



Awareness and use of nutrition information predict measured and self-rated diet quality of older adults in the USA

Anna Vaudin¹, Edwina Wambogo¹, Alanna Moshfegh² and Nadine R Sahyoun^{1,*}

¹Department of Nutrition and Food Science, University of Maryland, 01 12 Skinner Building, College Park, MD 20742, USA; ²Food Surveys Research Group, United States Department of Agriculture, Baltimore, MA, USA

Submitted 13 April 2020: Final revision received 14 September 2020: Accepted 12 November 2020: First published online 18 November 2020

Abstract

Objectives: To examine: (1) diet quality of older adults, using the Healthy Eating Index 2010 (HEI-2010) and self-rated diet quality, (2) characteristics associated with reported awareness and use of nutrition information and (3) factors associated with HEI score and self-rated diet quality.

Design: Cross-sectional study. Based on Day 1 and/or Day 2 dietary recalls, the Per-Person method was used to estimate HEI-2010 component and total scores. *T*-tests and ANOVA were used to compare means. Logistic and linear regressions were used to test for associations with diet quality, controlling for potential confounders.

Setting: National Health and Nutrition Examination Survey, 2009–2014.

Participants: Three thousand and fifty-six adults, aged 60 years and older, who completed at least one 24-h recall and answered questions on awareness and use of nutrition information.

Results: Mean HEI score for men was significantly lower than for women (56.4 ± 0.6 v. 60.2 ± 0.6 , $P < 0.0001$). Compared with men, more women were aware of (44.8% v. 33.7%, $P < 0.05$) and used (13.7% v. 5.9%, $P < 0.05$) nutrition information. In multi-variable analyses, awareness and use of nutrition information were significant predictors of both HEI and self-rated diet quality for both women and men. Groups with lower nutrition awareness included men, non-Whites, participants in nutrition assistance programmes and those with lower education and socio-economic status.

Conclusions: Nutrition awareness and use of nutrition information are associated with diet quality in adults 60 years and older. Gaps in awareness of dietary guidelines in certain segments of the older adult population suggest that targeted education may improve diet quality for these groups.

Keywords

Healthy Eating Index (HEI) 2010
Self-rated diet quality
Nutrition awareness
Nutrition information use
Older adults

As the older adult population grows, so does the need to identify factors that affect their health and contribute to successful ageing. Nutrition is an important factor in health, especially as older adults may experience functional, physiological and economic difficulties that put them at greater nutritional risk than the general population^(1,2). High-quality diets, containing fruits, vegetables, whole grains, nuts and legumes, in accordance with the Dietary Guidelines for Americans (DGA), are generally protective from disease^(3–5).

The Center for Nutrition Policy and Promotion, under the United States Department of Agriculture, releases food guidance tools for the general public to reference, such as MyPyramid and MyPlate⁽⁶⁾. These guides aim to make dietary standards available to and understandable by consumers through simple nutrition education tools⁽⁷⁾.

Research shows that nutrition knowledge and the use of nutrition information are associated with dietary intake and quality^(8–15). However, these associations have not been widely investigated in the older adult population⁽¹¹⁾. Specifically, there is limited research on how awareness and use of the Center for Nutrition Policy and Promotion food guide tools impact overall diet quality in the older adult population. Research has shown that older adults are less likely than adolescents and younger adults to be aware of food guide messaging from the government^(16–18), suggesting that they should be targeted with nutrition education. It is also important to identify which segments of the older adult population have the greatest need for nutrition education, and how this lack of awareness may be associated with their dietary intake. A recent study found that US adults, and especially those over aged 50 years, who

*Corresponding author. Email nsahyoun@umd.edu

© United States Department of Agriculture and The Author(s), 2020. To the extent this is a work of the US Government, it is not subject to copyright protection within the United States. Published by Cambridge University Press on behalf of The Nutrition Society



reported using MyPyramid or MyPlate nutrition information had better dietary intake with respect to individual measures of food groups and nutrients of interest⁽¹⁹⁾. However, the study did not focus on older adults or their characteristics. Additionally, the study did not examine intake using a measure of overall diet quality, and did not examine intake in association with nutrition awareness. Further research on nutrition awareness, use of nutrition information and diet quality in US older adults is warranted in order to inform policy and programmes on whom to target among older adults. Programmes can use this information to help older adults optimise their food selections and dietary patterns, with the aim of improving their health^(15,20,21).

To our knowledge, nationally representative studies that explore the diet quality of older adults in the USA are few in number^(22–27). Dietary pattern analysis, rather than a focus on single foods or ingredients, is an increasingly recognised approach for examining dietary practices and assessing the extent to which the practices adhere to current dietary guidance⁽²⁸⁾. Methods to assess the quality of dietary patterns include the use of diet indexes or scores, such as the Healthy Eating Index (HEI)^(29,30). A self-rated diet quality question, measured on a 5-point Likert scale from excellent to poor, has also been validated as a proxy measure for diet quality⁽³¹⁾. Studies have also shown self-rated diet quality to be associated with measures of overall dietary intake, such as the HEI⁽³²⁾, the Dietary Approaches to Stop Hypertension diet⁽³³⁾ and diet-related biochemical measures and health outcomes⁽²⁶⁾.

The current study aims to add to the body of knowledge about nutrition and older adults by: (1) determining their diet quality based on both perception and HEI-2010 score, (2) identifying the characteristics associated with their reported awareness and use of nutrition information and (3) examining factors associated with their HEI scores and self-rated diet quality.

Methods

Study design, participants and recruitment

The study population was adults aged 60 years and older from the 2009–2010, 2011–2012 and 2013–2014 cycles of the National Health and Nutrition Examination Survey (NHANES). The NHANES is a series of cross-sectional, population-based surveys, representative of non-institutionalised, civilian US residents, conducted by the National Center for Health Statistics to assess the diet, health, nutrition status and health-related behaviours of the US population. The NHANES is conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the National Center for Health Statistics Ethics Review Board. Written informed consent was obtained from all participants. The data from the three NHANES cycles were merged to increase the sample size.

Details of the NHANES study design, implementation, data sets, analytic considerations and other documentation are available online^(34,35).

In the current study, the sample size of respondents aged 60 years and older was 5477. Excluded from the analyses were those with no valid dietary recalls (= 509), those whose energy intakes exceeded three SD from mean energy intakes, by sex (n 14) and those who did not answer questions on awareness and use of nutrition information (n 1898). The final analytic sample was 3056.

