Dietary screening tool identifies nutritional risk in older adults[1–3]

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ABSTRACT

Background: No rapid methods exist for screening overall dietary intakes in older adults.

Objective: The purpose of this study was to develop and evaluate a scoring system for a diet screening tool to identify nutritional risk in community-dwelling older adults.

Design: This cross-sectional study in older adults (n = 204) who reside in rural areas examined nutrition status by using an in-person interview, biochemical measures, and four 24-h recalls that included the use of dietary supplements.

Results: The dietary screening tool was able to characterize 3 levels of nutritional risk: at risk, possible risk, and not at risk. Individuals classified as at nutritional risk had significantly lower indicators of diet quality (Healthy Eating Index and Mean Adequacy Ratio) and intakes of protein, most micronutrients, dietary fiber, fruit, and vegetables. The at-risk group had higher intakes of fats and oils and refined grains. The at-risk group also had the lowest serum vitamin B-12, folate, β-cryptoxanthin, lutein, and zeaxanthin concentrations. The not-at-nutritional-risk group had significantly higher lycopene and β-carotene and lower homocysteine and methylmalonic acid concentrations.

Conclusion: The dietary screening tool is a simple and practical tool that can help to detect nutritional risk in older adults. *Am J Clin Nutr* 2009;90:177–83.

INTRODUCTION

By 2030, the proportion of older adults in the United States aged >65 y is projected to reach 1 in 5 (1, 2), which will result in increased pressure on the health care system (3), the economy (4), and formal and informal caregivers (5). Many older adults are afflicted with age-related chronic disease, which significantly diminishes quality of life (6, 7); however, poor health is not necessarily an inevitable consequence of aging (8). High-quality diets are associated with reduced risk of major chronic disease and are associated inversely with mortality (9, 10). Thus, early detection of those with compromised dietary intakes may be an effective strategy to prevent nutritional risk and to lessen the burden of chronic disease within the older segment of the population. Proactive screening of older adults in the community is an effective public health strategy for targeting individuals who could make dietary improvements for primary or secondary prevention of disease (11) and thus reduce medical expenditures (8).

No rapid methods currently exist to screen the overall dietary intakes of older adults. We recently reported on a dietary screening tool (DST) that is capable of characterizing the overall dietary patterns of older adults (12). Two dietary patterns were derived via a principal components analysis of the DST: one pattern was represented by more healthful foods, including fruit, vegetables, and lean proteins, and the other pattern was represented by less optimal food choices, including sweets, processed meats, and salty snacks. Compared with the less healthful dietary pattern, the healthy pattern was associated with more favorable biomarkers of health status, more nutrient dense diets, and lower waist circumference. However, the dietary pattern analysis was not intended to be used in clinical settings to identify older adults at risk of poor dietary intakes. For clinical settings, a meaningful scoring algorithm was necessary. The purpose of this study was to develop and evaluate scores from the screening tool relative to dietary intakes and biochemical indicators of nutritional status.

SUBJECTS AND METHODS

Subjects

Specific details of subject recruitment have been published previously (12). Briefly, participants were part of an ongoing longitudinal study of older adults residing in rural Pennsylvania through the Geisinger Health Care System (n = 204). The age of the sample ranged from 73 to 94 y, with a mean (±SD) of 78.5 ± 4.0. Study participants were predominantly white (98%), married (65%), and had at least a high school education (82%). A greater proportion of our sample was female (60%). The study protocol was approved by the human investigation review boards at both the Pennsylvania State University and the Geisinger Health System.

Data collection

Participants were scheduled for an appointment at their local medical clinic for data collection. At this visit, participants

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completed the DST and a battery of self-administered questionnaires on demographic information, medical history, and functional status.

