Risk and Presence of Food Insufficiency Are Associated with Low Nutrient Intakes and Multimorbidity among Homebound Older Women Who Receive Home-Delivered Meals

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ABSTRACT This study examined the independent association of food sufficiency status with lowest nutrient intakes and multimorbidity among homebound older women who received home-delivered meals. Baseline data from the Nutrition and Function Study were used to identify three categories of food sufficiency status (food sufficient (FS), risk of food insufficiency (RFI) and food insufficient (FI)), calculate summary measures of musculoskeletal (calcium, vitamin D, magnesium and phosphorus) and overall nutrient intakes, and examine, using multivariable logistic regression models, the association of food sufficiency status with nutrition and health outcomes among 279 women who received regular home-delivered meals service (5 weekday meals/wk) and completed an in-home assessment and three 24-h dietary recalls. Independent of income and other variables, the adjusted odds for reporting lowest intakes in individual and multiple nutrients (≥2 musculoskeletal and ≥5 overall) were significantly greater among women who reported RFI [odds ratio (OR) = 1.96 to 2.91] and FI (OR = 2.85 to 5.21). In addition, FI women were more likely to report a burden of multimorbidity (OR = 3.69). Considering the importance of home-delivered meals as a primary source of food assistance to homebound older women, the results of this study suggest the need to reevaluate the traditional model of home-delivered meals and to include measures of food sufficiency status as an integral component of program assessment and evaluation for the targeting and monitoring of new, innovative and cost-effective strategies to alleviate risk and the presence of food insufficiency. J. Nutr. 133: 3485–3491, 2003.

KEY WORDS: • food insufficiency • homebound elderly • nutrient intake • home-delivered meal

The maintenance of good nutritional health is essential to functioning, the prevention or delay of chronic disease and disease-related complications and quality of life for older adults (1). This is especially vital for the growing number of older women, many of whom are homebound as a result of disability, illness or geographical isolation, and face greater vulnerability to poor nutritional health, increased burden of disease and further functional decline as a result of minority status, being poor, having a limited education and living alone (2–4). Several studies have linked inadequate intakes of nutrients and poor nutritional health to various health consequences, such as an increased burden of preventable illnesses (5), diminished immune response (6), longer hospital stays and increased hospital readmission (7), impairment in physical and cognitive function (8), poor lower extremity physical performance (9) and increased severity of disability (10). Food is the primary source of nutrient intakes, and the availability, affordability, accessibility and consumption of nutritionally adequate food are influenced by many factors. These include limited financial resources, increased financial demands (e.g., long-term and acute health care costs, transportation costs, heating and cooling costs and increased food costs), functional impairments (e.g., inability to acquire, prepare and eat food that is available), social isolation, household environment (e.g., food preparation and storage facilities), oral problems, adverse effects of multiple medications (e.g., dry mouth, altered taste and smell and diminished appetite) and depression (3,11–15).

The Older Americans Act Nutrition Programs (OAANP)4 recognized that these problems existed for homebound elders, who were at heightened vulnerability of nutritional inadequacy, and responded with the establishment of the home-delivered meals service, which targets homebound elders in the community who have the greatest economic and social need (16). This target population represents the subgroups of older adults that estimates project will experience the most...
dramatic increases in number over the next several decades: women, minorities and elders who live alone and are poor (17). Although OAANP home-delivered meals provide an important source of food assistance through the traditional model of five nutritionally balanced meals per week (each meeting at least 33% of daily nutrient requirements), substantial proportions of homedwelling participants still report not having enough food to eat (2,18,19). This examination focuses on food insufficiency, in which an inadequate amount of food intake is due to lack of resources (11,20). This can decrease the nutrient density of the diet, influence food selection (e.g., types, quantities and variety of foods) and alter meal patterns (e.g., frequency of consumption) (11,20–22).

Although previous investigations have identified some of the factors that may influence food insufficiency in elders, there is a limited understanding as to the extent of the risk and presence of food insufficiency among homedwelling women despite receipt of OAANP home-delivered meals (4,12,14,19,23). To advance our knowledge of food insufficiency, the goals of the present study were 1) to determine food sufficiency status (food sufficient (FS), risk of food insufficiency (RFI) or food insufficient (FI)) among homedwelling women who received homedelivered meals; 2) to examine the independent association of indicators of food sufficiency status with nutrient intakes as a percentage of Dietary Reference Intakes in individual and multiple nutrients, using multiple dietary recalls; and 3) to examine the independent association of RFI and FI with the burden of multiple diseases.

