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Food Avoidance and Food Modification Practices of Older Rural Adults: Association With Oral Health Status and Implications for Service Provision

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Purpose: Dietary variation is important for health maintenance and disease prevention among older adults. However, oral health deficits impair ability to bite and chew foods. This study examines the association between oral health and foods avoided or modified in a multiethnic rural population of older adults. It considers implications for nutrition and medical service provision to this population. ***Design and Methods:*** In-home interviews and oral examinations were conducted with 635 adults in rural North Carolina counties with substantial African American and American Indian populations. Avoidance and modification data were obtained for foods representing different dental challenges and dietary contributions. Data were weighted to census data for ethnicity and sex. Bivariate analyses of oral health measures and foods avoided used chi-square and logistic regression tests. Multivariable analyses used proportional odds or nominal regression models. ***Results:*** Whole fruits and raw vegetables were the most commonly avoided foods; substantial proportions of older adults also avoided meats, cooked vegetables, and other foods. Food avoidance was significantly associated with self-rated oral health, periodontal disease, bleeding gums, dry mouth, having dentures, and having fewer anterior and posterior occlusal contacts. Associations persisted when controlling for demographic and socioeconomic status indicators. From 24% to 68% of participants reported modifying specific fruits, vegetables, and meats. Modifying harder foods was related to location of teeth and periodontal disease and softer foods to oral pain and dry mouth. ***Implications:*** Food services for older adults should consider their oral health status. Policy changes are needed to provide oral health care in benefits for older adults.

Key Words: Nutrition, Elderly, Rural, Dentition, Dentures, Congregate meals programs

In this article, we describe how older adults avoid or modify foods in order to accommodate oral health deficits that they experience. We argue that behaviors that contribute to dietary intake are important because of diet's association with health maintenance and disease prevention. There is little research that considers the changes in eating that accompany oral health declines. We suggest that older adults make these changes in eating—food avoidance and food modification—as part of their nutritional self-management strategies.

Consuming a varied diet that includes fresh fruits and vegetables, nuts, and meats is associated with protection against a variety of chronic diseases and chronic disease risk factors. Vegetable consumption has been associated with reduced

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risk of some cancers (Edefonti et al., 2009; Kim & Park, 2008; Nomura et al., 2008; Wright et al., 2008). Diets that include vegetables, fruits, and nuts are also associated with lower incidence of diabetes, reduced risk of mortality from diabetes and cardiovascular disease, and lower rates of risk factors such as hypertension and obesity (Dauchet et al., 2007; Heidemann et al., 2008; Masala et al., 2008; Nash & Nash, 2008; Nettleton et al., 2008).

Loss of teeth and other oral health deficits that may accompany aging are associated with real and perceived declines in chewing ability. Having 20 natural teeth has been suggested as a threshold below which both laboratory-measured and self-reported chewing efficiency declines (Gotfredsen & Walls, 2007). Compared to persons with more teeth, those with fewer teeth report avoiding hard foods such as apples and raw vegetables more often (Hung, Colditz, & Joshipura, 2005). Nevertheless, studies sometimes fail to find declines in nutrient intake that might be expected from oral health deficits (Walls & Steele, 2004), raising the possibility that, in addition to food avoidance, some persons adopt adaptive food-related behaviors such as food modification. These behaviors may be responsible for the maintenance of adequate dietary intakes.

Older adults with oral health deficits are likely to avoid or modify foods that are problematic to eat due to difficulties in chewing and swallowing, due to pain, or due to fear of causing further harm to a fragile dentition. Avoiding foods can have a variety of dietary effects, depending on whether the avoidance prevents consumption of an adequate diet. These changes in diet, in turn, can affect nutritional status and health. Existing studies have demonstrated the impact of oral health deficits on nutritional status of older adults (Hung et al., 2003, 2005; Lee et al., 2004; Marcenes, Steele, Sheiham, & Walls, 2003; Nowjack-Raymer & Sheiham, 2007) and on chronic disease status (Garcia, Henshaw, & Krall, 2000). Modifying foods in ways that still permit their consumption may have fewer dietary consequences than food avoidance, thus permitting older adults to maintain their customary food consumption patterns.

Food plays a role in maintaining identity and feelings of connectedness to family and place (Quandt, 2006). Therefore, older adults may sometimes resist eliminating food from their diet (food avoidance) and practice food modification behaviors to facilitate consuming familiar foods to maintain their sense of well-being. Such foods help to reinforce ethnic group membership, regional affiliation, or attachment to families (Mintz & Du Bois, 2002).