Dietary intake variables

NHANES participants are administered a series of detailed questionnaires at an in-home interview, followed by a visit to a mobile examination centre, where they undergo health examinations. Two days of dietary intake data are obtained: one during the in-person dietary recall at the mobile examination centre, and the second by telephone, 3–10 d after the mobile examination centre interview⁽³⁶⁾. The recalls are collected on both weekdays and weekend days using the United States Department of Agriculture's fully computerised Automated Multiple-Pass Method for collecting 24-h recalls, with standardised probes to minimise misreporting of amounts of foods consumed⁽³⁴⁾. The resulting dietary data are known as What We Eat in America^(36,37).

Two dietary outcome variables were used to measure diet quality: the HEI-2010 and self-rated diet quality. The HEI uses a scoring metric that measures adherence to the DGA^(5,38,39). The 2010 version of the HEI was chosen in order to measure the adherence to the set of DGA that was in use during the years the dietary data were collected. The HEI is a density-based measure of diet quality, with most components scored in relation to energy intake, except for fatty acid ratio, and energy from solid fats, sugar and alcohol⁽³⁸⁾. The pertinent ratios and scoring of each HEI component are based on set standards of minimum and maximum scores⁽³⁸⁾. The HEI-2010 is composed of twelve components: nine of them assess dietary adequacy (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids ratio), while three assess components for which moderate consumption is recommended (refined grains, Na and energy from solid fats, sugar and alcohol)^(39,40). Higher intakes of adequacy components and lower intakes of moderation components indicate better compliance with the DGA and result in higher scores⁽⁴¹⁾. The total HEI score is the sum of the component scores, and the highest quality score is 100 points. Based on reported intakes from Day 1 recalls, and from Day 2 recalls, when available, total HEI-2010 and component scores were estimated using the Per-Person method. This method first calculates the ratio of the HEI components to energy intake at the individual level. Scores for each component are then calculated based on the scoring standards. The component scores are summed to calculate the total score. When more



than one 24-h recall is available, the HEI component intake from the two 24-h recalls is summed and used to estimate scores for each person^(38,42).

The other outcome variable in the current study was self-rated diet quality. In NHANES, participants answered the question, 'In general, how healthy is your overall diet?' on a 5-point Likert scale, with possible answers ranging from 'excellent' to 'poor.' Participants' responses to this question were used to categorise respondents into three groups: those who self-rated their diet as excellent, very good, those who self-rated their diet as good and those who self-rated their diet as fair or poor. For the logistic regression, those who perceived their diet to be excellent, very good and good were combined as one group. This method was consistent with those used in prior studies to categorise perceptions of diet quality^(31,33).

Awareness and use of nutrition information variables

Participants in the 2009–2010 and 2011–2012 NHANES surveys were asked whether they had (yes/no): (1) heard of MyPyramid, and (2) heard of the Food Pyramid or the Food Guide Pyramid. In the 2013–2014 survey, participants were asked if they had (yes/no): (3) heard of MyPlate. Affirmative responses to any of these three questions were coded as 'yes' for nutrition awareness, and otherwise they were coded as 'no'. If individuals responded positively to the awareness question described above, they were then asked about their use of this information. In the 2009–2010 and 2011–2012 surveys, participants were asked whether (yes/no) they had: (1) tried to follow the MyPyramid Plan/Pyramid plan. In the 2013–2014 survey, respondents were asked whether (yes/no) they had: (2) tried to follow the recommendations in the MyPlate plan. Using these questions, participants were divided into three categories: (1) those who reported awareness and use of nutrition information, (2) those who reported awareness but not use of nutrition information and (3) those who reported neither awareness nor use of nutrition information (referred to as no awareness throughout this article).

Socio-demographic, economic and health covariates

Respondents in NHANES were categorised into four food security categories (food security, marginal food security, low food security and very low food security), based on responses to the US Food Security Survey Model questions⁽⁴³⁾. In the current analysis, the two lowest categories (low and very low food security) were combined into one group. Participants in all three cycles of NHANES were asked 'Would you say your health in general is . . .', with possible answers on 5-point Likert scale ranging from 'excellent' to 'poor'. Participants were also asked if they were on a diet to lose weight or for some other health-related reason and were categorised based on whether they answered yes or no.

Additional covariates for the current analysis included age, sex, race/ethnicity, marital status, education, employment, food expenditure (money spent on food in supermarkets and other stores), use of social support services (Supplemental Nutrition Assistance Program (SNAP)⁽⁴⁴⁾, emergency food services, home-delivered meals, senior/community centre meals and cash assistance from government agencies) and poverty-income classification. Poverty level index classification in the NHANES is based on the ratio of household income to the poverty threshold developed by the US Department of Health and Human Services. A ratio of household income to the poverty threshold value of < 1.85 is commonly used to determine eligibility for federal assistance programmes^(35,45) and was used as the cut-off designating the poverty level in the current analysis.

Data analysis

Characteristics of respondents were examined by sex and compared using χ^2 tests for categorical variables, and pairwise differences in continuous variables between groups were tested using a univariate *t* statistic. Taylor series linearisation was used to compute variance estimates. Multivariate linear regression analyses were performed to examine associations of nutrition awareness and use of nutrition information with total HEI scores at the individual level. Multivariate logistic regression analyses were used to examine associations with self-rated diet quality. Prior to conducting our analyses, all covariates were assessed for multicollinearity, and no evidence was found of significant correlations. These regression analyses were adjusted for potential confounders shown to be related to diet quality, such as age, race/ethnicity, education, marital status, household size, self-reported health, food expenditure and food security. As interactions between sex and nutrition awareness and use of nutrition information were found to be significant, analyses were stratified by sex. Statistical analysis was performed using SAS software programme (version 9.4; SAS Institute Inc.)⁽⁴⁶⁾ and SAS-Callable SUDAAN version 11.0 (RTI International)⁽⁴⁷⁾. The analyses were adjusted for NHANES complex survey design⁽⁴⁸⁾.

