The Association between Self-Reported Difficulty of Food Access and Nutrient Intake among Middle-Aged and Older Residents in a Rural Area of Japan

Miwa Yamaguchi¹, Katsuya Takahashi², Ryosuke Kikushima², Megumi Ohashi², Maria Ikegawa², Tetsuro Yakushiji³ and Yosuke Yamada¹

¹Department of Nutrition and Metabolism, National Institutes of Biomedical Innovation, Health and Nutrition, 1–23–1 Toyama, Shinjuku-ku, Tokyo 162–8636, Japan
²Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries, 3–1–1, Kasumigaseki, Chiyoda-ku, Tokyo 100–0013, Japan
³Department of Food Management, Faculty of Nutritional Sciences, Nakamura Gakuen University, 5–7–1 Befu, Jouan-ku, Fukuoka 814–0198, Japan

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Summary We investigated the association of self-reported difficulty of food access, accounting for the perception of food-store accessibility, with nutrient intake among 474 inhabitants (145 men and 329 women) aged ≥40 y in a rural area of Japan. Information on self-reported difficulty of food access and dietary intake was obtained via a self-administered questionnaire. Analysis of covariance was performed to evaluate the adjusted associations between difficulty of food access and percentages of total energy (i.e., protein, fat, and carbohydrates). Among men, the adjusted means of percent energy from fat in the “difficulty of food access” group (19.2% energy) were significantly lower (by 2.4%) and the percent energy from carbohydrates for this group (57.3% energy) was significantly higher (by 3.3%) than for the “non-difficulty” group. In conclusion, this study found nutritional balance among residents experiencing difficulty of food access results in lower fat and higher carbohydrate intake than for those with non-difficulty of food access among middle-aged and older Japanese men in a rural area.

Key Words self-reported food accessibility, nutritional balance, low fat, high carbohydrate

Certain areas, termed food deserts (1), exist where the availability and accessibility of retail foods at reasonable prices are lacking. The social problem of the food desert was initially proposed in Western countries where there is considerable evidence regarding health problems, such as obesity and diabetes, in relation to ethnic minorities and socioeconomically disadvantaged neighborhoods (2). Iwama et al. (3, 4) and Yakushiji et al. (5, 6) proposed that ‘Japanese food deserts’ mainly affect older people residing in neighborhoods where smaller retail stores have closed because of the recent economic recession. Ikejima (7) reported approximately 35% of residents aged 65 y and older have poor access to fresh food in large Japanese cities. In addition, improvement in the food environment has been added to the second term of the National Health Promotion Movement in the 21st century (Health Japan 21 [the second term]) (8). Therefore, it is crucial to accumulate evidence related to food access and dietary habits.

In spite of some studies conducted on this issue, several questions remain unanswered. First, the association of food access with dietary habits in rural areas remains unclear. Rural neighborhoods have been facing a lack of public transportation and inequalities in potential food access due to the long distances to reach grocery stores compared to such distance in urban areas (9, 10). Second, studies investigating the association of subjective food accessibility with dietary habits have been scarce in Japan. A previous study indicated that low subjective availability of food access among Japanese older people is associated with low frequencies of fruits and vegetables (11). Perceived food accessibility has been measured and used elsewhere (12, 13). In addition, a previous review suggested the importance of the measurement of the food environment not only geographically (i.e., GIS-based measures) but also with non-geographic dimensions of access, such as affordability, accommodation and acceptability (13). Third, most of the dietary intake related to food access was focused on obtaining fresh food (i.e., vegetables, fruits, fish, and meat) (14–17), and did not use detailed nutrient intake (i.e., total energy intake, protein, fat, carbohydrates).

Thus, our aim is to investigate the association of self-reported difficulty of food access with nutrient intake among middle-aged and older people residing in a rural area of Japan. In addition, to consider the association of food access with the nutritional balance among older people in Japan (3–6), we employed the same model among people aged 65 y or older.