Biochemical biomarkers

A fasting venous blood draw (23 mL) was obtained during the clinic visit by a trained phlebotomist at each clinic and was placed on ice for transport to the central laboratory (Geisinger Medical Center, Danville, PA). The serum was separated by centrifugation ($3000 \times g$ for 12 min at 2°–8°C) and stored at −70°C. Serum vitamin B-12 was determined by electrochemiluminescence (Roche Elecsys 2010; Roche, Indianapolis, IN). The folate analysis was conducted by using a competitive, liquid-phase, ligand-labeled protein chemiluminescent assay (LKFO1; Siemens Medical Solutions Diagnostics, Malvern, PA). Homocysteine was measured by using a fluorescence polarization immunoassay by using the Abbott AXSYM system (Abbott Laboratories, Abbott Park, IL). Serum methymalonic acid concentrations were measured by gas chromatography and mass spectrometry by using the solid extraction method. Carotenoids were extracted and analyzed with a normal-phase HPLC system with a gradient reversed-phase system (Hewlett-Packard, Wilmington, DE).

Dietary assessment

Four 24-h dietary recalls were collected via telephone by trained interviewers at the Pennsylvania State University Diet Assessment Center during the 4- to 6-wk time period after the initial clinic visit (13). Dietary intake data were collected and analyzed by using the Nutrition Data System for Research software, version 2005, developed by the Nutrition Coordinating Center at the University of Minnesota, Minneapolis, Minnesota. Diet recalls were conducted on unannounced, random, nonconsecutive days with at least one weekend day of data by using a multipass methodology.

Dietary supplement data were collected at each 24-h dietary recall; detailed information about type, consumption frequency, and amount was collected for all individuals who reported use. Different forms of the vitamins were converted to the units of the dietary intake nutrient. For example, folic acid from dietary supplements typically is measured in micrograms, whereas the dietary form is measured in dietary folate equivalents (DFE). Thus, micrograms of folic acid from dietary supplement were converted to DFE.

Dietary and total nutrient intakes (ie, dietary intakes combined with dietary supplements) were calculated and adjusted for the effects of within- and between-person variability to ensure that the 24-h recall data were reflective of usual intakes by using a measurement error model developed by the National Academy of Sciences. Under this model, observed nutrient intakes on any recall day represent the summation of the usual nutrient intakes plus an error term. The between-individual variance component is used to estimate the variance in usual intakes, and the within-person variance component is used to estimate the measurement error (14).

Food groups were calculated by summing the corresponding subgroup servings created as part of the Nutrition Data System for Research analysis into the main food groups. The Nutrition Data System for Research Food Group Count System includes 166 groupings that have been assigned on the basis of recommendations made by the 2005 Dietary Guidelines for Americans (15). Serving sizes are based on Food and Drug Administration serving sizes. For this article, selected food groups are presented.

Two indexes of diet quality were calculated from the 24-h recall data. One index examined micronutrient intakes by using the Mean Adequacy Ratio (MAR) (16), and the other index, the US Department of Agriculture's 2005 Healthy Eating Index (HEI-2005) (17), examined adherence to the key recommendations in MyPyramid (18) and the 2005 Dietary Guidelines for Americans (15). The HEI-2005 is a measured score of 12 dietary components: total fruit, whole fruit, total vegetables (dark green and orange vegetables and legumes), total grains, whole grains, milk, meat and beans, oils, percentage of total calories from saturated fat, sodium, and calories from solid fat, alcohol, and added sugar. Total HEI-2005 scores range from 0 to 100, with a higher score indicating higher dietary quality.

To calculate the MAR, nutrient adequacy ratios (NARs) were calculated for 12 vitamins and minerals: vitamin C (mg), vitamin B-6 (mg), vitamin B-12 (μg), vitamin D (μg), vitamin A (RAE; retinol activity equivalents, in μg), vitamin E (mg), vitamin K (μg), folate (DFE), magnesium (mg), zinc (mg), potassium (mg), and calcium (mg) (16). An NAR for a nutrient represents the reported nutrient intakes (from dietary intake and supplements) divided by the Dietary Reference Intake, the Recommended Dietary Allowance when available, or the Adequate Intake when a Recommended Dietary Allowance is not established. To calculate the MAR, or overall profile of micronutrient intakes, all NARs were truncated at 1.0; the MAR was calculated by summing all NARs and dividing by the total number of NARs estimated. The most current Dietary Reference Intake recommendations were used to calculate each NAR.