Results

Sample characteristics and dietary factors

The total number of adults aged 60 years and older who completed at least one 24-h recalls for the 2009–2014 cycles of NHANES and answered the questions about nutrition awareness was 3056. The study population was composed of 49.2% men, the mean age was 69.5 years and almost half of the population (47.8%) was non-Hispanic White. Compared with women, a significantly higher proportion of men were married or partnered, were employed and lived in households that had higher incomes (Table 1). However, significantly more women than men had at least

Table 1 Characteristics of adults aged 60 years and above, NHANES 2009–2014

Characteristics	Men (<i>n</i> 1503)		Women (<i>n</i> 1553)		<i>P</i>
	Mean*	SE	Mean	SE	
Age (year)	69.2	0.3	69.7	0.2	0.09
Total HEI-2010 score	56.4	0.6	60.2	0.6	< 0.0001
	Weighted column %†				
Race/ethnicity					0.15
Non-Hispanic White	78.2		76.7		
Non-Hispanic Black	8.4		9.6		
Mexican American	4.2		3.4		
Others	9.3		10.3		
Marital status (married/partnered)	77.5		53.1		< 0.0001
Education (some college/college grad +)	47.6		52.4		0.02
Employment (employed)	34.9		24.9		0.0006
Monthly poverty level index					< 0.0001
≤ 1.85	28.5		37.2		
> 1.85	71.5		62.8		
Received cash assistance from a state or county welfare programme	2.5		2.4		0.8
Dietary factors					
Household food security					0.04
Full food security	88.9		86.1		
Marginal food security	4.4		5.7		
Low and very low food security	6.7		8.2		
Received emergency food last 12 months	4.1		6.3		0.04
Received SNAP or food stamps last 12 months	8.1		11.6		0.004
Received meals on wheels or other meals	2.3		3.1		0.08
Ate prepared meals at senior/community centre	3.8		7.2		0.004
On a special diet					0.02
Yes	16.2		22.1		
Self-rated diet quality					0.3
Excellent/very good	38.1		42.1		
Good	40.2		37.3		
Fair/poor	21.7		20.6		
Self-rated health					0.2
Excellent/very good	43.5		42.7		
Good	38.3		41.5		
Fair/poor	18.2		15.8		

NHANES, National Health and Nutrition Examination Survey; HEI, Healthy Eating Index; SNAP, Supplemental Nutrition Assistance Program.

*Significant difference in means tested using *t* test.

†Significant difference in proportions tested using χ^2 test for categorical variables, percentages down the column may not sum to 100 due to rounding.

some college education (Table 1). The mean HEI score of the study population was 58.5 ± 0.5 (results not shown), and women had a significantly higher HEI score when compared with men (Table 1). More men than women lived in food secure households (Table 1). A higher proportion of the women reported being on a special diet, receiving SNAP benefits and emergency food and eating meals at senior or community centres (Table 1).

Nutrition awareness and use of nutrition information

A significantly higher proportion of women compared with men reported awareness and use of nutrition information, and more men compared with women were not aware of this information (Table 2). Adults aged 60–75 years were significantly more nutritionally aware than those aged 76 years and older and were also more likely to report use of nutrition information (Table 2). Those who were non-Hispanic White were most likely to be aware of nutrition information, while those who were Mexican American were least likely to be aware of and least likely to be using

nutrition information (Table 2). Those with fair or poor self-rated health and self-rated diet were significantly less likely to have nutrition awareness, and those who self-rated their diet as excellent or very good and those who self-rated their health as excellent, very good or good were significantly more likely to report awareness and use of nutrition information (Table 2). Those who had received home-delivered meals, SNAP or emergency food in the past year were less likely to report awareness of nutrition information (Table 2). Results also show that a significantly higher proportion of those who were more educated, had higher income and were more food secure reported awareness of nutrition information as well as the use of this information (Table 2).

Healthy Eating Index by nutrition awareness and use of nutrition information

Those who reported both awareness and use of nutrition information had significantly higher total mean HEI scores compared with those who reported awareness but not use, and compared with those who did not report awareness (Table 3). They also had significantly higher scores than

**Table 2** Nutrition awareness and use of nutrition information by socio-demographic and economic characteristics, and OR showing associations of nutrition awareness and use of nutrition information with these characteristics, among adults aged 60 years and above (n 3056), NHANES 2009–2014*

Characteristics	Nutrition awareness (yes), information use (yes) (n 261)	Nutrition awareness (yes), information use (no) (n 727)	Nutrition awareness (no), information use (no) (n 2068)
	Weighted row %		
Gender			
Men	5.9†	27.8	66.3†
Women	13.7†	31.0	55.2†
Age group			
≥ 76 years	6.7†	23.9†	69.4†
60–75 years	11.3†	31.4†	57.3†
Education			
≤ High school/GED	6.5†	20.1†	73.4†
Some college/college +	12.7†	36.0†	51.4†
Employment			
Unemployed	10.6	25.9†	63.5†
Working at a job/business	9.0	38.3†	52.7†
Marital status			
Single, divorced, widowed	10.3	26.5	63.1
Married/partnered	10.0	31.2	58.7
Race/ethnicity			
Non-Hispanic White	10.9†	32.5†	56.7†
Non-Hispanic Black	8.6†	18.4†	73.0†
Mexican American	4.3†	15.8†	79.9†
Others	8.3†	22.0†	69.7†
Monthly poverty level index			
≤ 1.85	7.5†	23.5†	69.0†
> 1.85	11.8†	33.0†	55.2†
Received cash assistance from a state or county welfare programme			
Yes	13.0	23.1	63.9
No	10.1	29.9	60.0
Household food security			
Low and very low food security	5.8†	21.0†	73.2†
Marginal food security	8.7†	17.6†	73.7†
Full food security	10.7†	31.0†	58.3†
Emergency food last 12 months			
Yes	8.6	16.7†	74.7†
No	10.3	30.3†	59.4†
Home-delivered meals last 12 months			
Yes	6.5	19.8	73.6†
No	10.3	29.9	59.9†
Congregate meals last 12 months			
Yes	10.7	22.5	66.8
No	10.1	30.0	59.9
Received SNAP last 12 months			
Yes	7.1	21.5†	71.4†
No	10.5	30.6†	58.9†
On special diet			
Yes	17.9†	26.9	55.2
No	9.0†	30.7	60.3
Self-rated health			
Excellent/very good	13.0†	36.3†	50.7†
Good	9.5†	27.3†	63.2†
Fair/poor	5.8†	21.0†	73.2†
Self-rated diet			
Excellent/very good	15.0†	30.1	54.9†
Good	8.2†	30.0	61.8†
Fair/poor	2.6†	27.1	70.3†

NHANES, National Health and Nutrition Examination Survey; GED, General Education Development; SNAP, Supplemental Nutrition Assistance Program.