E-mail: myamaguchi@hosp.ncgm.go.jp
Table 1. Demographic characteristics of participants divided by self-reported difficulty of food access among men and women.

| Age (y) | Non-difficult (n=91) | Men | Difficult (n=54) | p-value | Non-difficult (n=161) | Women | Difficult (n=168) | p-value |
|---------|----------------------|-----|------------------|---------|-----------------------|-------|------------------|---------|
| 40–49   | 40 (4.4)             | 1 (1.9) | 1 (1.9)           | 0.700 | 8 (5.0) | 1 (1.8) | 3 (1.8) | 0.015* |
| 50–59   | 20 (22.0)            | 14 (25.9) | 14 (25.9)         |       | 30 (18.6) | 26 (15.5) |       |       |
| 60–69   | 29 (31.9)            | 14 (25.9) | 14 (25.9)         |       | 56 (34.8) | 45 (26.8) |       |       |
| ≥70     | 38 (41.8)            | 25 (46.3) | 25 (46.3)         |       | 67 (41.6) | 94 (56.0) |       |       |

| Body mass index (kg/m²) | Non-difficult (n=91) | Men | Difficult (n=54) | p-value | Non-difficult (n=161) | Women | Difficult (n=168) | p-value |
|-------------------------|----------------------|-----|------------------|---------|-----------------------|-------|------------------|---------|
| <18.5                   | 4 (4.4)              | 1 (1.9) | 1 (1.9)           | 0.440 | 12 (7.5) | 22 (13.0) |       |       |
| 18.5–24.9               | 66 (72.5)            | 37 (68.5) | 37 (68.5)         |       | 125 (77.6) | 106 (63.1) |       |       |
| ≥25                     | 21 (23.1)            | 15 (27.8) | 15 (27.8)         |       | 22 (13.7) | 36 (21.4) |       |       |

| Waist circumference (cm) | Non-difficult (n=91) | Men | Difficult (n=54) | p-value | Non-difficult (n=161) | Women | Difficult (n=168) | p-value |
|-------------------------|----------------------|-----|------------------|---------|-----------------------|-------|------------------|---------|
| <90 cm in men, <80 cm in women | 83 (86.3) (8.2) | 53 | 53 | 0.226 | 150 (83.2) (8.5) | 151 (84.1) (9.4) | 0.397 |       |
| ≥90 cm in men, ≥80 cm in women | 24 (26.4) | 24 (44.4) | 24 (44.4) |       | 109 (67.7) | 90 (64.8) |       |       |

| IADL¹ | Non-difficult (n=91) | Men | Difficult (n=54) | p-value | Non-difficult (n=161) | Women | Difficult (n=168) | p-value |
|-------|----------------------|-----|------------------|---------|-----------------------|-------|------------------|---------|
| <Median | 17 (35.4) | 14 (43.8) | 14 (43.8) | 0.454 | 42 (42.9) | 62 (54.9) |       |       |
| ≥Median | 31 (64.6) | 18 (56.3) | 18 (56.3) |       | 55 (56.1) | 49 (43.4) |       |       |

| Light-to-moderate exercise (times/wk) | Non-difficult (n=91) | Men | Difficult (n=54) | p-value | Non-difficult (n=161) | Women | Difficult (n=168) | p-value |
|-------------------------------------|----------------------|-----|------------------|---------|-----------------------|-------|------------------|---------|
| Almost none | 52 (57.1) | 32 (59.3) | 32 (59.3) | 0.071 | 76 (47.2) | 79 (47.0) | 0.641 |       |
| 1–4 | 27 (29.7) | 10 (18.5) | 10 (18.5) |       | 51 (31.7) | 55 (32.7) |       |       |
| ≥5 | 9 (9.9) | 12 (22.2) | 12 (22.2) |       | 30 (18.6) | 26 (15.5) |       |       |