The literature on the avoidance of foods due to oral health deficits is limited. A study of tooth loss in a large (>83,000) prospective sample of U.S. women found that women who lost teeth tended to begin avoiding hard foods such as raw fruits and vegetables (Hung et al., 2005). A study of 753 community-dwelling older adults in Great Britain found that those with fewer teeth and poorer oral condition avoided specific foods like apples, well-done meats, nuts, and raw carrots (Sheiham & Steele, 2001). In most cases, the oral health associations with food avoidance have been limited to tooth loss, functional posterior occlusal contacts (Hildebrandt, Dominguez, Schork, & Loesche, 1997; Marcenes et al., 2003; Sheiham et al., 2001), having dentures (Ellis, Thomason, Jepson, Smith, & Allen, 2008; Nowjack-Raymer & Sheiham, 2003), and dry mouth (Makhija et al., 2007; Rhodus & Brown, 1990). Although these have been examined individually in separate populations, no study has looked at multiple oral health deficits in the same sample. Existing studies have used a variety of ways to determine foods avoided. These include assuming avoidance by comparisons of foods on dietary recall measures of those with and without oral health deficits (e.g., Nowjack-Raymer & Sheiham) or using a list of foods exemplifying eating challenges (e.g., sticky, crunchy, stringy; Hildebrandt et al., 1997).

Studies of food modification—that is, making changes in the texture, size, or consistency of foods to facilitate their consumption—as a result of oral health deficits are rare. Occasional suggestions of food modification are found in a few studies (e.g., Anastassiadou & Heath, 2002), but no deliberate study of these practices has been conducted.

Despite the dearth of previous research documenting food avoidance and food modification for oral health deficits, the field of self-care and self-management research (Clark, 2003; Ory, 2008) suggests that older adults likely undertake such measures to adapt to changing health conditions and, to the extent possible, to maintain their diet. Health self-management is defined as behaviors undertaken to enhance health, prevent disease, limit illness, or restore health (World Health Organization, 1983). Self-management includes behaviors based on one's own resources (self-care), on informal support from family and friends, on

formal services, and on medical care. The self-management literature argues that older adults' primary means of dealing with health deficits is self-care: performing behaviors and leveraging resources to meet their health-related needs (Clark, 2003; Clark et al., 2008).

Nutritional self-management has been described as a specific type of health self-management. Quandt, Arcury, and Bell (1998) have proposed that older adults bring these four types of resources (self-care, informal support, formal services, and medical care) to bear on a set of three food-related tasks (food acquisition, food consumption, and maintaining food security) necessary to maintain adequate nutritional status (Quandt et al.). Behaviors that contribute to these food-related tasks can include gardening (for food acquisition), cooking food (for food consumption), and preserving food (for food security).

We propose that food avoidance and food modification are specific types of behaviors that contribute to older adults achieving "food consumption" in the context of a variety of problems, including oral health deficits. Food avoidance and food modification can be accomplished by self-care (choosing or modifying foods oneself), informal support (having others, most likely a family member, choose and prepare foods to accommodate dental problems), or formal services (having an aide prepare foods). This article focuses on a multiethnic sample of older adults in the rural South. The purposes of this article were to investigate a set of nutritional self-management practices related to oral health deficits by (a) quantifying the food avoidance and food modification practices of older adults in a rural, multiethnic population and (b) testing the hypothesis that food avoidance and food modification practices are significantly associated with oral health deficits.

Design and Methods

Sample and Recruitment

The Rural Nutrition and Oral Health Study was conducted in two rural North Carolina counties. These counties were chosen in 1996 for a long-term study of rural aging because they had a high proportion of minority older adults and older adults living in poverty compared to the remainder of the state. At that time, one county was classified as nonmetropolitan with a Rural–Urban Continuum Code of 6 and the other as nonmetropolitan with a code of 4 (nonmetropolitan, with an urban population of 20,000 or more, adjacent to a metropolitan area; United States Department of Agriculture, 2004). At the time of the present study, both counties were coded as 4.

To be eligible, an older adult had to be aged 60 years or older, community dwelling, and physically and mentally able to complete an interviewer-administered survey. Participants were located using a random dwelling selection and screening procedure based on a multistage cluster sampling design in which the primary sampling units (clusters) were stratified and selected with probability proportionate to their sizes. This procedure was designed and implemented by the investigators in consultation with the University of Illinois Survey Research Laboratory.

Within the 80 mapped clusters, 5,545 dwellings units were identified. Thirty-nine of these dwelling units were not screened, 4,647 were screened but did not include an eligible participant, and 859 included an eligible participant. The screening rate was 99.3%. Interviewers attempted to recruit participants who met the inclusion criteria by visiting each randomly selected dwelling in a cluster. Once an eligible resident was identified, the interviewer asked to speak with that individual. If the individual was not at home, the interviewer made an appointment to return. The interviewer made at least three additional attempts to contact the selected individuals at times at which other residents indicated that the individual would normally be at home. All randomly selected dwellings were maintained in the sample until their dispositions were finalized.