*Significant difference in proportions tested using χ^2 test for categorical variables, percentages across the row may not sum to 100 due to rounding.

†Percentages within a column with unlike superscript letters were significantly different ($P < 0.05$).

the other two groups for greens and beans (Table 3). Those who reported both awareness and use of nutrition information had significantly higher scores than those who did not report awareness for total fruit, whole fruit, total vegetables,

whole grains, seafood and plant proteins, and energy from solid fats, sugar and alcohol (Table 3). There was no significant difference between groups for dairy, total protein foods, fatty acids, refined grains and Na.

Table 3 Mean score and SE for HEI-2010 and its components by nutrition awareness, and nutrition information use among adults aged 60 years and above, NHANES 2009–2014*

HEI-2015 components	Maximum score	Nutrition awareness (yes), information use (yes) (n 261)		Nutrition awareness (yes), information use (no) (n 727)		Nutrition awareness (no), information use (no) (n 2068)	
		Mean	SE	Mean	SE	Mean	SE
Total HEI 2010 score	100	63.7 ^a	1.19	60.0 ^b	0.90	56.9 ^c	0.42
Adequacy							
Total fruit	5	3.3 ^a	0.17	3.1 ^a	0.09	2.7 ^b	0.07
Whole fruit	5	3.6 ^a	0.17	3.5 ^a	0.08	3.0 ^b	0.06
Total vegetables†	5	3.8 ^a	0.11	3.6 ^a	0.07	3.3 ^b	0.05
Greens and beans‡	5	2.5 ^a	0.18	1.9 ^b	0.12	1.7 ^b	0.08
Whole grains	10	4.6 ^a	0.35	4.1 ^a	0.17	3.5 ^b	0.10
Dairy	10	5.6	0.29	5.5	0.17	5.3	0.08
Total protein foods‡	5	4.6	0.07	4.5	0.06	4.5	0.02
Seafood and plant proteins	5	3.3 ^a	0.25	2.9 ^{a,b}	0.11	2.7 ^b	0.09
Fatty acids ratio§	10	5.6	0.27	5.5	0.20	5.2	0.08
Moderation							
Refined grains	10	7.2	0.25	6.9	0.21	6.6	0.10
Na	10	4.0	0.26	3.9	0.20	4.0	0.09
Energy from solid fats, sugars and alcohol	20	15.7 ^a	0.38	14.6 ^{a,b}	0.27	14.3 ^b	0.17

HEI, Healthy Eating Index; NHANES, National Health and Nutrition Examination Survey.

^{a,b,c}Means across a row with unlike superscript letters were significantly different ($P < 0.05$).

*Taylor series linearisation was used to compute variance estimates. Pairwise differences between groups were tested using a univariate *t* statistic. The significance level for statistical testing was set at $P < 0.05$.

†Any beans and peas not counted as total protein foods.

‡Beans and peas included here (and not with vegetables) when the total protein foods standard is not met.

§The ratio of unsaturated fatty acids to SFA.

||Threshold for counting alcohol is $> 13 \text{ g}/4184 \text{ kJ}$ (1000 kcal).

Multivariable associations of nutrition awareness and use of nutrition information with total Healthy Eating Index scores

When controlling for covariates in multivariate linear regression models, men who reported both awareness and use of nutrition information had a mean HEI score that was 6.0 points higher than men who did not report awareness ($P \leq 0.05$) (Table 4). In women, reporting nutrition awareness, both with and without use of nutrition information, was significantly associated with higher HEI scores, when accounting for covariates ($P \leq 0.01$) (Table 4). The multivariate model for both women and men showed that a special diet, older age, 'Other' race/ethnicity, education above high school, household food expenditure and excellent, very good or good self-rated health were all positively and significantly associated with HEI score ($P \leq 0.05$) (Table 4). Food security was associated with higher HEI scores for women only ($P \leq 0.01$), and Mexican American ethnicity was associated with higher HEI scores for men only ($P \leq 0.05$) (Table 4).

Multivariable associations of nutrition awareness and use of nutrition information with self-rated diet quality

Logistic regression models showed that many participant characteristics that were significantly associated with HEI were also significantly associated with self-rated diet quality perceived as excellent, very good or good (Table 5). In

multivariate logistic regression models, the odds of perceiving diet quality to be excellent, very good or good were significantly higher for both men (OR 5.6; 95 % CI 2.1, 15.0) and women (OR 2.1; 95 % CI 1.4, 3.0) who reported awareness and use of nutrition information (Table 5). Those with full food security had greater odds of better self-rated diet quality for both men (OR 2.2; 95 % CI 1.1, 4.3) and women (OR 1.6; 95 % CI 1.2, 2.2), compared to those with low and very low food security (Table 5). Women also had slightly higher odds of better self-rated diet quality if they lived in a household that was larger (OR 1.1 per person in household; 95 % CI 1.0, 1.3) or that spent more money on food (OR 1.3 per \$100 spent; 95 % CI 1.1, 1.4). Mexican American women had lower odds of reporting excellent, very good or good diet quality in comparison with non-Hispanic White women (OR 0.5; 95 % CI 0.3, 0.7). Women who had attended at least some college also had greater odds of better self-rated diet quality (OR 1.4; 95 % CI 1.0, 1.9) (Table 5). For both men and women, those who were married or partnered had higher odds of rating their diets as excellent, very good or good, compared with those who were single (men: OR 1.5; 95 % CI 1.1, 2.1; women: OR 1.4; 95 % CI 1.0, 2.0) (Table 5). For both sexes, those who rated their health as excellent, very good and good also had higher odds of rating their diet quality as excellent, very good or good (men: OR 3.9; 95 % CI 2.4, 6.3; women: OR 4.8; 95 % CI 3.2, 7.3) (Table 5).