| Diet treatment | Non-difficult (n=91) | Men | Difficult (n=54) | p-value | Non-difficult (n=161) | Women | Difficult (n=168) | p-value |
|----------------|----------------------|-----|------------------|---------|-----------------------|-------|------------------|---------|
| Yes | 13 (14.3) | 3 (5.6) | 3 (5.6) | 0.182 | 27 (16.8) | 21 (12.5) | 0.482 |       |
| No | 72 (79.1) | 49 (90.7) | 49 (90.7) |       | 130 (80.8) | 144 (85.7) |       |       |

| Self-rated health | Non-difficult (n=91) | Men | Difficult (n=54) | p-value | Non-difficult (n=161) | Women | Difficult (n=168) | p-value |
|-------------------|----------------------|-----|------------------|---------|-----------------------|-------|------------------|---------|
| Good | 68 (74.7) | 28 (51.9) | 28 (51.9) | 0.005* | 137 (85.1) | 116 (69.1) | 0.002* |       |
| Poor | 23 (25.3) | 26 (48.2) | 26 (48.2) |       | 24 (14.9) | 51 (30.4) |       |       |

| Food cost (yen/month/person)² | Non-difficult (n=91) | Men | Difficult (n=54) | p-value | Non-difficult (n=161) | Women | Difficult (n=168) | p-value |
|------------------------------|----------------------|-----|------------------|---------|-----------------------|-------|------------------|---------|
| T1 | 41 (45.1) | 19 (35.2) | 19 (35.2) | 0.553 | 59 (36.7) | 47 (28.0) | 0.023 |       |
| T2 | 20 (22.0) | 14 (26.0) | 14 (26.0) |       | 43 (26.7) | 50 (29.8) |       |       |
| T3 | 27 (29.7) | 19 (35.2) | 19 (35.2) |       | 46 (28.6) | 51 (30.4) |       |       |

| Unknown | 3 (3.3) | 2 (3.7) | 2 (3.7) |       | 13 (8.1) | 20 (11.9) |       |       |
| Job status                           | Men                      | Women                   |  |  |  |  |  |  |  |  |
|-------------------------------------|--------------------------|-------------------------|---|---|---|---|---|---|---|---|
| Full-time/part-time job             | 32 (35.2)                | 10 (18.5)               | 0.049* | 46 (28.6) | 38 (22.6) | 0.570 |
| Self-employed worker (i.e., agriculture) | 23 (25.3)                | 11 (20.4)               | 29 (18.1) | 30 (17.9) |
| Retired or other                    | 33 (36.3)                | 32 (59.3)               | 78 (48.5) | 93 (55.4) |
| Unknown                             | 3 (3.3)                  | 1 (1.9)                 | 8 (5.0) | 7 (4.2) |
| **Family members (persons)**        |                          |                         |   |   |   |   |   |   |   |
| Alone                               | 29 (31.9)                | 16 (29.6)               | 0.743 | 26 (16.5) | 47 (28.0) | 0.031* |
| 2                                   | 33 (36.3)                | 23 (42.6)               | 62 (38.5) | 63 (37.5) |
| ≥3                                  | 29 (31.9)                | 15 (27.8)               | 73 (45.3) | 57 (33.9) |
| Unknown                             | 0 (0)                    | 0 (0)                   | 0 (0) | 1 (0.6) |
| **Travel time (min)**               |                          |                         |   |   |   |   |   |   |   |
| T1                                  | 52 (57.1)                | 15 (27.8)               | 0.002* | 64 (39.8) | 53 (31.6) | 0.005* |
| T2                                  | 20 (22.0)                | 14 (25.9)               | 67 (41.6) | 54 (32.1) |
| T3                                  | 19 (20.9)                | 24 (44.4)               | 27 (16.8) | 54 (32.1) |
| Unknown                             | 0 (0)                    | 1 (1.8)                 | 3 (1.9) | 7 (4.1) |
| **Transportation**                  |                          |                         |   |   |   |   |   |   |   |
| Walk or bicycle                     | 4 (4.4)                  | 6 (11.1)                | 0.071 | 17 (10.6) | 11 (6.6) | <0.001** |
| Automobile or motorbike             | 85 (93.4)                | 46 (85.2)               | 141 (87.6) | 122 (72.6) |
| Public bus or other                 | 0 (0)                    | 2 (3.7)                 | 3 (1.9) | 32 (19.1) |
| Unknown                             | 2 (2.2)                  | 0 (0)                   | 0 (0) | 3 (2.2) |
| **Reasons for the difficulty of food access** |                      |                         |   |   |   |   |   |   |   |
| Distance to the grocery store       | 12 (22.2)                | 28 (16.7)               | 33 (19.6) |
| Physical disability                 | 9 (16.7)                 | 33 (19.6)               | 28 (16.7) |
| Unavailability of transportation    | 10 (18.5)                | 26 (15.5)               | 29 (17.3) |
| Lack of support for accessing food  | 10 (18.5)                | 26 (15.5)               | 29 (17.3) |
| Poor-quality products in food stores| 10 (18.5)                | 26 (15.5)               | 29 (17.3) |
| Other                               | 3 (5.6)                  | 14 (13.1)               | 14 (13.1) |
| Unknown                             | 0 (0)                    | 2 (1.2)                 | 2 (1.2) |

