Association Between Dietary Quality of Rural Older Adults and Self-Reported Food Avoidance and Food Modification Due to Oral Health Problems

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Abstract:

OBJECTIVES: To quantify the association between food avoidance and modification due to oral health problems, to examine the association between food practices and dietary quality, and to determine foods associated with these self-management behaviors.
DESIGN: Cross-sectional.
SETTING: Rural North Carolina.
PARTICIPANTS: Six hundred thirty-five community-dwelling adults aged 60 and older.
MEASUREMENTS: Demographic and food frequency data and oral health assessments were obtained during home visits. Avoidance (0, 1–2 foods, 3–14 foods) and modification (0–3 foods, 4–5 foods) due to oral health problems were assessed for foods representing oral health challenges. Food frequency data were converted into Healthy Eating Index-2005 (HEI-2005) scores. Linear regression models tested the significance of associations between HEI-2005 measures and food avoidance and modification.
RESULTS: Thirty-five percent of participants avoided three to 14 foods, and 28% modified four to five foods. After adjusting for age, sex, ethnicity, poverty, education, and tooth loss, total HEI-2005 score was lower ($P<.001$) for persons avoiding more foods and higher for persons modifying more foods ($P<.001$). Those avoiding three to 14 foods consumed more saturated fat and energy from solid fat and added sugar and less nonhydrogenated fat than those avoiding fewer than three foods. Those who modified four to five foods consumed less saturated fat and solid fat and added sugar but more total grains than those modifying fewer than four foods.
CONCLUSION: Food avoidance and modification due to oral health problems are associated with significant differences in dietary quality. Approaches to minimize food avoidance and promote food modification by persons having eating difficulties due to oral health conditions are needed.

Article:

An older adult's capacity to consume a healthful diet is a critical self-management practice and an important contributor to overall health status.[1,2] An important consideration in understanding dietary quality in older adults is how they adapt their eating practices to changes in oral health, such as their ability to chew and swallow. These challenges affect many people. Half of a sample

of 2,425 male military veterans always or sometimes ate with discomfort.[3] Numerous reports have found that dietary quality is compromised for older adults who shift their food choices toward foods that are softer and easier to chew and swallow and away from those that are crunchy, stringy, or dry, such as carrots, apples, steaks, and nuts.[4,5] Older adults avoid and modify foods to minimize discomfort when eating.[6,7] To advance efforts to improve the dietary quality of older adults, the ways that food avoidance and modification are related to a healthful diet should be better understood.

Age-related changes in eating habits can occur in response to acute and chronic conditions; disease states; gastrointestinal tract alterations; impaired swallowing; and shifts in taste, smell, and tactile sensations in the mouth.[1] Poor oral health in older adults is one condition that contributes to inadequate dietary intake.[8–15] The effects of tooth loss and other oral health problems on nutritional status have been associated with having a less-varied diet; eating fewer fruits, vegetables, and nuts; and eating more foods containing cholesterol and sodium.[16–18] Other effects include lower intake of water- and fat-soluble vitamins, carotenoids, minerals, and trace elements.[16–18] These and other reports have made it evident that a greater understanding of how older adults adapt their diet because of functional limitations due to oral health problems is needed. These findings have important implications for developing effective ways to improve their nutritional self-management.[19]

A conceptual framework for the self-management of nutritional risk has been proposed.[2] The model proposes that lifetime accumulation of financial and personal resources and ongoing changes in health, household composition, community resources, and knowledge shape nutritional self-management strategies (how older adults access, prepare, and consume sufficient amounts of food). These factors affect the strategies that elderly persons use (or have employed for them) to maintain their diets.[2] The importance of these strategies in older adults was reflected in a report that found that having difficulties fixing meals was associated with greater risk of mortality than even a lack of financial resources.[20]

Food avoidance and food modification are two self-management behaviors.[7] People who have impaired oral health may avoid foods that are difficult to eat or modify the ways that foods are prepared or eaten. Each can serve a different purpose. Without regard for the effect on the nutritional quality of the diet, avoidance can minimize the effects of chewing difficulties, tooth pain, and other oral health problems.[21] Modifying foods helps to maintain certain foods in the diet that one perceives to be beneficial or pleasant and overcomes difficulties with the inability to chew food properly.[6] In one of the few reports of food modification, 80% of elderly edentulous Greeks were willing to take the time to prepare foods to make them easier to eat to keep these foods in their diets.[6] To the degree that food avoidance eliminates foods that contribute to a healthful diet, people who avoid a greater number of foods may have poorer dietary quality than those who avoid fewer foods. Food modification may offer a means to maintain dietary quality and minimize the effect of oral health problems. Examining the relationship between food avoidance and modification offers the opportunity to refine this model by assessing how dietary quality is related to two ways that older adults can adapt their dietary practices in response to oral health problems.