Psychometric properties

Sensitivity, specificity, and positive predictive values were calculated for the DST. *Sensitivity* is the percentage of individuals who are correctly classified as positive by a screening tool. *Specificity* refers to the percentage of individuals who correctly test negative by a screening tool. *Positive predictive value* is defined as the proportion of individuals who are correctly diagnosed by a screening tool. To calculate these values, an operational definition for dietary nutritional risk was created by determining the percentage of the group with total nutrient intakes (diet and dietary supplements) below the Dietary Reference Intakes: the Estimated Average Requirement when available or an Adequate Intake when the Estimated Average Requirement was not available. The 12 nutrients selected for use in the MAR calculation were considered for dietary nutritional risk. Nutritional risk was operationally defined as having 4 of 12 micronutrient intakes below the Estimated Average Requirement or Adequate Intake.

DST scoring procedures

The original screening instrument included 37 items; 24 items were selected as follows for the instrument that would be scored. Principal components analysis identified 19 items that represented 2 dietary patterns, the details of which have been published (12). Five yes-or-no questions were added to the scored instrument; these questions were not included in the principal components

analysis because of the dichotomous nature of the response options. The additional 5 questions provided information on added fats and sugars. Thus, a total of 24 questions were included on the questionnaire. *See* the supporting data under "Supplemental data" in the online supplement to view a complete version of the DST with the scoring system. Note that the scoring algorithm was not provided for the version of the DST that participants completed.

A total point score of 100 was selected to increase clinical applicability and interpretability of scores. The 24 questions were first categorized into several major diet component categories (eg, fruit and vegetables) similar to the HEI-2005 (19). Points then were allotted to each major dietary component using the HEI-2005 as a guide (**Table 1**). The number of questions per major dietary category drove the selection of points for each question. For example, 2 vegetable questions emerged from the principal components analysis; 15 points were allotted to the component of vegetables. The vegetable question with a higher factor loading received more points (8) than the one with a lower factor loading (7). Questions associated with the healthier dietary pattern were awarded more points for higher reported consumption (eg, more points were awarded for higher reported consumption of fruits and vegetables), whereas questions associated with the less healthy pattern received higher points for lower reported intake (eg, higher points were awarded for low consumption of processed meats and added fats). All 5 yes-or-no questions were awarded one point. Five bonus points were awarded for use of a multivitamin and multimineral (MVMM) preparation.

Statistical analysis

Individuals were classified into 1 of 3 risk categories on the basis of DST scores. Score cutoffs were determined by using the percentiles from the frequency outputs of the total DST scores. Individuals in the lowest 25th percentile (DST scores <60) were categorized as "at risk," those in the 25–75th percentile (DST scores from 60 to 75) were labeled "possible risk," and those in the highest 25th percentile (scores >75) were "not at risk."

All data were analyzed by using the Statistical Analysis Software Package 9.1.3 (SAS Institute Inc, Cary, NC). Where appropriate, nonnormal data were log transformed before analysis. We tested for differences in the DST risk groups by using analysis of variance; post hoc tests were conducted by using a Tukey-Kramer adjustment for multiple comparisons only after establishing that the overall F statistic for the analysis of variance model was significant at $P < 0.05$. Group differences were controlled for the effects of sex and are presented as means with the 95% CIs. Contingency tables (ie, 2×2), necessary for the calculation of sensitivity, specificity, and positive predictive

TABLE 1
Scoring components, questions, and point classifications of the dietary screening tool (DST)[1]