T1, tertile 1 = 33rd percentile; T2, tertile 2 = 33rd percentile and < 67th percentile; T3, tertile 3 = 67th percentile; SD, standard deviation; IADL, instrumental activities of daily living.

1The result of IADL level is shown for those aged 65 y and older.

2The cutoff point of food cost was as follows: the 33rd percentile = 25,000 in men and 20,000 in women; the 67th percentile = 40,000 in men and 26,000 in women.

3The cutoff point of travel time was as follows: the 33rd percentile = 20 in men and 11 in women; the 67th percentile = 25 both in men and women.

A Chi-square test for categorical variables and a non-paired t-test for continuous variables were used to investigate the difference in self-reported difficulty of food access.

*p-value < 0.05, **p-value < 0.001.
**Materials and Methods**

**Participants.** According to the 2015 census in Japan (http://www.e-stat.go.jp/Sf1/chiiki/Toukei/DataSelect DispatchAction.do), the population aged \( \geq 65 \) y and its proportion of the total population in the small town we investigated \((2,345 [49.2%])\) were higher than that of urban areas \((51,027 [26.3%])\) in Tottori Prefecture. There were fewer food and beverage retail stores in the small town than in these urban areas (http://www.e-stat.go.jp/Sf1/chiiki/Toukei/DataSelectDispatchAction. do). The data were collected from a population-based mail survey by employing an unlinkable anonymizing method based on a research project on food supply chains at the Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries (5, 6). Each respondent in this survey was the person with the major meal preparation role in the household. After mail distribution of a self-administered questionnaire to all 2,113 households with the cooperation of the local government office, 520 people responded to the questionnaire in September 2015 (24.6% response rate). We excluded 18 people due to missing data on sex and age and 17 people aged \(<40\) y. Three people who had \(<500\) kcal/d of total energy intake, and eight people who omitted information on difficulty of food access were excluded from the data (18). Finally, 474 participants (145 men and 329 women) were used as eligible participants in the present study. This study was based on the Japanese Ethical Guidelines for Medical and Health Research Involving Human Subjects (19). Informed consent was obtained from the participants with the response. The study protocol was approved by the Ethics Committee of the National Center for Global Health and Medicine, Japan.

**Self-reported food accessibility.** According to the review (13), food access is commonly assessed with single-item indicators. In this study, we used one question on food accessibility, which is a respondent-based measurement, to capture the perceived accessibility of food or food stores (20). The question asked was as follows: “Do you have any difficulty in purchasing food in your daily life?” The difficulty of food access was defined by the following responses: “I have difficulty relating to food accessibility” or “I sometimes have difficulty relating to food accessibility.” Non-difficulty of food access was assessed by the following responses: “I don’t have any difficulty relating to food accessibility” or “I don’t have any difficulty relating to food accessibility.”