This article uses data from a population-based survey that measured oral health status and dietary quality in a multiethnic older adult population. Recent analyses of these data found that the number of foods avoided was related to the number and location of teeth, having dentures, self-reported oral health, periodontal disease, bleeding gums, and dry mouth. The types of foods modified were related to number and location of teeth, periodontal disease, oral pain, and dry mouth.[7] The foods most frequently avoided were whole fruits and raw vegetables and, to a lesser extent, meats and cooked vegetables. Twenty-five percent to 60% of the participants reported modifying specific fruits, vegetables, or meats,[7] although the interaction between food avoidance and modification and the effect of these behaviors on dietary quality were not assessed. Therefore, the purposes of this present investigation are to extend these findings to quantify the association between food avoidance and modification in response to oral health problems, examine the association between these practices and overall dietary quality, and determine foods that are most closely associated with these two nutritional self-management behaviors.

METHODS

Sampling Plan and Recruitment

Between January 2006 and March 2008, the Rural Nutrition and Oral Health (RUN-OH) Study conducted a population-based, cross-sectional survey of the dietary intake of an ethnically diverse (African American, American Indian, and white) population of older adults in two rural North Carolina counties. Individuals were considered eligible if they were aged 60 and older, spoke English, were able to give informed consent, and were physically able to complete the interview. A random dwelling selection and screening procedure was used to locate participants. The investigators, in consultation with the University of Illinois Survey Research Laboratory, designed and implemented the procedure, and details are presented elsewhere.[22] Briefly, based on a multistage cluster sampling design, sampling units (census clusters) with known proportions of minority residents were stratified and selected with probability proportionate to their size. Project staff visited each cluster and visually verified presences of a dwelling, and then a random sample of 70 dwellings was selected for each of the clusters. Of 5,445 dwellings selected within 80 clusters, 39 were not screened, 4,647 were screened but did not include an eligible participant, and 859 included an eligible participant, yielding a screening rate of 99.3%. The eligible residents in 635 of the 859 eligible dwelling units completed the interview, and 224 refused to participate, for a response rate of 73.9%.

Data Collection

The Wake Forest University School of Medicine institutional review board approved all procedures. The data were collected in face-to-face interviews lasting 1.5 to 2.5 hours at participants' homes. Data collection included the 1998 version of the Block Food Frequency Questionnaire (FFQ) (Nutrition Quest Block 98.2), which assesses usual intake of 110 foods. Participants were asked about typical frequency and portion sizes of foods eaten within the past year. Questions were read to participants. Cue cards with response categories were used, as well as individual portion size pictures, if necessary. Interviewers completed 8 hours of training and 6 hours of practice interviews. Ten percent of interviews were verified by telephone. One interview every month was audio recorded for each interviewer and reviewed by research staff, who provided written feedback.

Food avoidance measures were developed from results of 10 years of qualitative and quantitative nutrition research in the study population,[23–28] as well as a small pilot study. Respondents were read a list of foods and asked whether they avoided the food because of the condition of their teeth, mouth, or dentures. The list included common foods consumed in the population that require different types and intensities of biting or chewing (e.g., baked or stewed chicken vs grilled or fried pork chops, what is commonly referred to in this population as "hard fried meat") or present different problems for teeth or dentures (e.g., whole apples with skin, anterior biting; grilled or fried meats, posterior grinding; berries, nuts, seeds, and small pieces that become lodged in teeth or under dentures; sticky candy, food that can adhere to dental work). Respondents were asked whether there were any foods that they avoided that were not on the list. The research team reviewed these additional foods, and in all cases, these foods could be included in one of the existing food categories. These measures are further described elsewhere.[7] Because the distribution was skewed, a categorical variable was created for no foods avoided, one to two foods avoided, and three to 14 foods avoided.