**Table 4** Multivariable linear regression coefficients of the associations between nutrition awareness and use of nutrition information with HEI-2010 scores, controlled for covariates in adults aged 60 years and above, NHANES 2009–2014*

	Men		Women	
	β -regression coefficient	95% CI	β -regression coefficient	95% CI
Nutrition awareness and information use				
Awareness (no), information use (no)	1		1	
Awareness (yes), information use (no)	0.6	−2.2, 3.4	3.1	0.6, 5.6†
Awareness (yes), information use (yes)	6.0†	0.7, 11.4	4.2	1.6, 6.8‡
Money spent on food per household member in last 30 d (\$100 increments)	0.6†	0.1, 1.2	1.1	0.3, 1.8‡
On special diet				
No	1		1	
Yes	5.4‡	2.4, 8.5	3.4	1.1, 5.7‡
Household food security				
Low and very low food security	1		1	
Marginal food security	−2.2	−7.9, 3.5	2.5	−0.2, 5.2
Full food security	1.6	−1.7, 5.0	4.0	1.4, 6.6‡
Age (years)	0.2‡	0.1, 0.4	0.2	0.0, 0.3‡
Race/ethnicity				
Non-Hispanic White	1		1	
Non-Hispanic Black	1.2	−1.3, 3.6	−0.6	−2.6, 1.3
Mexican American	4.7†	0.8, 8.6	0.7	−2.2, 3.6
Others	4.9‡	2.6, 7.3	4.9	2.5, 7.2‡
Marital status				
Single, divorced, widowed	1		1	
Married/partnered	1.3	−1.2, 3.9	1.5	−0.3, 3.3
Education				
≤ High school/GED	1		1	
Some college/college +	5.3§	3.0, 7.6	2.1	0.2, 4.0†
Household size (count)	−0.6	−1.7, 0.5	0.1	−0.5, 0.7
Self-rated health				
Fair/poor	1		1	
Excellent/very good/good	4.7§	2.7, 6.7	2.6	1.1, 4.2‡

HEI, Healthy Eating Index; NHANES, National Health and Nutrition Examination Survey; GED, General Education Development.

*Multivariate adjusted linear regression models, accounting for complex survey design in NHANES.

† $P \leq 0.05$.‡ $P \leq 0.01$.§ $P \leq 0.0001$.

Discussion

This is one of the few nationally representative studies, to our knowledge, that has investigated the diet quality of older adults and its association with awareness and use of nutrition information, as well as other factors that may influence food access and choices. The results show that older adults who reported awareness of MyPyramid or MyPlate, the US tools for educating the public on the DGA, had diets that were closer to meeting these guidelines, as measured by the HEI. This effect was independent of potential confounders in women. These results suggest that interventions that are effective at improving nutrition knowledge may have a direct and positive effect on dietary habits. Awareness and use of nutrition information had an even stronger association with diet quality, and this relationship was significant for both men and women when controlling for confounders. Education programmes that go beyond increasing awareness to coaching people on how to implement their knowledge may result in larger improvements in dietary habits.

Participants who had no awareness of MyPlate and MyPyramid had significantly lower scores for most HEI

components. Our findings corroborate those of a 2019 study showing that adults aged 50 years and older who reported use of MyPyramid or MyPlate had beneficial dietary intake behaviours with regard to certain nutrients and recommended food pattern equivalents⁽¹⁹⁾. These studies cannot be directly compared because the 2019 study combined those who were not aware of the tools with those who were aware of them but did not use them, and it did not include the HEI as a measure of diet quality. However, both studies show a trend towards better diet quality for those with more familiarity with MyPlate and MyPyramid. In our study, these differences in total scores were driven by significantly lower component scores for total fruit, whole fruit, total vegetables, whole grains, seafood and plant proteins, and energy from solid fats, sugar and alcohol in those who were not aware of MyPlate and MyPyramid. These first five HEI components represent food groups that typically cost more money, and foods containing solid fats and sugar often come from less costly foods. It is possible that the differences in these component groups are driven by both a combination of decreased knowledge about what makes a nutritious diet and the relatively lower socio-economic status of those who are

Table 5 OR and CI of the associations between nutrition awareness and use of nutrition information with diet quality self-rated as excellent, very good or good, controlling for covariates, in adults aged 60 years and above, NHANES 2009–2014*

	Men		Women	
	OR	95% CI	OR	95% CI
Nutrition awareness and information use				
Awareness (no), information use (no)	1		1	
Awareness (yes), information use (no)	1.1	0.9, 1.5	1.0	0.8, 1.3
Awareness (yes), information use (yes)	5.6	2.1, 15.0	2.1	1.4, 3.0
Money spent on food per household member in last 30 d (\$100 increments)	1.0	0.9, 1.1	1.3	1.1, 1.4
On special diet				
No	1		1	
Yes	1.2	0.8, 1.7	1.1	0.7, 1.6
Household food security				
Low and very low food security	1		1	
Marginal food security	1.5	0.7, 3.2	1.2	0.8, 1.9
Full food security	2.2	1.1, 4.3	1.6	1.2, 2.2
Age (years)	1.1	1.0, 1.1	1.0	1.0, 1.1
Race/ethnicity				
Non-Hispanic White	1		1	
Non-Hispanic Black	1.1	0.8, 1.6	0.9	0.7, 1.2
Mexican American	0.7	0.4, 1.2	0.5	0.3, 0.7
Others	1.1	0.7, 1.6	1.1	0.8, 1.6
Marital status				
Single, divorced, widowed	1		1	
Married/partnered	1.5	1.1, 2.1	1.4	1.0, 2.0
Education				
≤ High school/GED	1		1	
Some college/college +	1.2	0.9, 1.7	1.4	1.1, 1.9
Household size (count)	0.9	0.8, 1.1	1.1	1.0, 1.3
Self-rated health				
Fair/poor	1		1	
Excellent/very good/good	2.5	1.7, 3.7	3.7	2.8, 4.9

NHANES, National Health and Nutrition Examination Survey; GED, General Education Development.

*Multivariate adjusted logistic regression models accounting for complex survey design in NHANES.

lacking in this knowledge. These are the factors that remained significant predictors in multivariate models, accounting for the effect of covariates.

Those who were women, employed, food secure, younger, more educated, higher income or of White race/ethnicity were more likely to report awareness of MyPlate or MyPyramid. These results are consistent with previous research showing that female sex, higher socio-economic status and higher educational attainment are the factors associated with nutrition-related knowledge, as measured by validated assessment^(15,20,49). Those more likely to report use of nutrition information were also younger, women, college-educated and of higher socio-economic status. Except for younger age, these characteristics are also associated with better diet quality in the literature^(50–53), as well as with better HEI scores in the results of this study. Lower nutrition awareness in racial and ethnic minorities and those of lower socio-economic status mirrors the well-researched health inequities that exist in the USA^(54,55). Addressing the social determinants of these disparities is imperative for improving not only access to nutrition information, but also the health of the country as a whole. Another characteristic associated with a lower likelihood of nutrition awareness is participation in food assistance programmes, such as receiving emergency food, home-delivered meals or congregate meals, or using SNAP in the last

12 months. Although many of these food assistance programmes, such as SNAP, have a nutrition educational component⁽⁵⁶⁾, it is not mandatory and may not be well-targeted nor sufficiently used by the target population. Nutrition awareness and opportunities for education should be investigated further for older adults receiving food assistance, as this population is already economically and nutritionally vulnerable^(52,57,58). Research has shown that nutrition education interventions can decrease nutritional risk in individuals receiving home-delivered meals⁽⁵⁹⁾. The existing relationship with a nutrition programme provides a channel for passing on information, which may be valuable to nutrition educators who wish to improve the diets of older adults.