**Estimation of nutritional intake.** To estimate dietary intake per day during the recent month, a commonly used and previously validated Japanese food frequency questionnaire (FFQ) was employed in the present study (21, 22). The FFQ, named ‘brief-type self-administered diet history questionnaire (BDHQ),’ included five sections: (1) intake frequency of 46 food and non-alcoholic beverage items, (2) daily intake of rice and miso soup, (3) frequency of drinking alcoholic beverages and amount per drink for five alcoholic beverages, (4) usual cooking methods, and (5) general dietary behavior (21, 22). With these sections, the total energy intake (kcal/d), and the amount (g/d) and energy percent of total energy intake (% energy) from protein, fat, and carbohydrates were estimated. As for other nutrients, the salt equivalent and dietary fiber (both soluble and insoluble fiber) \((g/1,000\) kcal) were included. The amount of intake by food group \((g/1,000\) kcal) was classified into six groups while aggregating several foods into related food groups as follows: (1) seafood (squid/octetopus/shrimp/shellfish, small fish with bones, canned tuna, dried fish/salted fish, oily fish, and lean fish); (2) meat (poultry, pork/beef, ham/sausage/bacon, and liver); (3) vegetables (pickled green leafy vegetables, other pickled vegetables, lettuces/cabbage [raw], green leafy vegetables, cabbage/Chinese cabbage, carrots/pumpkin, Japanese radish/turmi, other root vegetables, tomatoes, mushrooms, and seaweeds); (4) rice; (5) bread; and (6) noodles (Japanese noodles [i.e., Udon, Soba], Chinese noodles, and pasta).

**Other related variables.** To investigate the characteristics of a multifactorial background for the self-reported difficulty of food access, several variables were employed. Regarding the anthropometric variables, body mass index (BMI) \((kg/m^2)\) was calculated using self-reported weight (kg) and height squared \((m^2)\) to assess nutritional status (23) and was classified into three categories \(<18.5, 18.5–24.9, \text{or } \geq 25.0\). Further, self-measured waist circumference (cm) using a provided device was obtained to estimate visceral fat. According to a previous report among Japanese men and women aged 35–79 y (24), high correlations were observed between the measured and self-reported values for height, weight, BMI, and waist circumference (Pearson’s correlation coefficient, 0.73–0.99). The participants were classified into two groups accordingly, with the valid cutoff points as follows: 90 cm in men and 80 cm in women (25). We assessed the instrumental activities of daily living (IADL) by summing the scores for 13 items for people aged \(\geq 65\) y (26). High or low levels of IADL were arrived at by comparison to the median score (12/13 in men/women). Responses relating to the frequency of light-to-moderate exercise were grouped as 1–4 or \(\geq 5\) (times/wk). To investigate participants’ health status, information on diet treatment from medical doctors and/or dieticians (yes or no) and self-rated health (good or poor) was obtained. The variables of food cost (thousand yen/month/person) were categorized into tertiles (3rd percentile=25 and 20; 67th percentile=40 and 26 in men and women), and job status (full-time/part-time, self-employed, or retired/other) was used to assess socioeconomic status. To indicate household structure, the number of family members (persons) (alone, 2, or \(\geq 3\)) was used. To further investigate food accessibility, we obtained details of the travel time (min), which was grouped into tertiles (3rd percentile=20 and 11 in men and women, and 67th percentile=25 both in men and women), and the mode of transportation (by walking/bicycle, automobile/motorbike, or public bus/other). Previous studies which used self-reported food access (13) assessed a variety of dimensions of food access. We collected multiple reasons for the difficulty of food
access from participants with difficulty of food access from among the following options: distance to the grocery store, physical disability, unavailability of transportation, no support for accessing food, poor-quality products in food stores, and other.