For food modification, respondents were asked whether they prepared foods in a special way because of the condition of their teeth, mouth, or dentures. The foods included apples; steak, pork chops, or roasts; beans such as limas or black-eyed peas; carrots; and cooked greens. For each, preparation methods common in the area were queried. For example, for apples, respondents were asked if they prepared them by peeling, slicing thin, chopping into small pieces, scraping with a spoon, or cooking. Respondents could indicate more than one modification technique for each food. Modification techniques other than those included in the standard questionnaire were captured. The research team reviewed these additional techniques and was able to include the responses within existing modification measures. Measures were created indicating whether any or no modification method was used. Details of these modification measures are described in another report.[7] Two categories were created for the number of foods modified: zero to three foods and four to five foods.

Dentate participants (persons with at least one natural tooth) were asked to undergo an in-home oral examination. Of 413 dentate participants, 362 completed the oral examination, for a participation rate of 87.6%. Two dental hygienists who performed tooth counts and other measures not used in these analyses conducted all oral examinations. The hygienists underwent an initial 1-day training and 1-day calibration with a research dentist using volunteers who were representative of the study population. Calibration was repeated annually. The research dentist conducted five replicate examinations with each hygienist and performed an ongoing review of data collection forms to check for correct logic, legal values, and data ranges. Based on this on-going review, the research dentist provided feedback and further training to hygienists as needed.

Demographic data included information on sex, ethnicity, age, income, education, and marital status. Ethnicity was self-reported and categorized as African American, American Indian, or white. Income was dichotomized as above or below the poverty line using current-year federal poverty guidelines according to household size.[29] Education categories were less than high school graduate, high school graduate, or more than high school.

Dietary Assessment and HEI-2005 Scoring

The HEI-2005 contains 12 components.[30] These include cup equivalent (eq)/1,000 kcal of total fruit, whole fruit, total vegetables, dark green and orange vegetables, and legumes (after meat and bean component reach maximum values), and milk (dairy products including soy milk). Meat and beans (eggs, nuts, and soy foods, excluding drinks), total grains, and whole grains are calculated in ounce eq/1,000 kcal. The amounts of oils (nonhydrogenated fats found in mayonnaise, margarine, salad dressing, nuts and seeds, and fish) and sodium, measured in g/1,000 kcal, and the percentage of calories from saturated fat and solid fat, alcohol, and added sugar (SoFAAS) constitute the remaining components. The total HEI score (range 0–100) is the sum of scores for all components; the contribution (weighting) of each component to the total score varies. A score of 5 was given for meeting or exceeding recommended intake of total fruit, whole fruit, total vegetable, dark green and orange vegetables and legumes, total grains, or whole grains; a maximum score of 30 was represented by these components. A score of 10 was assigned for meeting or exceeding recommended amounts of milk, meat and beans, and oils and when saturated fat and sodium were equal to or less than recommended intake; a maximum score of 50 was represented by these components. The recommended percent of energy contributed by SoFAAS was assigned a score of 20 if it was equal to or less than the recommendations.

Completed FFQs were scanned using Nutrition Quest. Nutrition Quest provided gram amounts and calories for each questionnaire item for the calculation of HEI-2005 component scores in addition to standard output variables of daily intake of micro- and macronutrients and U.S. Department of Agriculture (USDA) servings of food groups. The USDA Food Search Tool 3.0[31] provided additional information to calculate HEI-2005 components, such as grams per cup or ounce, amounts of fat, or added sugar in certain reference foods. The conversion of dietary measures to HEI-2005 scores can be found in more detail elsewhere.[32]

Statistical Analysis

All analyses incorporated the multistage cluster sampling design and have been described elsewhere.[22] Weighted sample sizes were reported. Participants were categorized into six categories (two food modification categories and, within these, three avoidance subcategories). The Rao-Scott chi-square test was used to test for differences across these six categories for sex, ethnicity, income, education, poverty, and number of teeth. Linear regression models were used to test for differences across these six categories for age and body mass index. Linear regression models tested the main effects of food avoidance and food modification on total HEI-2005 score and its components after adjusting for the covariates age, sex, ethnicity, poverty status, education, and number of teeth. Interaction between food avoidance and food modification was tested for all models. If the interaction was not significant, the interaction term was dropped from the final model. Adjusted means and standard errors of total HEI-2005 score and its components were estimated from the models for all food avoidance/modification categories. All analyses were performed using SAS 9.1 (SAS Institute, Inc., Cary, NC), and a level of significance was set at $P<.05$.