Previous studies suggest that the relationship of living situation and diet quality in older adults differ based on demographic characteristics such as gender and race/ethnicity^(60–62). Some indicate that the relationship between living alone and poorer diet quality is particularly strong in men^(50,61), but we did not find this relationship in our data when controlling for covariates. Studies also report that older adults living with a spouse or partner have higher diet quality compared with those living alone, and also when compared with those living in households with people other than their spouse^(60,63). In our study, being married was associated with better self-rated diet quality for both



men and women, but there was no relationship between marital status and HEI score. One household characteristic that was an important predictor of diet quality was food security: in the multivariable analyses, household food security had a strong positive association with both total HEI scores and self-rated diet quality in women and with self-rated diet quality in men. Some studies have found no relationship between food security and diet quality in older adults when controlling for covariates^(64,65), and it is possible that this is because they combined men and women in these analyses. More research is necessary to understand the impact of food security on diet quality, differences by gender and the mechanisms behind any differences that exist.

In the multivariable logistic models, the predictors of self-rated diet quality were similar to the predictors of HEI for both men and women; however, race/ethnicity behaved differently. The 'other' race/ethnicity group had higher HEI scores compared with non-Hispanic Whites, but this relationship did not exist in association with self-rated diet quality. This suggests that certain racial and ethnic groups in this age category may have healthy traditions and habits that they do not themselves equate to diet quality, but nevertheless are resulting in a higher HEI score. Similarly, a study of adults in NHANES showed that Mexican Americans did not differ in measured diet quality across levels of self-rated diet quality, while in non-Hispanic Whites and Blacks, self-rated diet quality was associated with measured diet quality⁽³³⁾. Continued research is necessary to understand how different groups define diet quality, the possible influence of cultural values and perceptions, and the impact on the use of self-rated diet quality as a proxy for measured diet quality within these groups.

The current study shows important differences between older men and women in the USA with regard to economic factors, nutrition awareness and diet quality. The analysis showed that women may be more vulnerable than men, especially economically. Men in this cohort were more likely to be employed, had higher incomes and were more food secure. Despite being more socio-economically disadvantaged, usually a characteristic associated with poorer diet quality^(50–53,57), women had higher HEI scores. Notably, women were also more educated and were more likely to report nutrition awareness and use of nutrition information, suggesting that although they may not have the socio-economic resources associated with diet quality, nutrition information may empower them to make healthier dietary decisions. Previous studies in younger adults found that nutrition knowledge mediated the relationship between socio-economic status and diet quality^(66,67). Although continued work must be done to address the systemic inequities that predispose some groups to health and nutrition challenges⁽⁶⁸⁾, nutrition education may serve as a tool for ameliorating the impacts of these challenges. This effect must be further explored in

older adults, as nutrition interventions may be a viable and efficient option for improving diet quality and nutrition-related outcomes in those of lower economic means. The MyPlate and MyPyramid are evidence-based nutrition education tools that are readily available to nutrition and public-health professionals.

A strength of the current study is the large data set from a nationally representative sample of older adults, a less studied demographic. However, the current study has limitations inherent in all observational research. Data used to determine diet quality were obtained by using 24-h dietary recalls, which rely on self-report and may not represent typical intake. However, this is the only currently available scoring method for obtaining HEI scores at the individual level when more than one 24-h recall is available. Since the method is not based on usual intakes, these scores may be biased to the extent that the dietary recall data of the component are biased. In addition, because the current evidence is cross-sectional, a causal link between the characteristics reported in the current study and diet quality cannot be established. Even though models were adjusted for covariates in an attempt to remove influence from potential confounding, there could still be residual confounding. Despite these limitations, no known studies have examined awareness and use of nutrition information in relation to dietary quality in a representative sample of the US older adult population.

Conclusions

Nutrition awareness is significantly associated with diet quality in the US older adult population, with stronger associations in those who also report use of this information. Additionally, certain segments of this population have limited nutrition awareness (men, non-Whites, those with lower education and lower socio-economic status and those participating in nutrition assistance programmes). These segments of the population may benefit from nutrition education, which is a relatively low-resource, readily available intervention.

Acknowledgements

Acknowledgements: The authors would like to acknowledge Anne Brown Rodgers, USDA consultant, for her valuable editing of the manuscript. We have received permission from Ms. Rodgers to be acknowledged in the paper. *Financial support:* This work was supported by the USDA Agricultural Research Service Cooperative Agreement (grant #USDA-58-1235-3-122). *Conflicts of interest:* None. *Authorship:* N.R.S., A.V., E.W. and A.M. developed the concept and design of the study. E.W. analysed the data. E.W., A.V. and N.R.S. wrote the first draft. All authors reviewed and commented on subsequent drafts of

the manuscript. *Ethics of human subject participation*: The NHANES is conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the National Center for Health Statistics Ethics Review Board. Written informed consent was obtained from all participants.