**Statistical analysis.** To compare demographic characteristics of participants with self-reported difficulty of food access with those of participants with non-difficulty, we performed a chi-square test for categorical variables and a non-paired t-test for continuous variables. Due to a skewed distribution, the variables for nutritional intake were log-transformed. The exponential value of the log-transformation is shown in the results. An analysis of covariance was employed to evaluate associations of self-reported difficulty of food access with the amount of consumption (g/d) and percent energy (% energy) from three macronutrients, the salt equivalent (g/1,000 kcal), dietary fiber (g/1,000 kcal), and six food groups (g/1,000 kcal). Model 1 was a crude model. In Model 2, the categorical covariates, which had the possibility of being confounding factors in self-reported difficulty of food access and dietary intake, were added as follows: age, BMI, light-to-moderate exercise, diet treatment, food cost, job status, and number of family members. To investigate the relationship of self-rated health and transportation with associations of the difficulty of food access with nutrient intake and food groups, we added each variable to Model 2 when we found a significant association. For the analysis among residents aged 65 y or older, the same models were employed. We used all missing variables of covariates to increase statistical power. Furthermore, we employed a significance level of $\alpha=0.05$ for a two-tailed test. As all 15 items of the dietary variables were analyzed with self-reported difficulty of food access, the significance was assessed with a Bonferroni correction of $\alpha=0.05/15 (0.003)$. All statistical analyses were performed using STATA software, version 14.0 (StataCorp LP, College Station, TX).

**Results**

Table 1 shows the demographic characteristics of the participants divided by self-reported difficulty of food access among men and women. In women, the mean age of 70.7 y (standard deviation [SD] 11.1 y) for the difficulty of food access group was significantly higher than the mean age of 67.4 y (SD 10.6 y) for the non-difficulty group. The anthropometric status for difficulty of food access were more likely to be obese status (BMI $\geq 25$ kg/m$^2$ in women and waist circumference $\geq 90$ cm in men) than that in the non-difficulty group. A higher proportion of low IADL among women and poor self-rated health in both sexes was observed in the difficulty of food access group than that for individuals in the non-difficulty group. Higher proportions of "retired" or "other" job status among men and living alone among women were seen in the difficulty of food access group than in the non-difficulty group. Regarding food accessibility, our finding showed that the mean travel time (min) for the difficulty of food access group was significantly longer than for the non-difficulty group. The proportion of users of public buses/other for transportation in the difficulty of food access group was higher than in the non-difficulty group among women. Among the difficulty of food access, infrastructural problems were one of the major reasons for the difficulty.

The associations of the self-reported difficulty of food access with nutrient intake and food groups among men aged $\geq 40$ y are shown in Table 2. It was revealed that the fully adjusted means (least square means [ls means]) of the percent energy from fat was 19.2% energy (ls means $\pm$ standard error [SE] 18.4, 20.0) for the difficulty of food access group among men, which was significantly lower than for the non-difficulty group (21.6% energy [20.9, 22.3], $p$-value $=0.035$) in Model 2. The ls means of percent energy from carbohydrate for the difficulty of food access group was significantly higher than for the non-difficulty group among men (ls means $=57.4%$ energy [56.1, 58.8]; ls means $=54.0$ [53.1, 55.0] in the non-difficulty group, $p$-value $=0.046$). When self-rated health and transportation were respectively added to Model 2, the significant association of difficulty of food access with percent energy from fat and carbohydrates was attenuated ($p$-values adjusted for self-rated health and self-rated health, respectively, were 0.100 and 0.061 in the energy percent from fat; and $p$-values were 0.088 and 0.051 in the energy percent from carbohydrates [table not shown]). Among the intake of three types of staple foods, especially noodles, results were higher for the difficulty of food access group than for the non-difficulty group but not statistically significant among men.

