated with better diet quality as measured by Healthy Eating Index (HEI) scores (Pieroth et al., 2017). There is prior evidence that this relationship differs by gender, with social isolation having a stronger negative effect on men compared with women, particularly single or widowed men (Pieroth et al., 2017; Vinther et al., 2016; Noguchi et al., 2021).

While studies have documented how disability and social isolation affect nutrition status separately, few have examined the association between social isolation and diet quality and food access specifically among people living with a disability. Further, most studies that investigate disability limit the study population to older adults, excluding a substantial proportion of adults living with disability. Younger adults may experience the effects of social isolation differently than older adults (Emerson et al., 2020; Schwartz et al., 2019; Holt-Lunstad et al., 2015) and on average have worse diet quality (U.S. Department of Agriculture, 2015). This study aimed to address these gaps by assessing whether social isolation is associated with diet quality among a nationally representative sample of community-dwelling US adults living with a disability, and whether age and gender (Pieroth et al., 2017) are effect measure modifiers of the relationship between social isolation and diet quality. We hypothesized that social isolation would be associated with lower diet quality among people living with a disability, and that this relationship would be stronger among younger compared with older adults, and among men compared with women.

2. Methods

2.1. Data source and study population

We conducted a cross-sectional analysis using NHANES 2013–2018 data. NHANES is a nationally representative survey designed to assess the health and nutrition status of the non-institutionalized US population (Chen et al., 2020). Survey procedures and sampling design have been described extensively previously (Chen et al., 2020). Disability was defined using the Physical Functioning Questionnaire (PFQ), representing physical functioning limitations due to long-term physical, mental, and emotional problems or illness (An et al., 2015; Centers for Disease Control and Prevention, 2020). A positive response was "some difficulty," "much difficulty," or "unable to do" for any question regarding ability to complete activities within the categories of daily living, instrumental activities of daily living, lower extremity mobility, and general physical activities (An et al., 2015; Xu et al., 2012). The 29,400 participants in the NHANES 2013–2018 cycles included 5,994 adults with a self-reported disability. We excluded those who were pregnant or breastfeeding (n = 267) or had missing dietary data (n = 808). The final sample was 5,167 participants (Fig. 1), reflecting a weighted frequency of 67 million. This study was exempt from Institutional Review Board approval due to use of a publicly available, de-identified data source.

2.2. Healthy Eating index

Diet quality was measured using the HEI-2015, which examines how closely an individual's diet aligns with the 2015–2020 *Dietary Guidelines for Americans* (Kirkpatrick et al., 2019; Krebs-Smith et al., 2019). It is

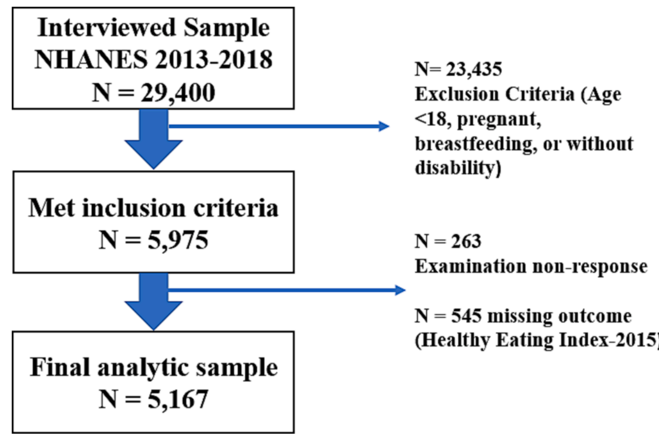

Fig. 1. Study Sample Flow Diagram.

comprised of 13 component scores: "adequacy" components (higher intake gives higher scores: total and whole fruits, total vegetables, greens and beans, whole grains, dairy, total proteins, seafood and plant proteins, fatty acids) and "moderation" components (higher intake gives lower scores: refined grains, sodium, added sugars, saturated fats). Scores range from 0 to 100; higher score corresponds with better diet quality. As it is recommended against using multiple versions of the HEI in a study due to possibility of score differences, we applied the HEI-2015 to all the data in our sample (Kirkpatrick et al., 2019). We categorized scores into < 51 ("poor" diet), 51–80 (diet "needs improvement") and 81 ("good" quality diet) (Choi et al., 2021; Basiotis et al., 2004).