RESULTS

Sample Characteristics

The total sample of 635 participants had a mean age (SE) of 71.5 (0.4) years. The sample included 344 women (54.2%) and 291 men (45.8%). The racial and ethnic sample composition was 21.4% African American, 30.7% American Indian, and 47.8% white. Thirty-two percent of

participants were below the poverty level, and 55.7% had less than and 19.8% more than a high school education. Approximately half of the participants had fewer than 11 teeth, indicating severe tooth loss (Table 1).

Table 1: Sociodemographic Characteristics and the Number of Teeth of Rural Older Adults Categorized by the Number of Foods Modified and Avoided Because of the Condition of their Teeth, Mouth, and Dentures

		Modify 0–3 Foods			Modify 4–5 Foods			
Characteristic	Total (N=635)	Avoid 0 Foods, n=230 (36.2%)	Avoid 1–2 Foods, n=127 (20.0%)	Avoid 3–14 Foods, n=116 (18.2%)	Avoid 0 Foods, n=16 (2.5%)	Avoid 1–2 Foods, n=39 (6.1%)	Avoid 3–14 Foods, n=107 (16.9%)	*P*-Value*
Age, mean (SE)	71.5 (0.4)	71.1 (0.6)	71.4 (1.0)	72.3 (1.0)	67.2 (1.6)	72.6 (1.4)	72.1 (0.9)	.07
Body mass index, feg/m^2, mean (SE)	29.4 (0.4)	30.0 (0.9)	28.6 (0.7)	28.1 (1.0)	33.2 (1.7)	29.7(1.1)	29.4(0.8)	.16
Sex, n (%)								
Women	344 (54.1)	113 (33.8)	55 (21.1)	64 (15.0)	9 (2.5)	26 (7.5)	69 (20.1)	.17
Men	291 (45.9)	116 (39.0)	72 (18.8)	52 (22.1)	7 (2.5)	13 (4.5)	38 (13.2)	
Ethnicity, n (%)								
African American	136 (21.4)	58 (29.9)	30 (22.0)	18 (13.6)	4 (3.0)	9 (6.6)	28 (20.7)	.02
American Indian	195 (30.7)	46 (34.0)	30 (15.4)	37 (19.0)	9 (4.5)	14 (6.9)	48 (24.4)	
White	304 (47.8)	125 (41.2)	67 (22.1)	60 (19.9)	3 (1.0)	16 (5.3)	32 (10.4)	
Income, n (%)								
Below poverty level	204 (32.1)	46 (22.7)	41 (20.0)	50 (24.7)	5 (2.4)	12 (5.8)	50 (24.5)	.001
Above poverty level	431 (67.9)	184 (42.6)	86 (20.0)	66 (15.2)	11 (2.6)	27 (6.3)	57 (13.3)	
Education, n (%)								
<High school	354 (55.7)	94 (26.5)	58 (16.3)	81 (22.9)	11 (3.2)	31 (8.9)	79 (22.3)	<.001
High school	156 (24.5)	59 (37.9)	44 (28.2)	27 (17.6)	2 (1.3)	4 (2.8)	19 (12.2)	
>High school	126 (19.8)	77 (61.5)	25 (20.3)	8 (6.1)	3 (2.2)	3 (2.4)	9 (7.5)	
Number of teeth, n (%)								
0–10	327 (51.5)	70 (21.4)	63 (19.3)	99 (30.3)	4 (1.1)	14 (4.4)	77 (23.6)	<.001
≥11	308 (48.5)	160 (51.9)	64 (20.7)	17 (5.4)	12 (4.1)	25 (8.0)	30 (9.9)	

*_P_-values were derived from the Rao-Scott chi-square test of the overall difference across the six food avoidance and modification categories. N=weighted sample size ; SE=standard error.