References

- Lee JS & Frongillo EA (2001) Factors associated with food insecurity among U.S. elderly persons: importance of functional impairments. *Jr J Gerontol B Psychol Sci Soc Sci* **56**, S94–S99.
- Sahyoun N & Basiotis P (2001) Food insufficiency and the nutritional status of the elderly population. *Fam Econ Nutr Rev* **13**, 58–60.
- US Department of Health and Human Services & US Department of Agriculture (2015) *2015–2020 Dietary Guidelines for Americans*, 8th ed. Washington, DC: US Government Printing Office.
- Trichopoulou A, Martinez-Gonzalez MA, Tong TY *et al.* (2014) Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. *BMC Med* **12**, 112.
- US Department of Health and Human Services & US Department of Agriculture (2010) *Dietary Guidelines for Americans, 2010*, 7th ed. Washington, DC: US Government Printing Office.
- Center for Nutrition Policy and Promotion & United States Department of Agriculture (2011) *A Brief History of USDA Food Guides*. <https://choosemyplate-prod.azureedge.net/sites/default/files/ABriefHistoryOfUSDAFoodGuides.pdf> (accessed August 2020).
- Davis CA, Britten P & Myers EF (2001) Past, present, and future of the food guide pyramid. *J Am Diet Assoc* **101**, 881–885.
- Spronk I, Kullen C, Burdon C *et al.* (2014) Relationship between nutrition knowledge and dietary intake. *Br J Nutr* **111**, 1713–1726.
- McKinnon L, Giskes K & Turrell G (2014) The contribution of three components of nutrition knowledge to socio-economic differences in food purchasing choices. *Public Health Nutr* **17**, 1814–1824.
- Geaney F, Fitzgerald S, Harrington JM *et al.* (2015) Nutrition knowledge, diet quality and hypertension in a working population. *Prev Med Rep* **2**, 105–113.
- Tabbakh T & Freeland-Graves J (2016) Healthy eating attitude: a mediator of nutrition knowledge and diet quality using the healthy eating index-2010 in young women. *J Womens Health, Issues Care*. Published online: 16 March 2016. doi: 10.4172/2324-8793.1000116.
- Beydoun MA, Powell LM & Wang Y (2009) Reduced away-from-home food expenditure and better nutrition knowledge and belief can improve quality of dietary intake among US adults. *Public Health Nutr* **12**, 369–381.
- Miller LM & Cassady DL (2015) The effects of nutrition knowledge on food label use. A review of the literature. *Appetite* **92**, 207–216.
- Kollanoor-Samuel G, Segura-Perez S, Shebl FM *et al.* (2017) Nutrition Facts Panel use is associated with diet quality and dietary patterns among Latinos with type 2 diabetes. *Public Health Nutr* **20**, 2909–2919.
- Wardle J, Parmenter K & Waller J (2000) Nutrition knowledge and food intake. *Appetite* **34**, 269–275.
- Tagtow A & Raghavan R (2017) Assessing the reach of MyPlate using National Health and Nutrition Examination Survey Data. *J Acad Nutr Diet* **117**, 181–183.
- Wright JD & Wang CY (2011) Awareness of federal dietary guidance in persons aged 16 years and older: results from the National Health and Nutrition Examination Survey 2005–2006. *J Am Diet Assoc* **111**, 295–300.
- Vaccaro JA & Huffman FG (2018) Are US consumers using MyPlate and restaurant menu labels and does their use equate with dietary and exercise behavior? *J Cons Behav* **17**, 418–425.
- Schwartz JL & Vernarelli JA (2019) Assessing the public's comprehension of dietary guidelines: use of MyPyramid or MyPlate is associated with healthier diets among US adults. *J Acad Nutr Diet* **119**, 482–489.
- Hendrie GA, Coveney J & Cox D (2008) Exploring nutrition knowledge and the demographic variation in knowledge levels in an Australian community sample. *Public Health Nutr* **11**, 1365–1371.
- Paulionis L (2008) The changing face of food and nutrition in Canada and the United States: opportunities and challenges for older adults. *J Nutr Elder* **27**, 277–295.
- Gao X, Martin A, Lin H *et al.* (2006) Alpha-Tocopherol intake and plasma concentration of Hispanic and non-Hispanic white elders is associated with dietary intake pattern. *J Nutr* **136**, 2574–2579.
- Bailey RL, Mitchell DC, Miller CK *et al.* (2007) A dietary screening questionnaire identifies dietary patterns in older adults. *J Nutr* **137**, 421–426.
- Anderson AL, Harris TB, Houston DK *et al.* (2010) Relationships of dietary patterns with body composition in older adults differ by gender and PPAR-gamma Pro12Ala genotype. *Eur J Nutr* **49**, 385–394.
- Reedy J, Krebs-Smith SM, Miller PE *et al.* (2014) Higher diet quality is associated with decreased risk of all-cause, cardiovascular disease, and cancer mortality among older adults. *J Nutr* **144**, 881–889.
- Bihuniak JD, Ramos A, Huedo-Medina T *et al.* (2016) Adherence to a Mediterranean-Style diet and its influence on cardiovascular risk factors in Postmenopausal women. *J Acad Nutr Diet* **116**, 1767–1775.
- Skarupski KA, Tangney CC, Li H *et al.* (2013) Mediterranean diet and depressive symptoms among older adults over time. *J Nutr Health Aging* **17**, 441–445.
- Machon M, Mateo-Abad M, Vrotsou K *et al.* (2018) Dietary patterns and their relationship with frailty in functionally independent older adults. *Nutrients* **10**, 406.
- Kant AK (2004) Dietary patterns and health outcomes. *J Am Diet Assoc* **104**, 615–635.
- Ford DW, Jensen GL, Hartman TJ *et al.* (2013) Association between dietary quality and mortality in older adults: a review of the epidemiological evidence. *J Nutr Gerontol Geriatr* **32**, 85–105.
- Lofffield E, Yi S, Immerwahr S *et al.* (2015) Construct validity of a single-item, self-rated question of diet quality. *J Nutr Educ Behav* **47**, 181–187.
- Adjoian TK, Firestone MJ, Eisenhower D *et al.* (2016) Validation of self-rated overall diet quality by Healthy Eating Index-2010 score among New York City adults, 2013. *Prev Med Rep* **3**, 127–131.
- Powell-Wiley TM, Miller PE, Agyemang P *et al.* (2014) Perceived and objective diet quality in US adults: a cross-sectional analysis of the National Health and Nutrition Examination Survey (NHANES). *Public Health Nutr* **17**, 2641–2649.
- Ahluwalia N, Dwyer J, Terry A *et al.* (2016) Update on NHANES dietary data: focus on collection, release, analytical considerations, and uses to inform public policy. *Adv Nutr* **7**, 121–134.