The eligible resident in 635 of the 859 eligible dwelling units completed the interview, and 224 refused to complete the interview, for a response rate of 73.9%. The University of Illinois Survey Research Laboratory provided weights for each participant based on size of the cluster from which he or she was selected and his or her probability of selection within each dwelling unit.

Data Collection and Quality Control

Data were collected in face-to-face home interviews lasting 1.5–2.5 hr. All interviewers completed 1 day of didactic training and recorded practice interviews. Ten percent of each interviewer's interviews were verified by telephone. Dentate participants (persons with at least one natural tooth) were asked to undergo an in-home oral examination. Edentulous participants were excluded because the

data to be collected would not have been available for them (e.g., functional occlusal contacts) or could be obtained with reasonable accuracy by self-report (e.g., number of teeth). Among 413 dentate participants, 362 completed the oral examination for a participation rate of 87.6%. Oral examinations were conducted by dental hygienists who performed tooth counts and assessed functional occlusal contacts. Two hygienists conducted all study assessments. They 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. All data collection procedures were approved by the Wake Forest University School of Medicine Institutional Review Board.

In addition to the oral health measures reported here, the dental hygienists conducted a soft tissue screening to look for any anomalies indicative of oral cancers or other serious health problems. Using a protocol approved by the Wake Forest University School of Medicine Institutional Review Board, a participant was given a written and oral summary of such findings. With the participant's permission, the information was sent to his or her health care provider. If the participant had no health care provider, contact information was provided for other health care providers. The research team recontacted the participant in 3 weeks; if no follow-up had occurred, the need to seek medical care was reiterated and another copy of the information was sent.

Measures

Food avoidance measures were developed based on data obtained over more than 10 years of qualitative and quantitative nutrition research in the study population (Quandt, Arcury, Bell, McDonald, & Vitolins, 2001; Quandt, Arcury, McDonald, Bell, & Vitolins, 2001; Quandt, McDonald, Arcury, Bell, & Vitolins, 2000; Quandt et al., 2006; Vitolins et al., 2000, 2007) as well as a small pilot study. Respondents were read a list of foods and asked if 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 and nuts, seeds and small pieces that become lodged in teeth or under dentures; sticky candy, food that can adhere to dental work). Because the distribution was skewed, a categorical variable was created for no foods avoided (0), 1–2 foods avoided (1), and 3–14 foods avoided (3). For food modification, respondents were asked whether or not 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 roast; 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. Measures were created for each food of any modification method used (1) or no modification method used (0).

Ethnicity was self-defined by participants and categorized as White, American Indian, or African American. Education was reported as highest grade completed and is categorized as Grade 8 or less, Grades 9–11, and high school graduate or higher. Income was obtained in categories and dichotomized as (0) at or above or (1) below the poverty line using federal poverty guidelines appropriate for the respondent's household size and for the year of data collection.

Self-rated oral health was obtained by asking participants to rate the condition of their mouth and teeth, including prosthetic replacements, as excellent, very good, good, fair, or poor. This was dichotomized as excellent, very good, and good versus fair and poor for data analysis. Participants reported the presence (1) or absence (0) of mouth pain, full dentures or partial dentures that do not fit, gum soreness or bleeding, dry mouth, and periodontal disease. Periodontal disease was coded as present if the participant reported ever having been told by a dentist that he or she had periodontal or gum disease or reported ever having had a loose tooth as an adult (not including trauma). Removable prostheses were coded as present (if the participant reported having at least one full or partial upper or lower removable

Table 1. Participant Characteristics ($N = 635$)

Characteristic	White	African American	American Indian
Age, *M* (*SE*)	72.2 (0.7)	72.2 (0.8)	70.1 (0.6)
Sex, *n* (%)			
Female	139 (45.7)	83 (61.1)	122 (62.5)
Male	165 (54.3)	53 (38.9)	73 (37.5)
Poverty, *n* (%)			
At or above poverty line	234 (77.0)	82 (60.7)	115 (58.7)
Below poverty line	70 (23.0)	53 (39.3)	81 (41.3)
Education, *n* (%)			
≤Grade 8	73 (23.9)	38 (28.0)	99 (50.7)
Grades 9–11	60 (19.7)	39 (28.8)	45 (23.0)
≥Grade 12	171 (56.4)	59 (43.2)	51 (26.2)
Dental insurance, *n* (%)			
Yes	34 (11.2)	16 (11.7)	14 (7.4)
No	270 (88.8)	120 (88.3)	180 (92.6)

denture) or absent. Participants were coded as dentate or edentulous based on self-reported number of teeth.

Functional units (Hildebrandt et al., 1997) were counted if a functional contact existed between two natural teeth, a natural tooth and a fixed prosthesis, or two fixed prostheses. Functional anterior units are ordered categories 0 functional units, 1–3 functional units, and 4–6 functional units. Functional posterior units are ordered categories 0 functional units, 1–3 functional units, and 4–10 functional units. Data on functional contacts are only available for those 362 persons who participated in the oral examination.