DST component	Point classification
Whole fruit and juice	15
How often do you usually eat fruit as a snack?	(5)
How often do you eat fruit (not including juice)?	(5)
How often do you drink some kind of juice at breakfast?	(5)
Vegetables	15
How often do you eat carrots, sweet potatoes, broccoli, or spinach?	(8)
How many different vegetable servings do you usually have at your main meal of the day?	(7)
Total and whole grains	15
How often do you usually eat whole-grain breads?	(5)
How often do you usually eat whole-grain cereals?	(5)
How often do you eat hot or cold breakfast cereal?	(5)
Lean proteins	10
How often do you eat chicken or turkey?	(5)
How often do you eat fish or seafood that is *not* fried?	(5)
Added fats, sugars, and sweets	25
How often do you usually eat candy or chocolate?	(4)
How often do you eat crackers, pretzels, chips, or popcorn?	(4)
How often do you eat cakes or pies?	(4)
How often do you eat cookies?	(4)
How often do you eat ice cream?	(4)
Do you usually add butter or margarine to foods such as bread, rolls, or biscuits?	(1)
Do you usually add fat (butter, margarine or oil) to potatoes and other vegetables?	(1)
Do you use gravy (when available) at meals?	(1)
Do you usually add sugar or honey to sweeten your coffee or tea?	(1)
Do you usually drink wine, beer, or other alcoholic beverages?	(1)
Dairy	10
How often do you drink a glass of milk?	(5)
How many servings of milk, cheese, or yogurt do you usually have each day?	(5)
Processed meats	10
How often do you eat cold cuts, hot dogs, lunchmeats, or deli meats?	(5)
How often do you eat bacon or sausage?	(5)
Total	100
Dietary supplement use	+5

[1] The scores in parentheses represent the specific points assigned to each question within the major diet component categories. For complete scoring guidelines, *see* supporting data under "Supplemental data" in the online issue.

values were derived via chi-square analysis. Thus, individuals in the possible-risk group were excluded from this portion of the analysis.

RESULTS

By using the DST scoring cutoffs previously described, several significant associations with dietary intakes were observed. Although no differences were noted for total energy or carbohydrate intakes, the at-risk group had significantly lower protein and higher total and saturated fat (as well as percentage of energy from total and saturated fat) than the possible-risk and the not-at-risk groups (**Table 2**). *trans* Fat and the percentage of energy from *trans* fat significantly differed for all 3 groups, with the at-risk group having higher concentrations than the other 2 groups. Both indicators of diet quality (ie, HEI-2005 and the MAR) and dietary fiber intakes were significantly different between all 3 groups: HEI, MAR, and fiber were lowest in the at-risk group. All significant findings were at $P < 0.05$.

Nutrient intakes from foods alone and from foods and dietary supplements combined (ie, total nutrient intakes) were examined by risk group (Table 2). Dietary intakes of vitamin A, vitamin E, and vitamin B-12 were significantly lower in the at-risk group compared with the not-at-risk group; dietary intakes of vitamin B-6, folate, and zinc were lower in the at-risk group compared with both the possible-risk and the not-at-risk groups. Dietary intakes of vitamin K, vitamin C, calcium, magnesium, and potassium were significantly different among all 3 risk groups with

TABLE 2
Mean dietary intakes estimated from four 24-h dietary recalls by using dietary screening tool (DST) risk classifications for older adults residing in rural Pennsylvania[1]