MATERIALS AND METHODS

Study population. The Nutrition and Function Study (NAFS) was conducted as a 2-y collaborative project between the School of Public Health at the University of North Carolina at Chapel Hill and OAANP home-delivered meals service providers in four North Carolina counties. All four service providers utilized the traditional service delivery model of 5 weekday homedelivered meals per week. One objective of the NAFS was to examine the determinants of dietary intake and health outcomes among a probability sample of homedelivered meal recipients who were at least 60 y of age and homedwelling as a result of disability, illness or isolation (2,24). In this analysis, we utilized baseline data collected (October 2000 to May 2001) from the 279 women who completed all components of the baseline in-home interview and telephone-administered dietary recalls. Eligibility requirements included age ≥60 y, ability to answer questions by telephone and in person without use of a proxy respondent and a score >16 on the telephone version of the Mini-Mental State Examination (25). After recruitment of a representative sample of women (n = 281, 80% eligible) from the homedwelling recipients of homedelivered meals, 279 women (99%) completed baseline home interviews (in each participant’s home) and telephone-administered dietary recalls. Nutritional risk, physical function, overall health and poverty status did not significantly differ among eligible (eligible vs. not eligible) and participant (participants vs. eligible nonparticipants) sample groups (24). A detailed description of the recruitment, including sample comparisons and data collection procedures, is reported elsewhere (24,26). All participants gave informed consent, and the study was approved by the University of North Carolina at Chapel Hill School of Public Health Institutional Review Board.

Sociodemographic characteristics. Questionnaires administered during the in-home interview provided self-reports for age (median 79 y; range 61 to 98 y), race/ethnicity (49% black), marital status (13% married), living arrangement (58% lived alone), level of education (30% completed <9 y), current tobacco use (15% positive), monthly income (70% ≤$750), Food Stamp Program participation (28% positive) and breakfast consumption (17% sometimes or rarely consumed breakfast).

Depression, medication use, and instrumental activities of daily living (IADL). Depression was defined, using the 15-item Geriatric Depression Scale—Short Form, as the presence of at least six depressive symptoms (29% positive) (27). Actual prescription medication containers were visually inspected and listed. Because the distribution of total medications was highly skewed (range 0 to 31), a dichotomous medication variable was created: 1 = ≥6 medications (53% positive). Two IADL tasks were selected that reflected the inability to shop for groceries (89% positive) and prepare meals (96% positive) without the assistance of another person (28). One variable was constructed that indicated the inability to either shop for groceries or to prepare meals without personal assistance (94% positive).

BMI. General nutritional health status was assessed with the BMI [weight/height2 (kg/m2)] (29). A detailed protocol for the measurement of weight and knee height during the in-home assessment has been described elsewhere (3). Stature was computed from knee height using gender- and race-specific formulas that adjust for gender and ethnic differences in the ratio of knee height to height in older persons (30), and BMI was calculated from this result. A fourcategory BMI variable was constructed: 0 = <25 kg/m2, 1 = 25.0 to 29.9 kg/m2, 2 = ≥30 kg/m2 and 3 = unable to measure. The latter category included 22 nonambulatory women (3).

Burden of disease. The burden of disease was assessed by self-reporting of the presence of a specific disease diagnosis and its current effect on daily activities (3,31). From a list of nine disease conditions, participants were first asked whether a physician had ever told them that they had a specific health condition: heart disease or angina, congestive heart failure, high blood pressure, diabetes, lung disease (e.g., emphysema or bronchitis), arthritis, osteoporosis, stroke and kidney disease. If so, they were then asked to evaluate the current effect of that specific disease condition on their daily activities (no effect, a little effect or a large effect). Each disease condition was coded as a dummy variable (not present or present and no effect = 0; present and little or large effect = 1). A summary burden of disease score was constructed from a total of disease conditions with little or large effect (median 2; range 0 to 8). Tertiles were then collapsed into a dichotomous burden of multimorbidity variable: 0 = <3 disease conditions; 1 = ≥3 disease conditions.