We calculated HEI scores by applying the respective scoring algorithm to the day 1 dietary interview data, which was conducted in-person using a 24-hour dietary recall via a multiple-pass method (U.S. Department of Agriculture, 2022.). Survey data is weighted according to day of the week of the interview. Dietary intake data is linked to the US Department of Agriculture (USDA) Food and Nutrition Database for Dietary Studies to determine nutrient breakdown of foods eaten (U.S. Department of Agriculture, 2022). We applied the "Simple HEI Scoring Algorithm – Per Day" using SAS macros, publicly available from the National Cancer Institute (National Cancer Institute, 2023).

2.3. Social isolation

We created a social isolation index based on existing validated social isolation indices that measure social isolation as a construct, measured across multiple domains (Berkman and Syme, 1979; Victor et al., 2008; Cornwell and Waite, 2009). Our index uses available NHANES questions covering domains of marriage/partnership (Berkman and Syme, 1979; Pohl et al., 2017), living alone (Cudjoe et al., 2020; Victor et al., 2000), and participation in social activities (Berkman and Syme, 1979; Cornwell and Waite, 2009; Cudjoe et al., 2020). Living alone has been used in the National Health and Aging Trends Study to measure social isolation among older adults, and is associated with nutrition risk (Cudjoe et al., 2020; Victor et al., 2000; Weddle and Fanelli-Kuczmarski, 2000).

The social isolation index computes a score ranging 0 to 4 (higher score representing more social isolation) based on four components: marital status (1 point for widowed, divorced, separated, or never married; 0 points for married or living with partner), living alone (1 point for household size of one), and two items from the PFQ: how much difficulty do you have "going out to things like shopping, movies or sporting events," and "participating in social activities [visiting friends, attending clubs or meetings or going to parties]" (one point for each with answers of "some difficulty," "much difficulty," or "unable to do"). This social isolation index was correlated with depression and with self-reported health status within our study sample (Spearman's correlation p <.01), which is similar to a method described previously for validating a new social support measure (Pohl et al., 2017).

2.4. Statistical analysis

We obtained frequencies and proportions of categorical variables and mean (SE) for HEI score. We used one-way ANOVA to compare the HEI scores by covariate categories.

Linear regression estimated the associations between social isolation and continuous HEI score. In the multivariable-adjusted linear regression models, we adjusted for covariates that have been associated with social isolation and/or total HEI score in the literature (cut points based on similar studies using NHANES data (Pieroth et al., 2017; Bigman and Ryan, 2021): age (categorized into 18–39, 40–59, and ≥ 60 years, similar to how NHANES dietary data is presented by the USDA, which groups age by decade (U.S. Department of Agriculture, 2022), gender (male, female), race/ethnicity (Mexican American or Hispanic, non-Hispanic White, non-Hispanic Black, Other), education (<high school, high school or GED, >high school), chronic condition count, smoking status (never, former, current), and physical activity level (using the Physical Activity questionnaire; sedentary: 0 min/week activity, somewhat active: > 0 min and < 75 min/week vigorous or 150 min/week moderate activity, active: ≥75 min/week vigorous or 150 min/week moderate activity). Chronic condition count included diabetes, hypertension, heart disease, stroke, chronic lung disease, cancer, arthritis, osteoporosis (Falvey et al., 2021), categorized as 0, 1, ≥2. Depression was defined based on positive screening via the patient health questionnaire 9 (PHQ-9) score ≥ 10 (Manea et al., 2012). We examined social isolation score as a categorical variable rather than continuous due to suspected non-uniformity in differences between score levels, and having fewer than five categories (Rhemtulla et al., 2012). We collapsed scores 3 and 4 into a single category due to small sample sizes and suspected similarity in severity of social isolation compared to lower score categories. A score of 0 was the reference category.