Data Analysis

All data analyses took into account the complex survey design of our study. Both observed sample size (n) and the weighted sample size (N) were reported when necessary. The association between two categorical variables was examined using Rao–Scott chi-square tests. The results from these bivariate analyses were then used to help develop more complicated regression models so that the effects of various explanatory variables on the food avoidance or food modification outcomes could be evaluated simultaneously. We suspected that some of the oral health variables were correlated in nature and might cause collinearity when put together in the regression models. The comparison of the unadjusted and the adjusted regression coefficients and the corresponding standard errors provided no evidence of significant effect of collinearity.

In this article, we used binary, ordinal, and nominal logistic regression models for analyses depending on the characteristics of the outcomes. Because the number of foods avoided is an ordinal variable, we first assessed the assumption of proportional odds ratios using Score tests for various explanatory variables indicating oral health status. This assumption appeared reasonable for all oral health variables except periodontal disease. Therefore, nominal logistic regression models were used for periodontal disease to allow the association between predictors and outcome to differ across outcome levels. For the rest of the oral health variables, proportional odds models were employed for the food avoidance outcome. The food modification outcomes were all binary, and therefore, logistic regression models were used. For all the regression models, we chose to present the odds ratios and the associated 95% confidence intervals instead of the raw regression coefficients (log odds) for an easier interpretation of the results. All analyses were performed using SAS 9.1 (SAS Institute Inc., Cary, NC), and a p value of $<.05$ was considered statistically significant.

Results

Mean (±*SE*) age of the sample was 72.2 ± 0.7 years for Whites, 72.2 ± 0.8 years for African Americans, and 70.1 ± 0.6 years for American Indians. About two in five minority participants, and one in four Whites, were below the poverty level (Table 1). Only 26% of American Indians had at least a high school diploma compared to 43% for African Americans and 56% of Whites. Dental insurance coverage was low, ranging from 12% of African Americans, and 11% of Whites, to 7% for American Indians.

Table 2. Number of Older Adults Reporting Avoidance of Common Foods (*N*=635)

	Foods													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Whole apples with skin	320													
2. Whole nuts, not chopped	176	209												
3. Sticky candy	151	103	208											
4. Carrot sticks or whole	181	135	196	204										
5. Corn	82	68	58	65	94									
6. Popcorn	91	63	52	61	34	88								
7. Grilled or fried pork chops or steak	78	65	49	60	29	31	88							
8. Lettuce or tossed salad	61	45	39	48	30	34	25	64						
9. Berries, including straw-, rasp-, and blueberries	29	19	17	20	11	18	10	9	32					
10. Fried chicken	24	22	15	20	13	14	20	11	5	26				
11. Raw tomatoes	21	12	9	18	9	13	8	8	13	2	23			
12. Fried fish or shrimp	7	7	6	4	5	3	5	3	1	3	1	7		
13. Ground beef or hamburger	5	5	3	4	3	4	4	2	1	4	1	1	5	
14. Baked or stewed chicken	4	4	3	3	4	3	1	3	1	2	2	3	1	4

Notes: Numbered columns correspond to similarly numbered rows. Values at the intersection of column and row indicate the number of persons that report avoiding one food who also avoid another food.

Food Avoidance

The food most commonly avoided due to oral health problems was whole apples, avoided by 320 persons (50%; Table 2). Whole nuts, sticky candy, and raw carrots were the foods next most frequently reported (32%). Corn, popcorn, and grilled or fried meats were avoided by about 14%. Other foods were avoided by 10% or fewer respondents. Persons who avoided one of the commonly avoided foods also tended to avoid the other commonly avoided foods (Table 2). For example, of the 204 respondents who reported avoiding carrots, 181 also avoided whole apples. Although a few foods (e.g., fried chicken, ground beef, and baked or stewed chicken) were avoided by relatively few respondents, those respondents who did avoid such foods reported avoiding almost all the other foods as well.

Almost two thirds (419; 66%) of the participants reported avoiding at least one food; 216 (34%) reported not avoiding any of the listed foods. Of those who avoided foods, 111 (26%) avoided only one food and 71 (17%) two foods. The remaining 237 persons (57%) avoided 3 to 14 foods.

The total number of foods avoided was related to self-rated oral health (Table 3). Almost two thirds of those reporting excellent, very good, or good oral health avoided no foods, whereas only one third of those reporting fair or poor oral health avoided no foods. The same pattern was found for all other self-reported oral health measures except oral pain, which was reported by only about 11% of the sample. The two measures obtained from oral examinations with dentate respondents, anterior and posterior functional occlusal units, were also associated with food avoidance. The larger the number of functional units, the fewer the foods reported as avoided.