Food sufficiency status. During the six months before the inhome assessment, food sufficiency status was operationalized from four self-reported food insecurity risk situations that were previously used in a national evaluation of elderly nutrition programs (2). Two situations related to the absence of food: 1) “In the past six months, were there days when there was no food in the house and no money for food?” and 2) “In the past six months, were there days when you skipped meals because there was no food in the house and no money for food?” The other two situations related to forced resource decisions: 1) “In the past six months, were there days when you had to choose between buying food and buying medication?” and 2) “In the past six months, were there days when you had to choose between buying food and paying bills?” Three mutually exclusive categories of food sufficiency status were defined: 1) food sufficiency (FS), responded no to all four risk situations; 2) risk of food insufficiency (RFI), responded yes to either of the forced resource decision situations and no to both absence of food situations; and 3) food insufficiency (FI), responded yes to either absence of food situation.

Dietary intake. Trained interviewers collected three 24-h dietary recalls from each participant on randomly selected, nonconsecutive days. The recalls represented food consumption on one weekend day and two weekday days. The first recall was at the home visit, and the second and third recalls were collected by telephone within 2 wk of the home visit (97% within 2 wk and 100% within 4 wk). The details of the dietary recall protocol, including administration and portion size estimation, have been described elsewhere (3). The Nutrition Data System for Research (NDS-R) version 4.03, Food and Nutrient Database 31 (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) provided nutrient calculations (32). Three-day mean nutrient intakes, using equal weighting for each of the three days of dietary recall, were calculated for each participant for energy, protein and 13 micronutrients: vitamin D, calcium, magnesium, phosphorus, vitamin K, pyridoxine, cobalamin, folate, ascorbic acid, vitamin E, vitamin A, iron, and zinc. Because this research focused on dietary intake, nutrient estimates were based exclusively on the consumption of foods (3), including meal supple-

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To compare individual nutrient intakes with recommended levels, relative nutrient intake as a percentage of newly released age- and gender-specific recommended dietary allowance (RDA) or adequate intake (AI) levels was calculated using individual mean values (33–35). Based on quartiles of relative nutrient intake in this sample, a separate dichotomous variable representing lowest intake was constructed for all 15 nutrients (1 = lowest quartile; 0 = other quartiles). Because an earlier report found that a summary measure of musculoskeletal nutrient intakes (vitamin D, calcium, magnesium and phosphorus) was associated with lower extremity physical performance in homebound elders (9), two summary scores were calculated by summing the lowest quartiles of relative nutrient intake: 1) summary musculoskeletal nutrient intakes (SMN) for vitamin D, calcium, magnesium and phosphorus and 2) overall summary nutrient intake (SNI) for all 15 nutrients. Iterative common factor analyses were conducted on both summary scores to determine whether a summary measure would explain the overall relative intake of these nutrients from the lowest to the highest number of nutrients with relative intake in the lowest quartile and a factor score of the shared variance among the four musculoskeletal nutrients (Cronbach’s $\alpha = 0.76$) and 85% of the shared variance among all 15 nutrients (Cronbach’s $\alpha = 0.88$). Based on the distributions of SMN (0 to 4) and SNI (0 to 15) scores, two dichotomous variables representing the worst scores were constructed: 1) musculoskeletal nutrient intake ($0 = \text{SMN} < 2; 1 = \text{SMN} \geq 2$) and 2) overall nutrient intake ($0 = \text{SNI} < 5$ nutrients; $1 = \text{SNI} \geq 5$ nutrients).

**Statistical analysis.** All statistical analyses were performed using STATA Release 7 statistical software (Stata, College Station, TX) (37). Sociodemographic and health-related characteristics and relative nutrient intakes were calculated for the entire sample. The difference by food sufficiency status in prevalence (categorical variables) of these variables was assessed for trend with contingency tables and linear tests by $\chi^2$ analysis. Because dietary recalls were collected from all 279 women for two weekdays (home-delivered meal service days) and one weekend day (no home-delivered meal service), the two weekdays were averaged and a Wilcoxon signed-rank test for equality of median relative intake (weekdays vs. weekend day) was conducted for each nutrient (37).

Multivariable (simultaneous entry) logistic regression models were constructed to examine the independent association of categories of food sufficiency status with the following dependent variables: 1) relative nutrient intakes for individual and multiple nutrients and 2) health-related outcome of burden of multimorbidity. Each regression model adjusted for race, income, education, age, living arrangement, marital status, tobacco use, Food Stamp Program participation, IADL, and BMI.