To assess whether age and sex were effect measure modifiers, stratified linear regression models assessed the association between social isolation and HEI score by age and sex (Pieroth et al., 2017; Kobayashi and Steptoe, 2018). The interaction was deemed significant if the p-values for likelihood ratio tests for global interaction (social isolation and age category, social isolation and gender) were <0.05. As a secondary analysis to assess potential mediation of the association between social isolation and nutrition by depression, we compared estimates for social isolation between multivariable models including and excluding depression (defined based on PHQ-9 score ≥ 10 (Manea et al., 2012). The delta beta between the two models is interpretable as the extent of mediation by depression (MacKinnon et al., 2007).

We conducted analyses using SAS Studio (Cary, NC). We used SAS survey procedures, accounting for sample weights, strata, and clustering parameters specific to the 2013–2018 NHANES cycles. We imputed missing data for variables with >5% missing: depression (missing n = 291) and each social isolation variable that comprise the index (missing n = 571 for computed social isolation score) using hotdeck method with jackknife variance estimation and weighted selection.

3. Results

Most participants were 60 years or older (60.0%), female (56.4%), White (72.3%), had greater than a high school education (54.8%), had at least two chronic conditions (61.4%), and were sedentary (60.6%) (Table 1). Depression was prevalent (16.4%). The weighted mean total HEI-2015 score was 50.1 (standard error (SE) 0.4), and over half (52.8%) had HEI-2015 scores below 51. Total HEI-2015 score significantly differed across most covariate categories. Notably, total HEI-2015 score increased with older age categories (44.9 for age 18–39 compared with 53.4 for age ≥ 60, p < 0.01 for ANOVA).

The most common social isolation components were being single

Table 1
Descriptive characteristics of adults with disability, NHANES 2013–2018, N = 5,167.

	N (Weighted %)	Total HEI Score[a], Mean (SE)	p (ANOVA)
Total HEI-2015 Score	–	50.1 (0.4)	–
<51	2722 (52.8)	–	
51–80	2332 (45.5)	–	
≥80[b]	113 (1.7)	–	
Sex			**<0.01**
Male	2356 (43.6)	48.9 (0.4)	
Female	2811 (56.4)	51.0 (0.5)	
Age			**<0.01**
18–39	548 (13.7)	44.9 (0.9)	
40–59	1189 (26.4)	47.7 (0.7)	
≥60	3430 (60.0)	52.4 (0.3)	
Social isolation components			
Single[c]			0.26
Yes	2479 (42.6)	49.8 (0.5)	
No	2688 (57.4)	50.4 (0.5)	
Living alone[d]			**<0.01**
Yes	1159 (20.1)	51.8 (0.7)	
No	4008 (79.9)	49.7 (0.5)	
Difficulty attending social events[e]			**<0.01**
Yes	1548 (28.5)	48.7 (0.6)	
No	3619 (71.5)	50.7 (0.4)	
Difficulty going out to things[f]			**<0.01**
Yes	1908 (34.5)	48.7 (0.5)	
No	3259 (65.5)	50.9 (0.4)	
Race/ethnicity			0.30
Non-Hispanic White	2362 (72.3)	50.1 (0.5)	
Non-Hispanic Black	1129 (10.5)	48.6 (0.6)	
Mexican American or Other Hispanic	1146 (10.0)	50.7 (0.6)	
Other	530 (7.2)	51.5 (1.0)	
Education			**<0.01**
<High school	1374 (17.0)	48.7 (0.6)	
High school	1333 (28.2)	48.5 (0.7)	
>High school	2450 (54.8)	51.4 (0.4)	
Missing	10 (0.10)	58.4 (5.6)	
Household income, ratio to poverty threshold			**<0.01**
<1.0	1196 (16.8)	46.7 (0.7)	
1.0–1.99	1499 (23.1)	49.9 (0.5)	
2.0–3.99	1135 (25.6)	49.4 (0.6)	
≥4.0	831 (26.4)	52.8 (0.7)	
Missing	506 (8.1)	51.3 (1.2)	
Employed			0.22
Yes	1396 (32.2)	49.5 (0.7)	
No	3764 (67.7)	50.4 (0.4)	
Missing	7 (0.11)	48.1 (6.0)	
Chronic condition count			0.10
0	676 (14.3)	49.1 (1.1)	
1	1139 (23.2)	49.4 (0.6)	
≥2	3283 (61.4)	50.6 (0.4)	
Missing	69 (1.1)	50.3 (2.1)	
Depression[g]			**<0.01**
Yes	875 (16.4)	47.5 (0.8)	
No	4292 (83.6)	50.6 (0.4)	
Smoking status			**<0.01**
Never	2354 (45.6)	52.1 (0.5)	
Former	1658 (32.4)	51.0 (0.5)	
Current	1151 (21.9)	44.9 (0.5)	
Missing	4 (0.02)	43.3 (4.0)	
Physical activity[h]			**<0.01**
Sedentary	3401 (60.6)	48.7 (0.3)	
Somewhat active	713 (15.8)	53.2 (0.9)	
Active	1044 (23.4)	51.8 (0.7)	
Missing	9 (0.11)	49.7 (3.8)	
BMI (kg/m^2), weighted mean (SE)	31.0 (0.2)	–	–
Prescription medication use, past month			**0.05**
Yes	4377 (84.2)	50.4 (0.4)	
No	784 (15.7)	48.5 (1.1)	
Missing	6 (0.12)	56.8 (2.6)	