Among women, the adjusted means of noodle intake (g/1,000 kcal) for the difficulty of food access group were lower than for the non-difficulty group ($p$-value $=0.008$) (Table 3).

Similar associations of self-reported difficulty of food access with nutrient intake and food groups were observed among men and women aged 65 y or older (Supplemental Online Material, Tables S1 and S2). Rice intake for the difficulty of food access group was statistically higher than for the non-difficulty group among men aged 65 y or older ($p$-value $=0.007$) (Table S1). Intake of dietary fiber for the difficulty of food access group was statistically lower than for the non-difficulty group among women aged 65 y or older ($p$-value $=0.035$) (Table S2).

**Discussion**

The present study indicated that the presence of self-reported difficulty of food access was associated with a lower energy percent from fat and higher energy percent from carbohydrates compared to the presence of non-difficulty of food access among Japanese men aged $\geq 40$ y in a rural area, but not in women. To our knowledge, this is the first study to investigate the association of self-reported food difficulty of food access with nutrient intake among Japanese neighbors in a rural area.

According to the National Diet and Nutrition Survey in Japan, Japanese people have relied on staple foods during economic growth periods after 1960 (i.e., 18.9–19.8%
Table 2. The association of self-reported difficulty of food access with nutrient intake and food groups analyzed with analysis of covariance among men aged 40 y and older.

| Self-reported difficulty of food access | Model 1 | Model 2 |
|----------------------------------------|---------|---------|
|                                        | Non-difficult (n=91) | Difficult (n=54) | p-value | Non-difficult (n=91) | Difficult (n=54) | p-value |
| Means±SE | Means±SE | p-value | Ls means±SE | Ls means±SE | p-value |
| Total energy (kcal/d) | 1,853 (1,777, 1,932) | 1,808 (1,713, 1,909) | 0.726 | 1,873 (1,794, 1,956) | 1,775 (1,675, 1,880) | 0.472 |
| Macronutrients | | | | | | |
| Protein (g/d) | 67.3 (63.9, 70.9) | 65.0 (60.8, 69.5) | 0.687 | 68.4 (64.8, 72.2) | 63.3 (58.9, 68.0) | 0.404 |
| Fat (g/d) | 44.0 (41.4, 46.6) | 39.4 (36.5, 42.5) | 0.259 | 45.0 (42.3, 47.9) | 37.8 (34.8, 41.1) | 0.109 |
| Carbohydrate (g/d) | 252 (241, 262) | 257 (244, 271) | 0.757 | 253 (242, 264) | 255 (241, 269) | 0.921 |
| Protein (% energy) | 14.5 (14.2, 14.9) | 14.4 (13.9, 14.9) | 0.805 | 14.6 (14.3, 15.0) | 14.3 (13.8, 14.7) | 0.557 |
| Fat (% energy) | 21.4 (20.7, 22.0) | 19.6 (18.8, 20.4) | 0.098 | 21.6 (20.9, 22.3) | 19.2 (18.4, 20.0) | 0.035* |
| Carbohydrate (% energy) | 54.3 (53.4, 55.3) | 56.8 (55.6, 58.1) | 0.113 | 54.0 (53.1, 55.0) | 57.4 (56.1, 58.8) | 0.046* |
| Other nutrients | | | | | | |
| Salt equivalent (g/1,000 kcal) | 11.2 (10.9, 11.5) | 11.8 (11.4, 12.2) | 0.203 | 11.2 (10.9, 11.5) | 11.9 (11.5, 12.3) | 0.188 |
| Dietary fiber (g/1,000 kcal) | 10.7 (10.3, 11.1) | 10.6 (10.1, 11.1) | 0.833 | 10.8 (10.4, 11.2) | 10.4 (10.0, 10.9) | 0.593 |
| Food groups | | | | | | |
| Seafood (g/1,000 kcal) | 21.4 (19.5, 23.5) | 20.5 (18.1, 23.1) | 0.762 | 21.7 (19.8, 23.8) | 20.0 (17.7, 22.6) | 0.601 |
| Meat (g/1,000 kcal) | 12.0 (10.8, 13.3) | 9.6 (8.3, 11.0) | 0.190 | 11.8 (10.6, 13.1) | 9.9 (8.6, 11.5) | 0.368 |
| Vegetables (g/1,000 kcal) | 58.2 (53.4, 63.5) | 59.1 (52.9, 66.2) | 0.909 | 58.7 (54.1, 63.8) | 58.3 (52.2, 65.0) | 0.955 |
| Rice (g/1,000 kcal) | 92.6 (86.1, 100) | 107 (97.5, 118) | 0.224 | 90.8 (84.3, 97.9) | 111 (100, 122) | 0.129 |
| Bread (g/1,000 kcal) | 4.5 (3.8, 5.2) | 4.4 (3.6, 5.3) | 0.904 | 4.5 (3.9, 5.6) | 4.3 (3.5, 5.2) | 0.845 |
| Noodles (g/1,000 kcal) | 10.9 (9.6, 12.4) | 11.7 (9.9, 13.7) | 0.751 | 9.7 (8.5, 10.9) | 14.3 (12.2, 16.7) | 0.065 |