**RESULTS**

**Food sufficiency status.** Almost 10% of the 279 homebound women reported FI status during the past 6 mo (responded yes to either absence of food situation); 5.7% reported no food in the house and no money for food; 86% of the food; 88% reported that they skipped meals during the same time period because there was no food and no money for food; and 44.4% reported both situations. Almost 32% of the women reported RFI status during the past 6 mo (responded yes to either forced resource decision situation and no to both absence of food situations): 19% reported that they had to choose between paying food and medication; almost 28% reported that they had to choose between buying food and paying bills; and 46% reported both forced resource decision situations.

**Sociodemographic and health-related characteristics.** The proportion of women who were younger (60 to 74 y), black, current tobacco users, and Food Stamp Program participants increased with decreasing food sufficiency status (Table 1). Several characteristics did not differ significantly by food sufficiency status: living arrangement, education, income, smoking, income, and burden of multimorbidity.

**Table 1. Prevalence of sociodemographic and health-related characteristics of 279 homebound women by food sufficiency status.**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>FS² (n = 163)</th>
<th>RFI (n = 89)</th>
<th>FI (n = 27)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sociodemographic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60–74</td>
<td>22.7</td>
<td>36.0</td>
<td>66.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>75–84</td>
<td>45.4</td>
<td>38.2</td>
<td>22.2</td>
<td></td>
</tr>
<tr>
<td>≥85</td>
<td>31.9</td>
<td>25.8</td>
<td>11.1</td>
<td></td>
</tr>
<tr>
<td>Black race</td>
<td>41.1</td>
<td>56.2</td>
<td>74.1</td>
<td>0.002</td>
</tr>
<tr>
<td>Married</td>
<td>9.2</td>
<td>22.5</td>
<td>7.4</td>
<td>0.180</td>
</tr>
<tr>
<td>Lives alone</td>
<td>60.7</td>
<td>52.8</td>
<td>63.0</td>
<td>0.418</td>
</tr>
<tr>
<td>Completed education &lt; 9 y</td>
<td>26.4</td>
<td>36.0</td>
<td>33.3</td>
<td>0.265</td>
</tr>
<tr>
<td>Tobacco use</td>
<td>12.9</td>
<td>10.1</td>
<td>40.7</td>
<td>0.018</td>
</tr>
<tr>
<td>Income &lt; $750/mo</td>
<td>66.3</td>
<td>73.0</td>
<td>81.5</td>
<td>0.080</td>
</tr>
<tr>
<td>Food Stamp Program</td>
<td>25.1</td>
<td>24.7</td>
<td>55.6</td>
<td>0.020</td>
</tr>
<tr>
<td>No breakfast³</td>
<td>16.0</td>
<td>13.5</td>
<td>29.6</td>
<td>0.280</td>
</tr>
<tr>
<td><strong>Health-related</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥6 Depressive symptoms</td>
<td>26.4</td>
<td>28.1</td>
<td>51.8</td>
<td>0.030</td>
</tr>
<tr>
<td>≥6 Prescription medications</td>
<td>50.0</td>
<td>53.9</td>
<td>66.7</td>
<td>0.130</td>
</tr>
<tr>
<td>IADL⁴</td>
<td>92.6</td>
<td>95.5</td>
<td>96.3</td>
<td>0.310</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>26.4</td>
<td>24.7</td>
<td>11.1</td>
<td></td>
</tr>
<tr>
<td>25–29.9</td>
<td>30.7</td>
<td>25.8</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>≥30</td>
<td>35.0</td>
<td>40.5</td>
<td>55.6</td>
<td>0.416</td>
</tr>
<tr>
<td>Unable to measure⁵</td>
<td>8.0</td>
<td>9.0</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>Burden of multimorbidity⁶</td>
<td>41.1</td>
<td>50.6</td>
<td>74.1</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

1 Values reported as percentages.
2 Abbreviations: FI, food insufficient; FS, food sufficient; IADL, Instrumental Activities of Daily Living; RFI, risk of food insufficiency.
3 Sometimes or rarely eat breakfast.
4 Unable to shop for groceries or prepare a regular meal without personal assistance.
5 Nonambulatory (n = 22).
6 Reported ≥3 diseases that had a little or large effect on daily activities (does not include diseases that had no effect on daily activities).