(continued on next page)

Table 1 (*continued*)

	N (Weighted %)	Total HEI Score[a], Mean (SE)	p (ANOVA)
Frequency of health problems causing difficulty[i]			
Chronic bone problem (arthritis, fractures, other bone/joint injury)	2808 (54.4)	50.6 (0.4)	0.06
Back or neck problems	2229 (43.9)	49.8 (0.5)	0.27
Other (senility, other injury or impairment)	1431 (28.5)	50.3 (0.5)	0.63
Cardiovascular/cerebrovascular	1520 (23.5)	50.3 (0.5)	0.71
Sensory (vision or hearing)	1139 (18.5)	50.0 (0.5)	0.83
Depression/anxiety/emotional	937 (18.4)	47.1 (0.7)	**<0.01**
Weight	644 (12.9)	48.5 (0.8)	**0.02**
Lung/breathing	596 (11.4)	47.7 (0.7)	**<0.01**
Diabetes	774 (10.4)	51.7 (0.7)	**0.01**
Cancer	186 (3.5)	49.6 (1.4)	0.75
Congenital/developmental	137 (2.8)	46.0 (1.7)	**0.02**

All analyses conducted using SAS survey procedures and adjusted using NHANES survey weights. Missing values were imputed for social isolation components and depression.

[a] HEI = healthy eating index; using HEI-2015.

[b] The ages of all respondents ages 80 years and older are coded as '80′ due to disclosure risk.

[c] Not married or not living with a partner; [d]Household size of one; [e]Activities like visiting friends, attending parties, clubs, meetings; [f]Activities such as shopping, movies, sporting events.

[g] Positive screening based on score ≥ 10 on the PHQ-9.

[h] Active = 150 min moderate or 75 min/week vigorous activity, Somewhat active = ≥ 0 min but < active.

[i] Health problems causing difficulty with activities assessed in physical functioning questionnaire; categories are not mutually exclusive. p-value for ANOVA (yes vs. no for each category). **Bold:** statistically significant at p < 0.05.

(42.6%), and having difficulty going out to things like shopping, movies, or sporting events (34.5%), while fewer participants reported having difficulty participating in social activities (visiting friends, going to parties, meetings, and clubs), or living alone. For social isolation score, the distribution ranged from 36.2% with a score of 0 (n = 1616), to 15.1% with a score of 3 or 4 (n = 630 for 3, and n = 274 for 4).

The most common health problems that participants identified as causing difficulty related to activities assessed by the PFQ were chronic bone problems (including arthritis, fractures; 54.4%) and back or neck problems (43.9%). Many reported sensory issues (18.5%), which was in similar frequency as emotional concerns including depression/anxiety (18.4%).