	At-risk group, DST score <60 (n = 58)	Possible-risk group, DST score 60–75 (n = 93)	Not-at-risk group, DST score >75 (n = 53)
Energy (kcal)	1498 (1398, 1597)	1457 (1378, 1555)	1494 (1398, 1600)
Carbohydrate (g)	183 (168, 197)	194 (183, 205)	201 (186, 216)
Protein (g)	55 (51, 59)[a]	59 (56, 63)[b]	65 (60, 69)[b]
Total fat (g)	60 (55, 65)[a]	52 (48, 56)[b]	51 (46, 56)[b]
Energy from total fat (%)	35 (34, 37)[a]	32 (31, 33)[b]	31 (29, 32)[b]
Saturated fat (g)	21 (19, 23)[a]	18 (16, 19)[b]	17 (14, 19) [b]
Energy from saturated fat (%)	12.0 (11.3, 12.7)[a]	10.8 (10.3, 11.4)[b]	9.9 (9.2, 10.7)[b]
trans Fat (g)	4.2 (3.8, 4.7)[a]	3.3 (3.0, 3.6)[b]	2.8 (2.4, 3.3)[c]
Energy from *trans* fat (%)	2.5 (2.3, 2.7)[a]	2.1 (1.9, 2.2)[b]	1.7 (1.5, 1.9)[c]
Fiber (g)	11.4 (10.2, 12.7)[a]	15.3 (14.3, 16.3)[b]	18.5 (17.2, 19.9)[c]
Healthy Eating Index	52 (50, 55)[a]	63 (61, 66)[b]	70 (67, 72)[c]
Dietary intakes			
Vitamin A (RAE)	552 (457, 647)[a]	652 (577, 727)[a,b]	756 (655, 857)[b]
Vitamin D (μg)	3.4 (2.8, 3.9)[a]	3.8 (3.4, 4.2)[a]	4.9 (4.3, 5.4)[b]
Vitamin E (mg)	6.9 (5.0, 8.8)[a]	9.2 (7.7, 10.7)[a,b]	10.0 (8.0, 12.0)[b]
Vitamin K (μg)	52 (35, 69)[a]	78 (65, 91)[b]	109 (91, 126)[c]
Vitamin C (mg)	60 (48, 73)[a]	85 (76, 95)[b]	105 (93, 118)[c]
Vitamin B-6 (mg)	1.3 (1.2, 1.5)[a]	1.7 (1.6, 1.9)[b]	1.8 (1.7, 2.0)[b]
Vitamin B-12 (μg)	4.2 (3.2, 5.1)[a]	4.8 (4.0, 5.5)[a,b]	5.1 (4.1, 6.1)[b]
Folate (DFE)	418 (358, 478)[a]	501 (454, 548)[b]	505 (442, 569)[b]
Calcium (mg)	626 (551, 701)[a]	689 (629, 748)[b]	791 (712, 871)[c]
Magnesium (mg)	193 (175, 210)[a]	236 (223, 250)[b]	271 (253, 290)[c]
Potassium (mg)	1881 (1718, 2043)[a]	2344 (2216, 2472)[b]	2610 (2438, 2783)[c]
Zinc (mg)	8.1 (6.9, 9.3)[a]	10.1 (9.2, 11.1)[b]	10.3 (9.0, 11.5)[b]
Mean Adequacy Ratio	0.60 (0.56, 0.63)[a]	0.68 (0.65, 0.70)[b]	0.74 (0.71, 0.80)[c]
Total nutrient intakes (diet and dietary supplements)			
Vitamin A (RAE)	2846 (1936, 3756)[a]	3032 (2318, 3747)[b]	3841 (2875, 4808)[b]
Vitamin D (μg)	5.7 (2.8, 8.5)[a]	8.6 (6.3, 10.8)[b]	11.6 (8.7, 14.7)[b]
Vitamin E (mg)	76 (25, 127)[a]	139 (99, 178)[b]	130 (76, 184)[b]
Vitamin K (μg)	55 (38, 72)[a]	85 (72, 98)[b]	188 (100, 136)[c]
Vitamin C (mg)	165 (67, 264)[a]	337 (259, 415)[b]	377 (272, 482)[b]
Vitamin B-6 (mg)	4.6 (−0.5, 9.6)[a]	9.1 (5.2, 13.1)[b]	10.2 (4.8, 15.5)[b]
Vitamin B-12 (μg)	20 (13, 82)[a]	80 (32, 129)[b]	65 (14, 130)[b]
Folate (DFE)	569 (486, 653)[a]	770 (704, 835)[b]	835 (746, 924)[b]
Calcium (mg)	916 (767, 1064)[a]	1133 (1017, 1249)[b]	1392 (1235, 1548)[b]
Magnesium (mg)	236 (200, 272)[a]	302 (274, 331)[b]	360 (322, 399)[c]
Potassium (mg)	1900 (1734, 2064)[a]	2384 (2254, 2514)[b]	2660 (2483, 2836)[c]
Zinc (mg)	19 (16, 23)[a]	20 (17, 23)[b]	22 (18, 26)[b]
Mean Adequacy Ratio	0.71 (0.69, 0.75)[a]	0.84 (0.81, 0.86)[b]	0.91 (0.86, 0.93)[c]