In addition, FI women reported the highest proportions of depression and burden of individual diseases (data not shown), burden of multiple diseases (heart disease, 48.1%; high blood pressure, 66.7%; diabetes, 48.1%), and burden of multimorbidity (≥3 diseases).

**Relative nutrient intake.** Relative nutrient intakes, as percent of the recommended RDA/AI, were low and decreased significantly with decreasing food sufficiency status (Table 2). Considering that the lowest quartile represented especially low intakes, increasing proportions of RFI and FI women reported intakes in the lowest quartile of energy, protein, calcium, magnesium, phosphorus, pyridoxine, folate, vitamin A and zinc. The proportional difference of women with the worst musculoskeletal nutrient intake (≥2 nutrients) and worst overall nutrient intake (≥5 nutrients) was significantly greater among women who reported food insufficiency, followed by those who were at risk of food insufficiency.

**Nutrient intake on weekend days versus weekdays.** In data not shown, the signed-rank test confirmed that median relative nutrient intakes on weekend days were significantly lower than on weekdays for all 15 nutrients (13 nutrients, P < 0.001; vitamins E and K, P < 0.05). For women who reported RFI, weekend day relative intakes were at least 20% lower than on weekdays for all 15 nutrients (13 nutrients, P < 0.001; vitamins E and K, P < 0.05). For women who reported RFI, weekend day relative intakes were at least 20% lower than on weekdays for all 15 nutrients (13 nutrients, P < 0.001; vitamins E and K, P < 0.05).
lower than on weekdays for cobalamin, magnesium and vitamins K and A and 16% lower for calcium and folate. Among the 27 women who reported FI, weekend day relative intakes were at least 20% lower than on weekdays for vitamin D, calcium, magnesium, phosphorus, vitamin K, pyridoxine, cobalamin and vitamins C and A.

**Correlates of lowest relative intake in individual nutrients.** Multivariable logistic regression models were used to examine the greater vulnerability of women who reported RFI and FI for the lowest relative intakes in individual nutrients, independent of race, income, education, age, living arrangement, marital status, tobacco use, Food Stamp Program participation, depression, medication use, IADL, BMI and multimorbidity (Table 3). For eight nutrients (energy, protein, calcium, magnesium, phosphorus, folate, vitamin E and zinc), the odds for reporting the lowest quartile of relative intake were almost two- to threefold (OR = 1.96 to 2.91) for homebound women who reported RFI, compared with FS women. In six nutrients, the odds were much greater for FI women: protein (OR = 4.17), magnesium (OR = 3.99), phosphorus (OR = 3.87), pyridoxine (OR = 2.85), vitamin A (OR = 3.59) and zinc (OR = 4.39). In addition, not regularly eating breakfast (compared with women who usually or always consumed breakfast) independently increased the odds for lowest relative intake in 9 of 15 nutrients (OR = 2.12 to 6.24).

**Correlates of worst multiple nutrient intakes and burden of multimorbidity.** Compared with FS women, the adjusted odds for reporting the worst musculoskeletal nutrient intakes (≥2 nutrients) and worst overall nutrient intakes (≥5 nutrients) increased with decreasing food sufficiency status (Table 4). Whereas homebound women who reported RFI were 178% more likely than FS women to report the worst multiple nutrient intakes, FI women were more than four times as likely as FS women to report the worst multiple nutrient intakes. In addition, the adjusted odds for reporting the worst musculoskeletal and overall nutrient intakes were greater for homebound women who did not regularly eat breakfast. Finally, the adjusted odds for burden of multimorbidity (≥3 diseases with little or large effect on daily activities) increased more than two times for FI women.

**DISCUSSION**

The present study showed that indicators of decreasing food sufficiency status (risk of food insufficiency and presence of food insufficiency), independent of income and other sociodemographic and health-related characteristics, increased the risk of low nutrient intakes (individual and multiple nutrients) and multimorbidity among 279 homebound older women who received food assistance through traditional home-delivered meals services.

As important as OAANP home-delivered meals service is to adequate nutrient intake, good nutritional health, physical and cognitive functions and independent functioning (9,38), the traditional approach to home-delivered meals may not be keeping pace with the short- and long-term needs of homebound older women. Using self-reported responses to four food insecurity risk situations, the current study provides a novel approach that estimates a three-level indicator of food sufficiency status: food sufficient (FS), risk of food insufficiency (RFI) and food insufficient (FI). This extends the putative use of a dichotomous measure of food insufficiency (i.e., food insufficiency vs. no food insufficiency), which may mask the presence of risk of food insufficiency in individuals who are neither food insufficient nor food sufficient. Three important findings warrant further comment.