In the unadjusted linear regression model, social isolation score was associated with lower total HEI-2015 score, with the estimate greatest for social isolation score 3 compared to score 0 (β = -2.81, 95% CI −4.30, −1.33) (Appendix, A.1). This association did not remain statistically significant in the adjusted model (Table 2). Social isolation score was associated with lower scores for several adequacy components. These included total vegetables for all social isolation score categories, and seafood and plant proteins for score categories 1 and 3 compared with score 0. For social isolation score 3, the β estimate for total vegetables was −0.36 (95% CI −0.55, −0.17) and for seafood and plant proteins, the estimate was −0.26 (95% CI −0.49, −0.03). In contrast, social isolation score 1 was associated with higher whole grains score compared to score 0 (β = 0.40, 95% CI 0.06, 0.73).

In adjusted analyses, no individual social isolation components had significant β estimates for total HEI-2015 score, when compared with the reference category of not meeting criteria for that component (Table 3). For HEI-2015 components, those who reported single status had a lower total vegetable score than those who were married or living with a partner (β = -0.21, 95% CI −0.33,-0.10). Participants who indicated difficulty with one of the social engagement measures, going out to do things like shopping, movies, sporting events, had lower scores for total vegetables, greens and beans, total protein foods, and seafood and plant proteins compared to those who did not report this difficulty. The largest magnitude of these associations was for seafood and plant proteins (β = -0.25, 95% CI −0.43, −0.08). This social engagement measure was also associated with lower added sugars score (β = -0.34, 95% CI −0.62, −0.06).

There was little evidence of effect modification by age or gender (likelihood ratio tests for global interaction, p values > 0.05) (Appendix, A.2).

In our sensitivity analysis with additional adjustment for depression (Appendix, A.3), estimates for social isolation and total HEI-2015 score, adequacy components, and moderation components were all similar to the model without adjustment for depression. This suggests that there

Table 2
Multivariable-adjusted linear regression results for HEI total and component scores by social isolation score among adults with disability, NHANES 2013–2018.

	Social Isolation Score[b]			
	0	**1**	**2**	**3**[c]
Sample size, unweighted n	1616	1186	1461	904
Total HEI-2015[a] score (SE)	50.9 (0.5)	49.1 (0.7)	50.9 (0.6)	48.1 (0.6)
	***β* estimate (95% CI)**			
Total HEI-2015 score	0.0 (ref)	-0.62 (-1.71, 0.47)	0.50 (-0.77, 1.95)	-1.08 (-2.40, 0.25)
HEI-2015 Score Component (max points)				
Adequacy Components[d]				
Total fruit (5)	0.0 (ref)	0.00 (-0.18, 0.19)	0.12 (-0.08, 0.33)	0.01 (-0.23, 0.25)
Whole fruit (5)	0.0 (ref)	−0.18 (-0.37, 0.01)	0.01 (-0.25, 0.27)	−0.14 (-0.40, −0.12)
Total vegetables (5)	0.0 (ref)	**−0.24 (-0.40, −0.08)****	**−0.21 (-0.39, −0.03)***	**−0.36 (-0.55, −0.17)****
Greens and beans[e] (5)	0.0 (ref)	−0.08 (-0.30, 0.13)	−0.00 (-0.24, 0.23)	−0.18 (-0.44, 0.08)
Whole grains (10)	0.0 (ref)	**0.40 (0.06, 0.73)***	0.20 (-0.13, 0.53)	−0.07 (-0.43, 0.29)
Dairy (10)	0.0 (ref)	−0.07 (-0.47, 0.32)	0.19 (-0.18, 0.55)	−0.04 (-0.54, 0.45)
Total protein foods (5)	0.0 (ref)	−0.10 (-0.26, 0.06)	−0.04 (-0.18, 0.11)	−0.03 (-0.19, 0.12)
Seafood and plant proteins (5)	0.0 (ref)	**−0.31 (-0.57, −0.05)***	−0.17 (-0.38, 0.03)	**−0.26 (-0.49, −0.03)***
Fatty acids (10)	0.0 (ref)	−0.24 (-0.61, 0.13)	−0.08 (-0.45, 0.29)	−0.05 (-0.50, 0.40)
Moderation components[f]				
Refined grains (10)	0.0 (ref)	0.25 (-0.16, 0.67)	0.31 (-0.00, 0.63)	0.23 (-0.23, 0.68)
Sodium (10)	0.0 (ref)	0.17 (-0.26, 0.59)	0.30 (-0.14, 0.75)	0.09 (-0.38, 0.56)
Added Sugars (10)	0.0 (ref)	−0.20 (-0.59, 0.19)	−0.08 (-0.49, 0.33)	−0.28 (-0.69, 0.12)
Saturated Fats (10)	0.0 (ref)	−0.02 (-0.45, 0.41)	0.02 (-0.30, 0.34)	0.02 (-0.46, 0.49)

All analyses conducted using SAS survey procedures and adjusted using NHANES survey weights.