Food Avoidance and Modification Categories

Participants were categorized into two modification categories (0–3 foods modified and 4–5 foods modified). Within these two categories, participants were categorized into three subcategories based on the number of foods they reported avoiding (0, 1–2, and 3–14). The descriptive characteristics of these six subcategories are also found in Table 1. Three-quarters of the sample modified zero to three foods (n=473). Of these, 48.6% (n=230) did not report avoiding any of the listed foods, and 25% (n=116) reported avoiding three to 14 foods. In contrast, of those who reported modifying four to five of the foods (n=162), only 9.9% (n=16) indicated that they did not avoid any of the listed foods, whereas two-thirds (n=107) avoided three to 14 foods. Ethnicity, poverty status, education, and severity of tooth loss were related to the food modification and avoidance patterns of these participants (Table 1). Whites were less likely than other groups to modify four to five foods and avoid three to 14 and were more likely to modify zero to three foods and avoid none (*P*=.02). Those whose incomes were above the poverty line were less likely to modify four to five foods and avoid three to 14 foods and more likely to modify zero to three and avoid no foods (*P*=.001). Similarly, 61.5% of those with more than a high school education modified fewer foods and avoided none, and 9.5% reported modifying four to five and avoiding three to 14 foods (*P*<.001). Finally, 51.9% of those with 11 or more teeth modified zero to three foods and avoided none, in contrast to 21.4% with severe tooth loss (*P*<.001).

HEI-2005 Scores

After adjusting for the effects of age, sex, ethnicity, poverty status, education, and severity of tooth loss, total HEI-2005 score and four of the 10 food categories constituting the total score differed based according to whether a participant reported modifying or avoiding foods. There were no statistically significant interactions between food modification category and food avoidance category. Therefore, the results of linear regression models that tested the main effects of food modification and avoidance categories on HEI scores are reported (Table 2).

Table 2: Relationship Between Number of Foods Modified and Avoided and Healthy Eating Index-2005 (HEI-2005) Total Score and Estimated Intake of Component Foods (Least Square Mean (SE))[1]

	Mean (Standard Error)							
	Modifies 0–3 Foods			Modifies 4–5 Foods			*P*-Value[*]	
HEI-2005 Category	Avoid 0, n=230 (36.2%)	Avoid 1–2, n=127 (20.0%)	Avoid 3–14, n=116 (18.2%)	Avoid 0, n=16 (2.5%)	Avoid 1–2, n=39 (6.1%)	Avoid 3–14, n=107 (16.9%)	Avoid	Modify
Total score (0–100 points)	61.8 (1.0)	62.7 (1.3)	58.8 (1.0)	64.7 (1.0)	65.6 (1.3)	61.7 (0.8)	<.001	<.001
Total fruit (cup eq/1,000 kcal[4])	0.56 (0.03)	0.58 (0.04)	0.48 (0.04)	0.62 (0.04)	0.64 (0.04)	0.53 (0.04)	.08	.13
Whole fruit (cup eq/1,000 kcal)	0.36 (0.02)	0.35 (0.02)	0.27 (0.03)	0.40 (0.02)	0.39 (0.03)	0.34 (0.02)	.14	.06
Total vegetable (cup eq/1,000 kcal)	0.88 (0.06)	0.89 (0.06)	0.76 (0.04)	0.89 (0.06)	0.90 (0.06)	0.78 (0.04)	.13	.70
Dark green and orange vegetables and legumes (cup eq/1,000 kcal)	0.47 (0.04)	0.50 (0.05)	0.39 (0.35)	0.50 (0.04)	0.53 (0.05)	0.42 (0.03)	.06	.28
Total grains (oz/1,000 kcal)	2.44 (0.11)	2.56 (0.09)	2.41 (0.11)	2.80 (0.15)	2.91 (0.13)	2.77 (0.13)	.34	.005
Whole grains (oz/1,000 kcal)	0.94 (0.07)	1.06 (0.07)	0.89 (0.07)	1.12 (0.11)	1.25 (0.11)	1.80 (0.09)	.07	.05
Milk (cup eq/1,000 kcal)	0.49 (0.03)	0.45 (0.05)	0.48 (0.06)	0.42 (0.06)	0.38 (0.06)	0.42 (0.04)	.76	.16
Meat and beans (oz eq/1,000 kcal)	2.39 (0.10)	2.27 (0.08)	2.33 (0.10)	2.32 (0.11)	2.27 (0.12)	2.20 (0.07)	.48	.46
Oils (g eq/1,000 kcal)	5.83 (0.39)	5.91 (0.54)	4.62 (0.47)	5.29 (0.46)	5.38 (0.59)	4.09 (0.42)	.03	.20
Saturated fat (% of kcal)	11.4 (0.2)	10.8 (0.2)	11.3 (0.2)	10.7 (0.3)	10.1 (0.3)	10.6 (0.2)	.04	.004
Sodium (mg/1,000 kcal)	1,352 (28.1)	1,299 (24.5)	1,329 (29.9)	1,328 (31.2)	1,275 (30.5)	1,305 (23.9)	.20	.33
Energy from solid fat, alcohol, and added sugar (% of kcal)	28.0 (0.9)	28.5 (0.9)	30.6 (0.9)	25.9 (0.9)	26.5 (0.9)	28.6 (0.7)	.01	.03