In unadjusted regressions, all oral health measures were significantly associated with total number of foods avoided (Table 4). For example, older adults with excellent, very good, or good self-rated oral health were half as likely to report avoiding foods, whereas those with bleeding gums were four times as likely to report avoiding foods. In regressions adjusted for sex, age, ethnicity, education, and poverty status, all oral health deficits remained significantly associated with oral health measures except for oral pain. In general, the odds ratios for oral health deficits were slightly attenuated when adjusted for the covariates. In the adjusted regressions, both education and poverty were significantly associated with the oral health measures, whereas sex, age, and ethnicity were not associated with any oral health variables.

Food Modification

The percentage of older adults reporting any type of modification of foods ranged from 23.8% for beans to 67.8% for apples (Table 5). The most common single modification was peeling apples. Across all foods, the most common modification was usually slicing thin or chopping the food into

Table 3. Bivariate Comparisons of Oral Health Status, by Categories of Number of Foods Avoided[a]

Characteristic	Number of Foods Avoided, *N* (%)				*p*
	Total	0	1–2	3–14	
Self-rated oral health					
Excellent, very good, good	347 (55.0)	161 (66.0)	86 (52.3)	100 (44.9)	.0153
Fair, poor	284 (45.0)	83 (34.0)	78 (47.7)	123 (55.1)	
Periodontal disease					
Yes	310 (48.9)	81 (33.0)	102 (61.5)	127 (57.2)	.0002
No	324 (51.1)	165 (67.0)	64 (38.5)	95 (42.8)	
Bleeding gums					
Yes	135 (21.4)	20 (8.3)	36 (21.6)	79 (36.1)	<.0001
No	495 (78.6)	225 (91.7)	130 (78.4)	140 (63.9)	
Oral pain					
Yes	70 (11.0)	17 (6.8)	19 (11.3)	34 (15.2)	.1143
No	565 (89.0)	229 (93.2)	147 (88.7)	189 (84.8)	
Dry mouth					
Yes	309 (48.7)	91 (36.9)	79 (47.6)	139 (62.3)	.0005
No	326 (51.3)	155 (63.1)	87 (52.4)	84 (37.7)	
Number of teeth					
0	328 (47.1)	42 (17.1)	116 (69.9)	170 (76.1)	<.0001
>0	369 (52.9)	204 (82.9)	112 (67.7)	53 (23.9)	
Removable prosthesis					
Yes	381 (60.0)	99 (40.1)	112 (67.7)	170 (76.1)	<.0001
No	254 (40.0)	147 (59.9)	54 (32.3)	53 (23.9)	
Dentures ill fitting					
Yes	135 (21.4)	22 (8.9)	34 (20.7)	79 (35.9)	<.0001
No	496 (78.6)	224 (91.1)	130 (79.3)	142 (64.1)	
Functional occlusal units, anterior[b]					
0	95 (27.7)	27 (17.6)	28 (26.5)	40 (49.3)	<.0001
1–3	56 (16.3)	13 (8.2)	24 (22.9)	19 (22.6)	
4–6	192 (56.0)	115 (74.2)	54 (50.6)	23 (28.1)	
Functional occlusal units, posterior[b]					
0	105 (30.4)	35 (22.5)	30 (27.6)	40 (49.3)	.0001
1–3	89 (25.8)	30 (19.1)	32 (30.1)	27 (32.9)	
4–10	151 (43.8)	91 (58.3)	45 (42.3)	15 (17.8)	

Notes: [a]*N* = weighted *n*.
[b]*N* = 362 (data obtained only from dentate participants who completed the oral examination).

small pieces. More than half of participants reported modifying apples and meats in this way. For all foods, including apples that are commonly eaten raw, cooking a long time to soften was reported. More than one third reported using this technique for meats due to the condition of their teeth, mouth, or dentures. Rates were lower, but still substantial, for carrots (31.6%), beans (22.4%), and greens (14.7%).

Examining the association of any modification of each food with oral health measures (Table 6) showed that different types of foods were related to different oral health deficits. Modifying apples was associated with all oral health deficits except oral pain and dry mouth. Modifying carrots had a similar pattern except that it was not associated with self-rated oral health. Modifying meat was related to all oral health deficits except periodontal disease and oral pain. Modifying beans and modifying greens were related to fewer oral health deficits. Notably, modifying beans and modifying greens were not related to being dentate, having prostheses, and functional contacts. However, both were related to oral pain and dry mouth.