First, despite regular receipt of home-delivered meals, almost 32% of the sample subjects were at risk of food insufficiency; that is, they were neither food sufficient nor food insufficient. They did, however, report that in the previous six months, they were forced to choose between buying food and medications and/or paying bills; almost half reported that they had to choose between food and both medications and bills. An additional 9.7% were considered to be food insufficient, because they responded yes to questions regarding at least one of two situations in which there was no food in the house and no money for food (44% of FI women responded yes to both situations). By using a three-level approach to food sufficiency status, which differentiated RFI from FS and FI, this study observed incrementally larger proportions of low nutrient intake, depression (≥6 depressive symptoms), nutrition-related chronic diseases (heart disease, high blood pressure and diabetes), and burden of multimorbidity as food sufficiency declined (from FS to RFI to FI).

Second, evaluation of three dietary recalls (two weekdays and one weekend day) from each of the 279 homebound women showed that the dietary intake as a proportion of the newly released RDA/AI was low in key nutrients, and decreased significantly across food sufficiency status. This study found that, regardless of the food sufficiency status, home-delivered meal recipients reported significantly lower intakes of all nutrients on weekend days when they did not receive a home-delivered meal, compared with weekdays when they did receive a meal. However, the difference in key nutrients between weekend days and weekdays was great for RFI women and greater for FI women. Although traditional home-delivered meals service, which provides one hot meal a day for five
Food Insufficiency and Homebound Women