[1]Adjusted for covariates (age, sex, marital status, poverty status, and severity of tooth loss).
[*]*P*-values were derived from linear regression models that tested the main effects of food avoidance and food modification after adjusting for covariates.
N=weighted sample size.

For the total sample, the HEI-2005 mean total score (SE) was 61.87 (0.72) of the possible 100 points. Those who avoided three to 14 foods had lower HEI-2005 total scores than those who avoided fewer foods (*P*=.001). Modifying four to five foods was associated with HEI-2005 total scores that were approximately 3 points higher than modifying zero to three foods across all of the food avoidance categories (*P*=.009). The net effect can be found by comparing the extremes; participants who modified four to five foods and avoided none had a HEI-2005 total score that was approximately 6 points higher (64.70 (1.01)) than the group who avoided three to 14 foods and modified zero to three foods (58.78 (1.02), *P*<.001).

Differences in total grains, saturated fat, SoFAAS, and oils (nonhydrogenated fats) were related to these food practices. Higher reported intake of total grains was related to modifying four to five foods (*P*=.005) but not related to number of foods avoided (*P*=.34). Those who modified four to five foods consumed less energy from saturated fat (*P*=.04) and SoFAAS (*P*=.03) than

those who modified zero to three foods. Percentage of energy from saturated fat was related to number of foods avoided (P=.04), with persons who avoided one to two foods consuming less saturated fat than those who avoided no foods or three to 14 foods. Those who avoided more foods consumed more energy from SoFAAS (P=.01). Those who avoided three to 14 foods and modified zero to three were estimated to consume 30.6% (0.9%) of their energy from SoFAAS, compared with 25.9% (0.9%) for those who modified four to five foods and avoided no foods. The intake of oils was lower for those who avoided more foods (P=.03). The estimated amounts of fruit, vegetables and legumes, whole grains, milk products, meat and beans, and sodium were not related to food modification and avoidance practices.

DISCUSSION

These results are consistent with several studies reporting that people who adapt to impaired oral health by avoiding certain foods are likely to have poorer dietary quality.[33–36] This study corroborates that research and builds on it by demonstrating that modifying foods in response to oral health problems was associated with higher HEI-2005 scores. Taking these two strategies together, people who avoided many foods and modified several foods had total HEI-2005 scores that were comparable with the scores of those who had less trouble eating (they did not avoid any foods and modified few). This was true even when the effects of poverty, ethnicity, education, and most importantly, severity of tooth loss were controlled for in the analysis. To the authors' knowledge, this is the first report to link these two nutrition self-management strategies; it also begins to define how self-management of impaired oral health leads to poorer dietary quality.

Participants were asked whether they avoided or modified because of oral health conditions. The list included whole apples, carrots, grilled or fried meats, berries, nuts, seeds, sticky candy, beans, and certain vegetables. Given this wide array of foods, it was not hypothesized which of the HEI-2005 component foods would contribute to the number of foods avoided. Those avoiding three to 14 foods had higher intake of saturated fats and percentage of energy from solid fat and added sugar and consumed lower amounts of fats found in salad dressing, nuts, seeds, and fish. Persons who modified four to five foods consumed less saturated fat, solid fat, and added sugar and consumed more total grains, although a statistically significant association was not found between avoidance and modification and the fruit, vegetable, and meat components. This may reflect that not all fruits, vegetables, and meats are hard to chew or swallow (e.g., bananas, peas, or ground meat), and participants are likely to continue to eat similar foods that contribute to those component scores. A previous study found that reported avoidance of hard and difficult-to-chew foods was correlated with perceived chewing ability but not total fruit and vegetable intake.[37] Other reports have shown that people with greater tooth loss consumed less of foods such as carrots and salads and had lower dietary intake or serum levels of certain vitamins,[8,36,38] although these reports did not directly test the association between the intake of these foods and nutrient intake or serum levels of vitamins or minerals. Others have not found any association between having difficulties eating solid food and nutrient intake, nor have they found that oral health problems, chewing difficulties, or temperature sensitivity were associated with food avoidance, but they did find that people with fewer natural teeth and poorly fitting dentures had less food variety in their diets.[11] It may be that the combined effect of eliminating certain fruits and vegetables because of oral health problems, along with

greater consumption of foods high in fat and sugar, contributed to the differences in dietary quality found in people avoiding more foods.