Discussion

Several aspects of this study set it apart from existing studies. This study used a larger, population-based sample of older adults for which considerable preliminary work had established common foods consumed. The list of foods examined for both food avoidance and food modification was thus grounded in the local diet, including ethnic

Table 4. Regression Analyses, Unadjusted and Adjusted, for the Association Between Food Avoidance (Response) and Oral Health Status (Predictor)

	Unadjusted, OR (95% CI)	Adjusted,[a] OR (95% CI)
Self-rated oral health	0.5 (0.3, 0.8)**	0.5 (0.3, 0.9)*
Periodontal disease: avoid 1–2 foods versus 0[b]	3.3 (1.7, 6.4)**	3.4 (1.7, 6.5)**
Periodontal disease: avoid 3–14 foods versus 0	2.7 (1.5, 4.8)**	2.5 (1.4, 4.5)**
Bleeding gums	3.9 (2.3, 6.4)**	3.5 (2.1, 5.9)**
Oral pain	2.0 (1.0, 3.9)**	1.8 (0.8, 3.8)
Dry mouth	2.3 (1.4, 3.6)**	2.1 (1.4, 3.4)**
Edentulous	4.5 (2.9, 7.2)**	4.0 (2.5, 6.6)**
Removable prosthesis	3.6 (2.3, 5.6)**	3.2 (2.1, 5.0)**
Dentures ill fitting	3.8 (2.4, 5.8)**	3.3 (2.1, 5.2)**
Functional occlusal units, anterior		
0 versus 4–6	4.5 (2.3, 8.8)**	4.4 (2.3, 8.4)**
1–3 versus 4–6	4.1 (2.5, 6.7)**	3.2 (1.9, 5.6)**
Functional occlusal units, posterior		
0 versus 4–10	3.8 (2.0, 7.2)**	3.5 (1.7, 7.4)**
1–3 versus 4–10	3.1 (1.7, 5.8)**	2.8 (1.3, 5.9)**

Notes: CI = confidence interval; OR = odds ratio.

[a]Adjusted for age, education, ethnicity, sex, and poverty status.

[b]Periodontal disease analyzed separately for two categories of food avoidance because the proportional odds ratios assumption was not valid for this variable.

*$p < .05$; **$p < .01$.

and regional foods and those locally produced. The inclusion of food modification as well as avoidance presents an expanded range of food behaviors over most studies, which focus only on avoidance and use a list of foods or food types assumed to be difficult to chew (e.g., Hildebrandt et al., 1997), though not necessarily common to the population. Direct questioning about food avoidance or modification also sets this study apart, as many studies have relied on 24-hr dietary recalls (e.g., Nowjack-Raymer & Sheiham, 2007) or semiquantitative food frequency questionnaires (e.g., Hung et al., 2003) and assumed that associations between absent foods and oral health deficits were indicators of avoidance.

These analyses show that substantial proportions of older adults avoid a large number of foods due to problems with their teeth, mouth, or dentures. They also show that persons who avoid one food are likely to avoid others. Previous research on food avoidance due to oral health has used a limited list of foods (e.g., Anastassiadou & Heath, 2002). In contrast, the present study used such obvious foods as raw carrots and nuts while also including potentially easier-to-eat varieties of the same food type (e.g., tomatoes and greens). These results demonstrate that even foods that are relatively soft are avoided by significant numbers of people.

Food modification has rarely been documented as an accommodation to oral health deficits. This study shows that it is a common practice in this elderly population, suggesting that it also may be practiced in other populations. The food avoidance and food modification behaviors documented here are two dimensions of behaviors related to food consumption in the model by Quandt and colleagues (1998) nutritional self-management where food consumption is one of three primary tasks (the others being food acquisition and maintaining food security) that older adults must satisfactorily perform to achieve or maintain adequate nutritional status. It is likely that most of these behaviors are self-care or use informal support, as this sample included only community-dwelling individuals, most living alone or with a spouse. By establishing food modification as a common behavioral adaptation to oral health deficits, this article adds considerable new detail to the nutritional self-management model, demonstrating that older adults are active managers of their food consumption.

This study should not be interpreted as an endorsement of food avoidance or food modification as positive self-management behaviors for accommodating oral health problems. Chewing and biting foods of a variety of textures help to maintain bone density and muscle strength. Variety in the diet reduces the chance of nutrient deficiency. Other studies suggest that these accommodations should be avoided because once individuals start

Table 5. Number and Percentage of Older Adults Reporting Food Modification Practices due to the Condition of Teeth, Mouth, or Dentures

Food modification practice	*N*(%)
Apples	
Any modification	397 (67.8)
Peel	325 (51.2)
Slice thin	299 (47.1)
Chop into small pieces	158 (24.9)
Cook	69 (10.9)
Scrape	33 (5.2)
Steak, pork chops, or roast	
Any modification	349 (56.6)
Chop into small pieces	268 (42.3)
Cook a long time or stew	218 (34.4)
Slice thin	155 (24.5)
Tenderize	66 (10.3)
Beans like butterbeans, lima beans, black-eyed peas, or field peas	
Any modification	148 (23.8)
Cook an extra long time	142 (22.4)
Mash	30 (4.7)
Add ingredients	1 (0.2)
Carrots	
Any modification	253 (45.4)
Cook an extra long time	200 (31.6)
Chop into small pieces	128 (20.2)
Shred	71 (11.3)
Baby carrots	17 (2.7)
Leafy greens, like collards or cabbage	
Any modification	241 (39.2)
Chop into small pieces	237 (37.4)
Cook an extra long time	93 (14.7)
Cream	5 (0.7)

to avoid foods, they do not automatically resume eating them when the dental problem is alleviated. Studies of food consumption before and after dental care indicate that providing dental care that restores function through implants, dentures, or other means does not always result in improved dietary intake (Ellis et al., 2008). Thus, efforts need to be made at younger ages to prevent dental problems. In addition, restoration of dental function likely needs to be accompanied by dietary interventions tailored to improve knowledge and change attitudes toward food consumption (Bradbury et al., 2008).