[1] All values are means; confidence limits in parentheses. DFE, dietary folate equivalents; RAE, retinol activity equivalents. ANOVA models are adjusted for sex. Values in the same row with different superscript letters are significantly different, $P \leq 0.05$ (ANOVA using a general linear model with Tukey-Kramer adjustment for multiple comparisons).

the at-risk group at the lowest intakes of these nutrients; the at-risk subjects also have the lowest MAR. When nutrient intakes including dietary supplements (ie, total nutrient intakes) were examined, vitamin K, magnesium, and potassium were significantly different in each group. For all other micronutrients examined—vitamin A, vitamin D, vitamin E, vitamin C, vitamin B-6, vitamin B-12, folate, calcium, and zinc—total nutrient intakes were significantly lower in the at-risk group compared with both of the other groups. The MAR was also calculated with the use of dietary supplements and was significantly different for each risk group.

Intakes from food groups were also compared by the DST groupings; all 3 groups had significantly different mean servings per day of fruit and vegetables (**Table 3**). The at-risk group had a higher number of servings of fats and oils and refined grains, with lower intakes of whole grains than the other 2 risk groups. The not-at-risk group had higher intakes of low-fat dairy products than the other 2 risk groups and lower intakes of sweets (eg, candy, cakes, pies) than the at-risk group.

The DST classifications also were related to biochemical indicators of nutritional status. The at-risk group had significantly lower serum vitamin B-12 and folate than the other 2 groups (**Table 4**). The not-at-risk group had significantly lower methylmalonic acid and homocysteine concentrations when compared with both of the other risk groups. Several differences emerged in the carotenoids: the not-at-risk group had higher lycopene and β-carotene concentrations than the other 2 risk groups, whereas the at-risk group had lower β-cryptoxanthin concentrations than both of the other groups. Lutein and zeaxanthin concentrations were significantly different in all 3 groups, with the at-risk group having the lowest concentrations.

Nutritional risk from the DST was compared with an operationally defined nutritional risk variable composed of inadequate dietary intakes from multiple 24-h recalls as described in Subjects and Methods. A contingency table was calculated with those classified at risk and not at risk by the DST and the 24-h recalls. This comparison yielded 83% sensitivity, 75% specificity, and a 79% accuracy level and a positive predictive value of 75%.

DISCUSSION

In this study, we report on a screening tool developed to classify individuals at varying degrees of nutritional risk. Scores from the DST were related to nutrient intakes estimated from multiple 24-h recalls and to biological biomarkers of nutrition status. Our results confirm that a population-specific approach to dietary screening has the potential to identify individuals who may be at nutritional risk in a clinic setting and advances the body of literature supporting the efficacy of population-specific dietary screening tools (20–22).

Primary care clinics provide an excellent setting for chronic-disease prevention and nutrition education interventions (23). Previous research shows that physicians can affect dietary change (24, 25); however, several barriers to physician involvement in promoting healthy behaviors have been reported, including lack of time, perceived lack of counseling ability, inadequate tools to provide an education framework, and reimbursement concerns (26–28). Lack of reliable information on patients' diets is another reported barrier to clinicians providing dietary counseling (29).