35. Centers for Disease Control and Health Promotion (2018) National Health and Nutrition Examination Survey: analytic Guidelines, 2011–2014 and 2015–2016. <https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/11-16-analytic-guidelines.pdf> (accessed April 2018).
36. US Department of Agriculture, Agricultural Research Service WVEIA/NHANES Overview (2020). <https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/wveianhanes-overview/> (accessed December 2020).
37. Rhodes DG, Adler ME, Clemens JC *et al.* (2017) What we eat in America food categories and changes between survey cycles. *J Food Comp and Analysis* **64**, 107–111.
38. Kirkpatrick SI, Reedy J, Krebs-Smith SM *et al.* (2018) Applications of the healthy eating index for surveillance, epidemiology, and intervention research: considerations and caveats. *J Acad Nutr Diet* **118**, 1603–1621.
39. Guenther PM, Kirkpatrick SI, Reedy J *et al.* (2014) The Healthy Eating Index-2010 is a valid and reliable measure of diet quality according to the 2010 Dietary Guidelines for Americans. *J Nutr* **144**, 399–407.
40. Guenther PM, Casavale KO, Reedy J *et al.* (2013) Update of the healthy eating index: HEI-2010. *J Acad Nutr Diet* **113**, 569–580.
41. US Department of Agriculture & Center for Nutrition Policy and Promotion Healthy Eating Index (HEI) (2020). <https://www.fns.usda.gov/resource/healthy-eating-index-hei> (accessed December 2020).
42. National Cancer Institute Division of Cancer Control & Population Sciences. SAS Code (no date). <https://epi.grants.cancer.gov/hej/sas-code.html> (accessed December 2020).
43. Gary B, Nord M, Price C *et al.* (2000) Guide to Measuring Household Food Security, Revised 2000. Alexandria VA: US Department of Agriculture, Food and Nutrition Service.
44. US Department of Agriculture & Food and Nutrition Service Supplemental Nutrition Assistance Program (SNAP) (no date). <https://www.fns.usda.gov/snap/supplemental-nutrition-assistance-program> (accessed December 2020).
45. National Center for Health Statistics (2015) National Health and Nutrition Examination Survey. 2013–2014 Data Documentation, Codebook, and Frequencies. https://www.cdc.gov/nchs/nhanes/2013-2014/inq_h.htm (accessed July 2020).
46. SAS Institute Inc (2013) SAS [computer program]. Version 9.4. Cary, NC.
47. RTI International (2012) SUDAAN Version 11.0. Research Triangle Park, N.C.
48. SAS Institute Inc SAS/STAT Software Survey Analysis (no date). <https://support.sas.com/rnd/app/stat/procedures/SurveyAnalysis.html> (accessed December 2020).
49. Jackey BA, Cotugna N & Orsega-Smith E (2017) Food label knowledge, usage and attitudes of older adults. *J Nutr Gerontol Geriatr* **36**, 31–47.
50. Atkins JL, Ramsay SE, Whincup PH *et al.* (2015) Diet quality in older age: the influence of childhood and adult socio-economic circumstances. *Br J Nutr* **113**, 1441–1452.
51. Drewnowski A & Eichelsdoerfer P (2010) Can low-income Americans afford a healthy diet? *Nutr Today* **44**, 246–249.
52. Leung CW, Ding EL, Catalano PJ *et al.* (2012) Dietary intake and dietary quality of low-income adults in the supplemental nutrition assistance program. *Am J Clin Nutr* **96**, 977–988.
53. Hiza HA, Casavale KO, Guenther PM *et al.* (2013) Diet quality of Americans differs by age, sex, race/ethnicity, income, and education level. *J Acad Nutr Diet* **113**, 297–306.
54. Keppel KG (2007) Ten largest racial and ethnic health disparities in the United States based on Healthy People 2010 Objectives. *Am J Epidemiol* **166**, 97–103.
55. Braveman PA, Cubbin C, Egerter S *et al.* (2010) Socioeconomic disparities in health in the United States: what the patterns tell us. *Am J Public Health* **100**, S186–S196.
56. US Department of Agriculture & Food and Nutrition Service Supplemental Nutrition Assistance Program Education (SNAP-Ed) (2019). <https://www.fns.usda.gov/snap/SNAP-Ed> (accessed December 2020).
57. Hilmers A, Chen TA, Dave JM *et al.* (2014) Supplemental Nutrition Assistance Program participation did not help low income Hispanic women in Texas meet the dietary guidelines. *Prev Med* **62**, 44–48.
58. Lee JS, Shannon J & Brown A (2015) Characteristics of older Georgians receiving older Americans act nutrition program services and other home- and community-based services: findings from the Georgia Aging Information Management System (GA AIMS). *J Nutr Gerontol Geriatr* **34**, 168–188.
59. Wunderlich S, Bai Y & Piemonte J (2011) Nutrition risk factors among home delivered and congregate meal participants: need for enhancement of nutrition education and counseling among home delivered meal participants. *J Nutr Health Aging* **15**, 768–773.
60. Davis MA, Murphy SP, Neuhaus JM *et al.* (2000) Living arrangements affect dietary quality for U.S. adults aged 50 years and older: NHANES III 1988–1994. *J Nutr* **130**, 2256–2264.
61. Conklin AI, Forouhi NG, Surtees P *et al.* (2014) Social relationships and healthful dietary behaviour: evidence from over-50s in the EPIC cohort, UK. *Soc Sci Med* **100**, 167–175.
62. Bloom I, Edwards M, Jameson KA *et al.* (2017) Influences on diet quality in older age: the importance of social factors. *Age Ageing* **46**, 277–283.
63. Chang Y & Hickman H (2018) Food insecurity and perceived diet quality among low-income older Americans with functional limitations. *J Nutr Educ Behav* **50**, 476–484.
64. Deierlein AL, Morland KB, Scanlin K *et al.* (2014) Diet quality of urban older adults age 60 to 99 years: the Cardiovascular Health of Seniors and Built Environment Study. *J Acad Nutr Diet* **114**, 279–287.
65. Champagne CM, Casey PH, Connell CL *et al.* (2007) Poverty and food intake in rural America: diet quality is lower in food insecure adults in the Mississippi Delta. *J Am Diet Assoc* **107**, 1886–1894.
66. Beydoun MA & Wang Y (2008) Do nutrition knowledge and beliefs modify the association of socio-economic factors and diet quality among US adults? *Prev Med* **46**, 145–153.
67. McLeod ER, Campbell KJ & Hesketh KD (2011) Nutrition knowledge: a mediator between socioeconomic position and diet quality in Australian first-time mothers. *J Am Diet Assoc* **111**, 696–704.
68. Baum F & Fisher M (2014) Why behavioural health promotion endures despite its failure to reduce health inequities. *Social Health Illn* **36**, 213–225.