Adjusted for age, gender, race, education, chronic condition count, physical activity, smoking status.

[a] Healthy Eating Index-2015, maximum score 100 points.

[b] Higher scores indicate more social isolation.

[c] Includes those positive for 3 or 4 components.

[d] Higher intakes result in higher scores.

[e] Dark green and orange vegetables and legumes.

[f] Higher intakes result in lower scores *p < 0.05, **p < 0.01.

Table 3
Multivariable-adjusted linear regression results for HEI total and component scores by social isolation component among adults with disability[a], NHANES 2013–2018.

	Social Isolation Component			
	Single[b]	Living alone[c]	Difficulty going out to things[d]	Difficulty with social activities[e]
Sample size, unweighted n	2479	1159	1908	1548
Total HEI-2015[a] score (SE)	48.7 (0.6)	51.8 (0.7)	48.7 (0.6)	48.7 (0.5)
		β estimate (95% CI)		
Total HEI-2015 score	−0.31 (-1.29, 0.67)	0.69 (-0.61, 1.99)	−0.85 (-1.86, 0.16)	0.12 (-0.81, 1.04)
HEI-2015 Score Component (max points)				
Adequacy Components[f]				
Total fruit (5)	0.00 (-0.16, 0.16)	0.16 (-0.04, 0.36)	0.00 (-0.13, 0.14)	0.06 (-0.16, 0.28)
Whole fruit (5)	−0.11 (-0.27, 0.06)	0.09 (-0.12, 0.30)	−0.03(-0.22, 0.15)	0.01 (-0.23, 0.25)
Total vegetables (5)	**−0.21 (-0.33, −0.10)****	−0.11 (-0.27, 0.05)	**−0.18 (-0.32, −0.04)***	−0.17 (-0.35, 0.01)
Greens and beans[g] (5)	−0.03 (-0.22, 0.17)	0.09 (-0.14, 0.31)	**−0.20 (-0.38, −0.03)***	−0.13 (-0.31, 0.05)
Whole grains (10)	−0.02 (-0.23, 0.19)	0.04 (-0.33, 0.40)	−0.02 (-0.28, 0.24)	0.10 (-0.19, 0.39)
Dairy (10)	−0.14 (-0.39, 0.06)	−0.12 (-0.49, 0.25)	0.15 (-0.21, 0.51)	0.20 (-0.10, 0.49)
Total protein foods (5)	0.05 (-0.05, 0.16)	0.00 (-0.13, 0.13)	**−0.12 (-0.24, −0.01)***	−0.03 (-0.14, 0.09)
Seafood and plant proteins (5)	−0.10 (-0.26, 0.07)	0.07 (-0.14, 0.28)	**−0.25 (-0.43, −0.08)****	−0.13 (-0.32, 0.05)
Fatty acids (10)	0.07 (-0.21, 0.35)	0.17 (-0.20, 0.54)	−0.24 (-0.57, 0.09)	0.01 (-0.30, 0.33)
Moderation components[h]				
Refined grains (10)	0.07 (-0.21, 0.35)	0.13 (0.22, 0.49)	0.13 (-0.14, 0.40)	0.23 (-0.03, 0.49)
Sodium (10)	0.12 (-0.15, 0.40)	−0.01 (-0.34, 0.33)	0.23 (-0.14, 0.60)	−0.01 (-0.41, 0.38)
Added Sugars (10)	−0.10 (-0.37, 0.18)	0.13 (-0.21, 0.47)	**−0.34 (-0.62, −0.06)***	−0.03 (-0.30, 0.25)
Saturated Fats (10)	0.06 (-0.22, 0.34)	0.05 (-0.29, 0.39)	0.02 (-0.34, 0.39)	0.01 (-0.34, 0.35)