The DST is completed in <10 min and uses simple food- and behavior-specific questions. In both this study and in a test-retest reliability study, participants reported no difficulty with answering the DST questions. The DST can be scored in <5 min by a clinician. Categorization of individuals into 3 nutritional risk categories provides a format by which clinicians can determine who may require follow-up or assessment. Once individuals are screened, a clinician can determine the appropriate course of action for treatment. The component scoring system of the DST guides a clinician in identifying specific areas of the diet that may be problematic and allows for tailored, personalized nutrition education messages.

The DST has adequate sensitivity (83%), specificity (75%), and positive predictive values (75%) when compared with nutritional risk based on the Dietary Reference Intakes. Block et al (30) found similar ranges of these indexes with a fruit and vegetable screener (sensitivity, specificity, and positive predictive value of 52%, 86%, and 66%, respectively) and 2 fat screeners, one screening for percentage energy from fat (sensitivity, specificity, and positive predictive values of 52%, 93%, and 57%, respectively) and another screening for saturated fat intakes (sensitivity, specificity, and positive predictive value of 60%, 87%, and 63%, respectively). However, Block et al (30) compared the screening tools to a food-frequency questionnaire, whereas we compared our screening tool to multiple 24-h recalls. In a separate study, community-dwelling older adults completed the DST on 2 occasions with at least a 2-wk time period between

TABLE 3
Mean number of servings per day of food groups estimated from four 24-h dietary recalls by using dietary screening tool (DST) risk classifications for older adults residing in rural Pennsylvania[1]

	At-risk group, DST score <60 (n = 58)	Possible-risk group, DST score 60–75 (n = 93)	Not-at-risk group, DST score >75 (n = 53)
Fruits and vegetables	3.1 (2.6, 3.6)[a]	4.6 (4.2, 5.0)[b]	5.5 (4.9, 6.0)[c]
Fats and oils	3.8 (3.4, 4.2)[a]	3.2 (2.8, 3.6)[b]	3.0 (2.5, 3.5)[b]
Sweets	1.4 (1.2, 1.9)[a]	1.1 (0.9, 1.4)[a,b]	0.8 (0.5, 1.2)[b]
Low-fat dairy	0.34 (0.2, 0.5)[a]	0.49 (0.4, 0.6)[a]	0.82 (0.7, 0.9)[b]
Whole- and reduced-fat dairy	0.58 (0.4, 0.7)	0.54 (0.4, 0.7)	0.38 (0.2, 0.5)
Whole grains	1.2 (0.8, 1.5)[a]	2.2 (1.9, 2.6)[b]	2.2 (1.9, 2.6)[b]
Refined grains	4.3 (3.7, 4.6)[a]	3.4 (3.0, 3.7)[b]	2.9 (2.6, 2.5)[b]

[1] All values are means; confidence limits in parentheses. ANOVA models are adjusted for sex. Values in the same row with different superscript letters are significantly different, $P \leq 0.05$ (ANOVA using a general linear model with Tukey-Kramer adjustment for multiple comparisons).

TABLE 4
Biochemical markers of nutritional status by dietary screening tool (DST) risk classifications for older adults residing in rural Pennsylvania[1]