TABLE 3
Adjusted odds ratios for lowest quartile of nutrient intakes among 279 homebound women by food sufficiency status and other characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Energy OR (CI)</th>
<th>Protein OR (CI)</th>
<th>Vitamin D OR (CI)</th>
<th>Calcium OR (CI)</th>
<th>Magnesium OR (CI)</th>
<th>Phosphorus OR (CI)</th>
<th>Vitamin K OR (CI)</th>
<th>Pyridoxine OR (CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No breakfast2</td>
<td>3.23a (1.51–6.92)</td>
<td>2.18 (0.99–4.83)</td>
<td>1.16 (0.53–2.55)</td>
<td>4.52b (2.05–9.97)</td>
<td>3.25a (1.53–6.91)</td>
<td>3.12c (1.00–10.53)</td>
<td>0.99 (0.43–2.26)</td>
<td>3.14a (1.49–6.61)</td>
</tr>
<tr>
<td>Disease3</td>
<td>1.04</td>
<td>0.87</td>
<td>0.91</td>
<td>1.49</td>
<td>0.76</td>
<td>0.99</td>
<td>1.17</td>
<td>1.48</td>
</tr>
<tr>
<td>Medication4</td>
<td>1.54</td>
<td>1.92</td>
<td>0.85</td>
<td>1.25</td>
<td>1.21c</td>
<td>0.85</td>
<td>0.97</td>
<td>0.87</td>
</tr>
<tr>
<td>Depreciation5</td>
<td>0.77</td>
<td>0.86</td>
<td>1.62</td>
<td>1.02</td>
<td>1.17</td>
<td>1.40</td>
<td>0.94</td>
<td>0.70</td>
</tr>
<tr>
<td>RFI6</td>
<td>2.23c (1.16–4.32)</td>
<td>1.96c (1.00–3.83)</td>
<td>1.45</td>
<td>2.01a</td>
<td>2.06c</td>
<td>2.28a</td>
<td>1.09</td>
<td>1.77</td>
</tr>
<tr>
<td>FI</td>
<td>1.94</td>
<td>4.17a</td>
<td>2.07</td>
<td>2.75</td>
<td>3.99a</td>
<td>3.87a</td>
<td>2.63</td>
<td>2.85c</td>
</tr>
<tr>
<td>(0.69–5.45)</td>
<td>(1.49–11.70)</td>
<td>(0.70–6.10)</td>
<td>(0.98–7.68)</td>
<td>(1.47–10.88)</td>
<td>(1.39–10.76)</td>
<td>(0.89–7.82)</td>
<td>(1.04–7.77)</td>
<td></td>
</tr>
<tr>
<td>Pseudo R² of model</td>
<td>0.098</td>
<td>0.092</td>
<td>0.073</td>
<td>0.174</td>
<td>0.113</td>
<td>0.086</td>
<td>0.075</td>
<td>0.096</td>
</tr>
<tr>
<td>Variable</td>
<td>Cobalamin OR (CI)</td>
<td>Folate OR (CI)</td>
<td>Ascorbic acid OR (CI)</td>
<td>Vitamin E OR (CI)</td>
<td>Vitamin A OR (CI)</td>
<td>Iron OR (CI)</td>
<td>Zinc OR (CI)</td>
<td></td>
</tr>
<tr>
<td>No breakfast</td>
<td>1.79</td>
<td>6.24b (0.84–3.83)</td>
<td>2.51a (2.87–13.57)</td>
<td>2.82a (1.19–5.30)</td>
<td>0.87 (1.32–6.03)</td>
<td>4.77b (0.38–1.99)</td>
<td>2.27b (2.10–10.33)</td>
<td>2.124</td>
</tr>
<tr>
<td>Disease</td>
<td>0.75</td>
<td>1.49</td>
<td>1.42</td>
<td>1.14</td>
<td>1.44</td>
<td>1.44</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>Medication</td>
<td>0.79</td>
<td>0.79</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Deprcation</td>
<td>1.52</td>
<td>1.69</td>
<td>1.91</td>
<td>1.15</td>
<td>0.92</td>
<td>1.06</td>
<td>1.22</td>
<td>1.22</td>
</tr>
<tr>
<td>RFI</td>
<td>0.80–2.89</td>
<td>0.87–3.27</td>
<td>0.93–3.69</td>
<td>0.61–2.17</td>
<td>0.48–1.75</td>
<td>0.56–2.02</td>
<td>0.64–2.31</td>
<td>0.56–2.02</td>
</tr>
<tr>
<td>FI</td>
<td>0.53–2.21</td>
<td>0.38–1.65</td>
<td>0.63–2.48</td>
<td>0.53–2.24</td>
<td>0.83–3.38</td>
<td>0.57–2.40</td>
<td>0.24–1.12</td>
<td>0.14–0.85</td>
</tr>
<tr>
<td>(0.76–2.85)</td>
<td>(1.14–4.23)</td>
<td>(0.34–1.35)</td>
<td>(1.23–4.46)</td>
<td>(0.93–3.52)</td>
<td>(0.88–3.31)</td>
<td>(1.29–10.03)</td>
<td>(0.58–4.81)</td>
<td>(1.51–17.22)</td>
</tr>
<tr>
<td>Pseudo R² of model</td>
<td>0.088</td>
<td>0.088</td>
<td>0.088</td>
<td>0.088</td>
<td>0.088</td>
<td>0.088</td>
<td>0.096</td>
<td>0.092</td>
</tr>
</tbody>
</table>

1 Adjusted odds ratios (OR) and 95% CI calculated from multiple logistic regression analysis (n = 276), controlling for race, income, education, age, living arrangement, marital status, tobacco use, Food Stamp Program participation, Instrumental Activities of Daily Living (IADL), and BMI. Three women were excluded because of missing data on prescription medications. P-values: a P ≤ 0.01; b P ≥ 0.001; c P ≤ 0.05.
2 Sometimes or rarely eat breakfast (reference category: usually or always eat breakfast).
3 Burden of multimorbidity: >3 diseases with little or large effect on daily activities (reference category: <3 diseases).
4 Take ≥6 prescription medications daily (reference category: take <6 prescription medications daily).
6 Abbreviations: RFI, risk of food insufficiency; FI, food insufficient (reference category: FS, food sufficient).