The oral health problems associated with food avoidance and modification are not easily eliminated in this population. This study focused on a rural area with a large minority and economically disadvantaged population. Rural areas face a shortage of dentists and, therefore, limited access to dental care for rural residents (Allison & Manski, 2007; Wall & Brown, 2007). Rural residents may be at greater risk of oral health deficits than persons in urban areas. Many rural areas lack public water systems and water fluoridation that can help prevent caries. High rates of self-employment and employment by small businesses limit the number of persons with dental insurance.

The results of this study should be interpreted in light of several limitations. First, the food avoidance and modification data were obtained through self-reports, which are subject to errors in recall. Although respondents were asked if they avoided or modified foods due to oral health problems, it is possible they included foods they avoided for other reasons. However, the whole interview focused on oral health, so this is not probable. Second, the sample consists of older adults in a rural region of the southern United States. Therefore, the results may not be applicable to other regions. Third, less than 20 foods were included, though they were chosen to represent different categories of food (e.g., fruits, vegetables, meats, snacks) and with reference to foods commonly eaten in this population. Fourth, the cross-sectional design and lack of qualitative data prevent making causal arguments. Nevertheless, the data come from a large, population-based sample of older adults that is diverse in sex, ethnicity, and social class composition. None of the existing studies have sizable African American or American Indian samples. The present study includes a more extensive list of foods than most existing studies; this list is grounded in extensive ethnography in the study population.

Implications of the Study

This study has implications for those who support older adults with compromised dentition, including both informal and formal helpers. Avoiding foods or modifying them may indicate oral pain, dry mouth, or other dental problems. In the short term, efforts to note which foods are being avoided or modified can be used to prepare foods in ways that can increase their consumption. However, in the long term, obtaining appropriate dental care for the older adult to prevent further declines in food intake is necessary.

Service providers, such as those providing congregate or home-delivered meals, should note food avoidance practices of older adults and work to obtain needed dental care for their clients. They should also tailor menus and food preparation techniques to clients' needs. Although this study

Table 6. ORs and 95% Confidence Intervals From Regression Analysis, Unadjusted and Adjusted, for Associations Between any Modification of Selected Foods (Response) and Oral Health Status (Predictor)[a,b]