The individuals who avoided the most foods were approximately evenly split when categorized as modifying zero to three foods or four to five foods. Those who avoided the most foods were more often ethnic minorities, had lower education and income, and had experienced greater tooth loss, although these results do not tell us what characteristics distinguish people who avoid many foods yet are able or willing to modify their foods from those who do not modify. Research has found that the inability to fix meals for oneself, lack of companionship, and widowhood were related to nutritional status and mortality.[20,25,39] Limited cooking ability has been associated with risk of early mortality in older community-dwelling black and white adults.[20] Companionship has been found to mediate the effects of poor appetite on dietary quality in older adults.[39] Rural widows were more likely to skip meals, had less food variety, and prepared foods less frequently.[25] The results of the current study also indicate that it is important to understand the effect of meal preparation support and the particular barriers faced by older adults who want to modify their foods but are unable to do so.

This study has several strengths. The results are based on a large population-based survey of older adults living in rural multiethnic communities where they are more likely to be obese or overweight, experience high rates of chronic disease, and have limited access to preventive healthcare.[40–42] Furthermore, the study differed from other research on the effects of oral health on food choices, because it considered the associations between dietary quality and food avoidance and modification. Finally, the diets of rural older adults were examined using the HEI-2005, which reflects the most recent USDA guidance and uses density standards rather than absolute amounts of food (the food amounts per 1,000 kcal of intake vs amounts per day).[30] For older adults with often low energy intake, the HEI-2005 density standard provides a useful approach for understanding food choices of older adults regardless of the total amounts of food.[43–45]

The limitations of this report call attention to the need for future research. First, this was a cross-sectional investigation, so causal relationships cannot be established. These results are based on a single time point, so it is not possible to assess the quality of participants' diets before changes in their oral health. It suggests a need to consider how declining oral health affects ability to chew and eat without pain, leading to food adaptations and subsequent declines in dietary quality. Second, the functional and health status of older adults vary widely. The effects of these differences on participants' food choices and preparation efforts were not considered. These may have a substantial effect on nutritional self-management practices, particularly for people with diabetes mellitus or cardiovascular disease, in whom nutritional self-management is a standard clinical recommendation. Finally, the cooking and food acquisition habits of older adults vary based on the level and quality of support received from family, friends, and community services.[2] Participants receiving help preparing their foods may be more likely to eat foods that are difficult to chew if someone prepares these items for them so that they are easier to eat.

CONCLUSION

This study links two nutritional self-management practices, food avoidance and modification, and current USDA dietary recommendations, furthering understanding of how changes in oral

health relate to declines in dietary quality. Future research is needed to provide a more-complete picture of how older adults adapt to tooth loss and other oral health concerns, particularly in poor communities with fewer resources. This research should extend to resources providing food to older adults, such as home healthcare workers, family members, congregate meals, and home-delivered meals. The level of awareness of meal providers about these self-management strategies and the degree to which these are considered in their efforts to help older adults maintain a healthful diet need to be understood. Nutrition and health promotion programs for older adults should focus directly on how participants adapt to oral health problems and on ways to increase how food can be made easier to eat. Last, eating pleasure is an important component of daily living, and learning more about how quality of life changes when eating becomes less enjoyable should be explored.

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AUTHOR CONTRIBUTIONS

Margaret Savoca, Thomas Arcury, Ronny Bell: study design, data interpretation, and manuscript preparation. Xiaoyan Leng, Haiying Chen: study design, data analysis and interpretation and manuscript preparation. Andrea Anderson, Gregg Gilbert: data analysis and manuscript preparation. Teresa Kohrman: acquisition of subjects and manuscript preparation. Sara Quandt: study design, acquisition of subjects, data interpretation and manuscript preparation.

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