All analyses conducted using SAS survey procedures and adjusted using NHANES survey weights.
Adjusted for age, gender, race, education, chronic condition count, physical activity, smoking status.
[a] Healthy Eating Index-2015, maximum score 100 points.
[b] Single compared to those who were married or living with a partner.
[c] Those with household size of one compared to those with household size > 1.
[d] Those with difficulty going out to do things shopping, movies, sporting events compared to those without difficulty.
[e] Those with difficulty participating in social activities such as visiting others, going to meetings, clubs, parties compared to those without difficulty.
[f] Higher intakes result in higher scores.
[g] Dark green and orange vegetables and legumes.
[h] Higher intakes result in lower scores *p <.05; **p <.01.

was not substantial mediation by depression, when adjusting for other covariates.

4. Discussion

This study is among the first to examine the association between social isolation and diet quality among adults with disability in a nationally representative US sample. Higher social isolation was associated with lower overall diet quality, but this did not remain significant in the adjusted analysis. Observed associations were modest. Social isolation score was associated with lower intake of total vegetables and seafood and plant proteins, but associations were sometimes inconsistent across social isolation score categories. When we evaluated specific social isolation components, we found that single status was associated with lower vegetable intake, and having difficulty going out to things was associated with lower intake of total vegetables, greens and beans, total protein foods, and seafood and plant proteins, and higher intake of added sugars. There were no differences in the association between social isolation and HEI score stratified by gender or age.

Our observed differences were small (<1.0 point lower for the significant HEI-2015 score components), although they are on par with prior literature examining HEI-2015 component scores among women, which observed one-third to one-half points lower on certain adequacy components comparing those with and without disability (Deierlein et al., 2022). It has been proposed that for intervention studies comparing HEI scores across groups, a clinically significant difference in scores would be 5 or 6 points to achieve a moderate effect size of 0.5 (Kirkpatrick et al., 2019). Our adjusted estimates are substantially lower than this. Importantly, however, the majority of observed total HEI scores (overall and across all social isolation scores) would be categorized as diet quality that is poor (<51) or needs improvement (51–80); <2% of scores were above 81, the cutoff often used to reflect "good" diet quality (Kirkpatrick et al., 2019; Choi et al., 2021; Basiotis et al., 2004). Diet quality of adults in the US population overall needs improvement; 10.7% of older adults in the 2013 Health Care and Nutrition Survey had "good" diet quality (Choi et al., 2021). Thus, these results emphasize the need to improve diet quality among adults with disability in the setting of needed improvements among the US population overall. Our results may highlight specific dietary components that scored lower in association with social isolation, but given the small magnitudes observed, this warrants further investigation.

Studies focusing on middle-aged and older adults have reported similar associations between social isolation and nutrition. A study of NHANES 2007–2008 data among adults age 40 + found that social isolation was associated with lower diet quality, and lower component scores for total and whole fruit, whole grains, seafood and plant proteins, fatty acids, and empty calories (Pieroth et al., 2017). Significant findings were restricted to men, while we found evidence of associations for both men and women.

Other studies have observed similar findings with fewer social contacts or social isolation associated with lower consumption of fruits and vegetables (Sahyoun and Zhang, 2005; Kobayashi and Steptoe, 2018). Additionally, studies outside the US have revealed stronger associations between marital status and less healthy eating patterns among men compared with women (Vinther et al., 2016; Noguchi et al., 2021). We could not identify prior studies examining whether the relationship between social isolation and HEI score differs by age group. The age distribution of our sample, with only 40% below age 60, as well as the limitations of our social isolation index may have limited the ability to detect effect modification. Given the constraints of the available items in recent NHANES cycles, our social isolation index did not fully capture important domains such as size of social network, frequency of social contact, and church or club participation (Pohl et al., 2017). These domains may be important within strata of age and/or gender.

Single status as a risk factor for lower vegetable intake is consistent with prior literature. Longitudinal studies examining marital transitions among middle-aged and older adults in England and Japan reported lower intake of fruits and vegetables among widowed, separated or divorced adults, particularly men (Vinther et al., 2016; Noguchi et al., 2021). Potential mechanisms for this association pertinent to relationships and health status include gender norms (e.g. food preparation, women monitoring health of their partners), and marital partnership's effects on promoting healthy behaviors through self-regulation and meaning, purpose, and obligation (Umberson, 1987).