	Apple		Steak		Beans		Carrots		Greens	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Self-rated oral health	1.8 (1.1, 2.8)*	1.8 (1.0, 3.0)*	1.9 (1.2, 3.0)*	1.6 (1.0, 2.6)*	2.4 (1.4, 4.1)*	2.1 (1.4, 3.4)*	1.6 (1.0, 2.7)	1.6 (0.9, 2.8)	1.7 (1.1, 2.6)*	1.5 (1.0, 2.1)
Periodontal disease	2.6 (1.5, 4.5)**	2.6 (1.5, 4.5)**	1.9 (1.0, 3.4)*	1.6 (0.9, 3.1)	2.1 (1.4, 3.4)*	1.7 (1.1, 2.6)*	2.7 (1.6, 4.7)**	2.4 (1.4, 3.9)*	1.9 (1.2, 3.0)*	1.6 (0.9, 2.7)
Bleeding gums	6.8 (3.5, 13.2)**	6.4 (3.1, 13.4)**	4.4 (2.4, 8.1)**	3.4 (1.8, 6.6)**	2.4 (1.5, 4.1)**	1.8 (1.1, 3.2)*	3.6 (2.1, 6.2)**	3.3 (1.8, 5.9)**	1.7 (1.0, 2.9)	1.3 (0.7, 2.2)
Oral pain	1.5 (0.7, 3.3)	1.2 (0.5, 3.2)	1.4 (0.7, 2.8)	1.1 (0.5, 2.5)	3.4 (1.7, 6.7)**	2.8 (1.3, 6.2)*	1.6 (0.9, 2.9)	1.4 (0.7, 3.0)	2.6 (1.4, 4.7)*	2.1 (1.0, 4.3)*
Dry mouth	2.1 (1.1, 4.0)*	1.9 (1.0, 3.7)	2.2 (1.1, 4.4)*	2.1 (1.1, 4.2)*	1.7 (1.1, 2.5)*	1.5 (1.0, 2.3)	1.6 (1.0, 2.6)	1.5 (0.9, 2.4)	1.6 (1.1, 2.5)*	1.6 (1.0, 2.4)*
Edentulous	8.7 (4.7, 16.1)**	8.4 (4.1, 16.8)**	3.4 (2.1, 5.5)**	3.4 (1.9, 5.9)**	1.2 (0.8, 1.9)	0.9 (0.6, 1.4)	4.7 (2.8, 7.8)**	4.2 (2.2, 8.0)**	1.0 (0.6, 1.5)	0.9 (0.6, 1.4)
Removable prosthesis	3.7 (2.4, 5.7)**	3.6 (2.2, 5.7)**	2.0 (1.2, 3.3)*	1.9 (1.2, 3.1)*	1.2 (0.8, 2.0)	1.0 (0.7, 1.6)	2.6 (1.5, 4.5)*	2.3 (1.2, 4.2)*	0.9 (0.6, 1.5)	0.8 (0.5, 1.4)
Dentures ill fitting	4.6 (2.8, 7.8)**	4.1 (2.5, 6.7)**	3.0 (1.8, 4.9)**	2.7 (1.6, 4.3)**	2.6 (1.4, 4.6)*	2.1 (1.2, 3.7)*	2.5 (1.3, 4.6)*	2.2 (1.1, 4.3)*	2.2 (1.5, 3.4)**	2.1 (1.4, 3.2)**
Functional occlusal units, anterior										
0 versus 4–6	3.5 (1.7, 7.1)**	4.5 (2.1, 9.5)**	2.8 (1.3, 5.9)*	2.9 (1.4, 6.1)*	1.7 (0.8, 3.6)*	1.7 (0.8, 3.5)*	2.2 (1.0, 5.1)*	2.3 (1.1, 4.9)*	1.2 (0.6, 2.7)	1.2 (0.6, 2.5)
1–3 versus 4–6	5.8 (2.4, 14.0)**	6.8 (2.6, 17.5)**	2.3 (1.1, 4.5)*	2.0 (0.9, 4.2)*	3.4 (1.5, 7.4)*	3.0 (1.3, 7.0)*	3.1 (1.1, 8.8)*	2.6 (0.9, 8.0)*	1.5 (0.7, 3.2)	1.4 (0.6, 3.1)
Functional occlusal units, posterior										
0 versus 4–10	5.3 (2.4, 11.5)**	7.1 (3.2, 15.8)**	2.5 (1.3, 4.6)*	2.6 (1.3, 5.0)*	1.9 (1.0, 3.6)	1.9 (0.9, 3.7)	3.7 (1.7, 7.8)*	4.2 (2.1, 8.7)**	1.4 (0.8, 2.5)	1.3 (0.7, 2.5)
1–3 versus 4–10	5.1 (3.0, 9.0)**	6.3 (3.4, 11.4)**	2.5 (1.3, 4.7)*	2.2 (1.0, 4.6)*	1.5 (0.7, 3.3)	1.3 (0.7, 2.8)	4.3 (1.8, 10.1)*	4.9 (2.3, 10.3)**	1.4 (0.8, 2.5)	1.2 (0.6, 2.3)

Notes: OR = odds ratio.

[a]Adjusted for age, education, ethnicity, sex, and poverty status.

[b]Overall significant level is indicated, though some individual OR may include 1.0.

*$p < .05$; ** $p < .001$.

focused primarily on the consistency of food and chewing, other qualities of food (e.g., temperature, dryness) may affect the consumption of food and should be taken into account when planning menus for older adults with oral health deficits.

Assessing food avoidance and modification should be made part of assessments for planning care for older adults. A chronic disease approach should be used that supports managing oral health problems as well as supporting older adults' ability to consume a normal food diet. Interventions such as providing dietary education or helping older adults obtain appropriate implements (e.g., large-handled knives and peelers) should be developed.

Substantial policy changes are necessary for older adults such as those interviewed here to receive adequate dental care. Relatively few older adults have private dental insurance. Among National Health and Nutrition Examination Survey III respondents, 64% of those aged 60–69 years lacked dental insurance compared to 74% of those aged 70–79 years and 83% of those aged 80 years and older (Stancil, Li, Hyman, Reid, & Reichman, 2005). Many older adults seek dental care only for emergency situations and then, due to cost or to disparities in care, resort to extracting teeth rather than restoring them. African Americans and persons of low socioeconomic status are more likely than Whites and persons of higher socioeconomic status to have extractions rather than restorations once they enter the dental care system (Gilbert, Duncan, & Shelton, 2003). In addition, African American and low-income persons are more likely to receive dental care from practices characterized by doing more extractions and fewer replacements of extracted teeth (Gilbert, Litaker, & Makhija, 2007). Dental services (except oral surgery) are not included in health care programs such as Medicare. Efforts to change policy to provide such services are needed.

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