	At-risk group, DST score <60 (n = 58)	Possible-risk group, DST score 60–75 (n = 93)	Not-at-risk group, DST score >75 (n = 53)
Vitamin B-12 (pmol/L)	450 (373–527)[a]	571 (511–631)[b]	724 (641–806)[b]
Folate (μmol/L)	24 (21–26)[a]	28 (26–30)[b]	29 (26–32)[b]
Methylmalonic acid (μmol/L)	304 (261–346)[a]	249 (217–281)[a]	222 (178–266)[b]
Homocysteine (μmol/L)	11.4 (10.4–12.4)[a]	10.1 (9.3–10.9)[a]	8.7 (7.7–9.8)[b]
Lycopene (μmol/L)	0.51 (0.43–0.58)[a]	0.59 (0.53–0.65)[a]	0.62 (0.53–0.70)[b]
β-Cryptoxanthin (μmol/L)	0.08 (0.06–0.10)[a]	0.12 (0.10–0.14)[b]	0.14 (0.12–0.17)[b]
β-Carotene (μmol/L)	0.39 (0.26–0.53)[a]	0.41 (0.30–0.51)[a]	0.63 (0.48–0.79)[b]
Lutein and zeaxanthin (μmol/L)	0.19 (0.14–0.24)[a]	0.23 (0.19–0.27)[b]	0.31 (0.25–0.36)[c]

[1] All values are means; confidence limits in parentheses. ANOVA models are adjusted for sex. Values in the same row with different superscript letters are significantly different, $P \leq 0.05$ (ANOVA using a general linear model with Tukey-Kramer adjustment for multiple comparisons).

admissions. The sample consisted of 18 individuals (15 females, 3 males) with a mean (±SD) age of 77 ± 8 y (range: 68–94 y). The test-retest coefficient was 0.83 ($P < 0.001$), which is well above the acceptable level of 0.70 (31). The reliability, sensitivity, specificity, and positive predictive values add confidence to the use of the DST for nutrition screening in older adults.

There are limitations with the current investigation. This study was composed almost exclusively of white, older adults, which limits the generalizability of our results to more diverse populations. Nonetheless, many of the foods represented on the DST are similar to national dietary guidelines (eg, fruit, vegetables, whole grains), and the process of developing a population-specific tool is broadly applicable. Future research that tests the DST in more racially and ethnically diverse populations, as well as in nonclinical settings, is warranted. The scoring system was developed in the sample in which the data were collected; therefore, the scoring system should be tested in other samples. The DST has the potential to be included in the routine care of older adults within the Geisinger Health Care System and will be incorporated into the larger screening protocol in >20,000 older adults to assess screening with long-term health and nutrition outcomes.

Older adults represent a unique population for whom nutrient requirements may be difficult to achieve. For a variety of reasons, such as compromised absorption and decreased energy intakes, MVMM preparations may add key nutrients to the diet and reduce the proportion of older adults who are not meeting micronutrient intake recommendations (32). Accordingly, the Food Guide Pyramid for Older Adults currently recommends the use of dietary supplements for adults aged >70 y (33). For these reasons, we chose to award 5 additional points for MVMM supplementation.

Note that MVMM users tend to have higher dietary intakes of micronutrients and healthier diets in general compared with those who do not use MVMM supplements (34, 35). Multiple studies indicate that MVMM supplement users also tend to have healthier lifestyles (36, 37), be more physically active (38), have a lower prevalence of obesity (39), and have better serologic indicators of nutritional status (40). Thus, it is difficult to disentangle the use of MVMM supplements from many other healthy lifestyle and dietary practices (36).

Older adults residing in rural areas face additional barriers that may preclude optimal health care. Various environmental, social, and physical factors place rural older adults at nutritional risk (41). An inability to travel long distances prevents these older adults from obtaining goods and services and also contributes to social isolation. Thus, older adults who reside in rural areas could benefit greatly from preventative measures to ensure adequate health.

Many of the diseases common to aging, including obesity, diabetes, cancer, and heart disease, are influenced by diet. However, dietary assessment in the clinical treatment of older adults is not a routine practice. Older adults are vulnerable to nutritional risk; therefore, effective and evidence-based screening strategies are essential to help combat age-related chronic disease and reverse declines in the quality of life associated with nutritional risk. The clinical setting provides an ideal environment for dietary screening of older adults (42). This study shows that the DST is a practical and effective tool for dietary screening of older adults in a clinical setting.

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