weekdays and meets one-third of the RDA, makes an important contribution to nutrient intake and is an important source of food assistance to vulnerable elders (2), this study suggests that the traditional “school-lunch” model of home-delivered meals service may not be enough to prevent inadequate nutrient intakes in homebound older women, especially those who experience risk or presence of food insufficiency. Third, the results of multivariable logistic regression models extend our knowledge by identifying the risk and presence of food insufficiency in homebound women as independent correlates of lowest nutrient intakes for individuals and multiple nutrients (3,9). Considering the relationship of musculoskeletal nutrient intake to physical performance (e.g., balance, mobility and leg strength) and the severity of disability in homebound elders (9,10), it is of special concern that the odds for the worst level of musculoskeletal nutrient intake, after controlling for other independent variables (sociodemographic and health-related characteristics), were greater with reduced food sufficiency status—more than twofold with risk of food insufficiency and more than fivefold with food insufficiency. Overall relative intakes were especially low for three of the musculoskeletal nutrients (vitamin D, calcium and magnesium), and they were significantly lower on weekend days than during the weekdays. The odds for the worst level of overall nutrient intake (≥5 nutrients), which included antioxidants and nutrients associated with the immune system and physical and cognitive functions (8), were >100% greater for homebound RFI women and >400% greater for FI women. This suggests that the risk and presence of food insufficiency, which reflect more limited available financial resources, may affect nutrient intake through altered quantity and quality of food and decreased nutrient densities available in the household (22). Furthermore, food insufficiency in this sample increases the odds for reporting burden of multimorbidity by >200%, holding sociodemographic and health-related characteristics constant. This is of great concern, given that poorly managed chronic diseases contributed to increased health care expenditures, functional decline, increased disability and loss of independence (40,41).

These findings are especially important given certain considerations: 1) the reliance on home-delivered meals for long-term food assistance; 2) the RDA/AI concern nutrient intakes for healthy individuals and may underestimate nutrient requirements because they have not been modified for frail older
individuals who suffer from specific health conditions and regularly take several medications, which may alter nutrient absorption and utilization \( ^{42,43} \); and 3) dietary modification is part of the disease prevention and management process, especially for diseases that are highly prevalent among the elderly \( ^{44,45} \).

Strengths and limitations. The present study has several particular strengths. First, this study completed a greater number of comprehensive in-home assessments and dietary recalls from homebound elderly women than previous reports \( ^{3,24} \). Second, to our knowledge, this is the first study of a three-level indicator of food sufficiency status in homebound older women, all of whom participated in home-delivered meals service. Third, the use of four food insecurity risk situations, which tapped into the adequacy of resources, allowed for an examination of variations in food sufficiency status and what it means, from dietary and health-related perspectives, to be at risk of food insufficiency and to be food insufficient. Fourth, relative dietary intake was evaluated based on three 24-h dietary recalls that minimized respondent burden, included both weekdays and weekend days and used the newly-released RDA/AI \( ^{3} \). Finally, multivariable regression models allowed for an examination of the association of food sufficiency status to nutritional and health-related outcomes, independent of income and other variables.

The author acknowledges several limitations of this study.

Although food sufficiency status was self-reported for the six months preceding the in-home assessment, all data were collected at one time point, which precluded making causal inferences from the cross-sectional design of this study. Because no data on duration and frequency of food insufficiency situations were collected, this study could not differentiate between acute and chronic food insufficiency, which is a recurring problem in other studies of elderly populations \( ^{46} \). The study sample was representative (e.g., sex, age and race) of all participants in home-delivered meals programs in the counties of interest and in North Carolina. However, it is possible that exclusion criteria selected a study sample with nutrient and food sufficiency profiles different from those of nonparticipants. Finally, an additional limitation is an absence of data on meal coping strategies, and the association of various strategies with the measures of food insufficiency and nutrient intakes \( ^{14} \).

As a major source of food assistance to homebound elders, many of whom are at high-risk for nutrition-related problems and rely on their daily meal as the main source of food intake, OAANP plays a critical role in community-based long-term care by providing nutritious meals through home-delivered meals service \( ^{2} \). Although nutrient intakes of participants in home-delivered meals programs are better than those of comparable nonparticipants \( ^{2} \), this study extends our knowledge by identifying the vulnerability of homebound women who receive home-delivered meals to the risk and presence of food insufficiency. It also makes several recommendations to draw attention to the importance of improving dietary intake, increasing food sufficiency and improving health status: 1) expand data collected during program assessment and reassessment to include additional measures of food sufficiency status for the targeting and monitoring of programs, interventions and program outcomes relative to FI and RFI older persons; 2) evaluate the adequacy of meal requirements that set a minimum of one-third of RDA/AI as a target; 3) consider increasing nutrient intakes through the addition of a home-delivered breakfast meal \( ^{47} \); and 4) utilize food sufficiency status measures as a method of identifying community partners and targeting homebound elders in need of additional nutrition support, especially on weekends.

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