One of the two social engagement measures we examined was associated with lower intake of several adequacy components. This measure represents those with difficulty accessing the physical environment outside the home, such as shops and entertainment, and may potentially extend to other activities, such as those related to instrumental activities of daily living. Vegetables, total protein, and seafood and plant proteins may represent fresh foods, thus the association may be driven by difficulty with shopping for or affording these fresh foods. This is consistent with the food insecurity and various environmental barriers to food access that adults with disability face, including transportation, neighborhood environment (curbs, walkability), and store environment (Schwartz et al., 2019; Huang et al., 2012; Jackson et al., 2019). Inadequate social support can exacerbate these barriers, whereas adequate social support can mitigate them. Turning to comfort foods due to stress and anxiety, as suggested previously in analyses of dietary patterns during the COVID-19 pandemic lockdowns, may influence the higher intake of added sugars observed in this group (Bennett et al., 2021).

Limitations

Importantly, our social isolation index is not a validated measure, although it is based on previously validated social isolation measures. Also, the index was correlated with depression and self-reported health status, consistent with previously validated measures (Pohl et al., 2017). It does not capture all important domains of social isolation (e.g., size of social network, frequency of contact), so there is potential for misclassification of exposure. However, the highest level of social isolation measured by our index potentially represents a lower level of social isolation compared to indices that capture all domains, so our results may be an underestimation of the true association between social isolation and diet quality.

The cross-sectional design limits the ability to assess temporality and causality in the relationship between social isolation and diet quality. Additionally, NHANES excludes institutionalized adults, so results may not be generalizable to those living in nursing facilities, who may have more severe disability or experience factors influencing their nutritional intake that differ from adults living independently in the community. For our classification of disability, defined as a physical functioning limitation, we were unable to discern chronicity/duration of the disability. Finally, use of a single 24-hour dietary recall is also an imperfect albeit acceptable method for assessment of dietary intake (National Cancer Institute, 2023; U.S. Department of Agriculture, 2022).

Strengths

This study has numerous strengths including the use of nationally representative data. The study population was also novel for inclusion of all adults with disability, whereas most studies in this field have focused on middle-aged or older adults. We controlled for a comprehensive set of covariates with prior established associations with social isolation, nutrition, or both. Our findings also suggest that depression was not a major mediator of the results, emphasizing the need for further investigation of this relationship. Social isolation in this population may operate outside a solely mental health pathway to impact nutrition.

5. Conclusions

In this nationally representative study of US adults with disabilities, these findings have significant public health impact because they indicate that this population is not meeting national nutrition standards. Social isolation may adversely impact intake of vegetables and quality protein sources, consistent with results from studies of middle-aged and older adult populations. Among adults with disabilities, these associations were inconclusive and warrant further study. If confirmed, focused interventions would be important, as inadequate intake of these foods may contribute to worsened disability progression and chronic disease risk.

Further study is needed across the age spectrum of adults with disability, particularly younger adults. Validated social support questionnaires should be incorporated into national surveys to further examine social isolation as a risk factor for dietary quality and other health behaviors and outcomes. Emerging research on how social isolation related to COVID-19 pandemic lockdowns affected nutrition status of certain populations should include adults with disabilities. These findings support the need to screen adults with disability for social isolation and nutrition status.

CRediT authorship contribution statement

Nadia T. Saif: Conceptualization, Methodology, Writing – review & editing, Writing – original draft, Data curation. **Odessa R. Addison:** Conceptualization, Methodology, Writing – review & editing. **Kathryn Hughes Barry:** Methodology, Writing – review & editing. **Jason R. Falvey:** Methodology, Writing – review & editing, Data curation. **Elizabeth A. Parker:** Conceptualization, Methodology, Writing – review & editing, Data curation.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: During the preparation of this manuscript, K. H. Barry's spouse was employed at Verily Life Sciences. Neither her spouse nor Verily Life Sciences had any role in the present project. The authors have no other conflicts of interest.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102413.

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