Ls means±SE, least square means (Ls means−standard error, Ls means+standard error).

Fully adjusted geometric means of log-transformed value were calculated by employing a general linear model. The analysis of covariance was performed to investigate the association of self-reported difficulty of food access with nutritional status in Model 1 and Model 2 with possible covariance as below.

1 Model 1, crude model.

2 Model 2, age (40–49, 50–59, 60–69, or ≥70 y), body mass index (<18.5, 18.5–24.9, ≥25 kg/m², or unknown), light-to-moderate exercise (almost none, 1–4, ≥5 times/wk, or unknown), diet treatment (yes, no, or unknown), food cost (<25, 25–39, ≥40 thousand yen/month/person, or unknown), job status (full-time and part-time job, self-employed worker, retired or others, or unknown), and number of family members (alone, 2, ≥3, or unknown).

*p-value<0.05, p-value<0.003 (Bonferroni correlation α=0.05/15) was not shown.
|                      | Model 1¹ | Model 2² | p-value | Model 1¹ | Model 2² | p-value |
|----------------------|----------|----------|---------|----------|----------|---------|
| **Self-reported difficulty of food access** |          |          |         |          |          |         |
|                      | Non-difficult (n=161) | Difficult (n=168) | p-value | Non-difficult (n=161) | Difficult (n=168) | p-value |
|                      | Means±SE | Means±SE |         | Means±SE | Means±SE |         |
| **Total energy (kcal/d)** | 1,674 (1,631, 1,719) | 1,700 (1,657, 1,744) | 0.680 | 1,661 (1,618, 1,706) | 1,713 (1,669, 1,757) | 0.422 |
| **Macronutrients** |          |          |         |          |          |         |
| Protein (g/d) | 67.9 (65.5, 70.3) | 70.8 (68.4, 73.2) | 0.394 | 67.2 (64.9, 69.6) | 71.4 (69.0, 73.9) | 0.224 |
| Fat (g/d) | 44.8 (43.2, 46.5) | 45.6 (44.0, 47.3) | 0.746 | 43.8 (42.2, 45.5) | 46.6 (44.9, 48.3) | 0.265 |
| Carbohydrate (g/d) | 236 (230, 242) | 235 (230, 241) | 0.986 | 235 (229, 241) | 236 (230, 242) | 0.958 |
| Protein (% energy) | 16.2 (15.9, 16.5) | 16.6 (16.4, 16.9) | 0.240 | 16.2 (15.9, 16.4) | 16.7 (16.4, 16.9) | 0.185 |
| Fat (% energy) | 24.1 (23.6, 24.6) | 24.1 (23.7, 24.6) | 0.949 | 23.8 (23.3, 24.2) | 24.5 (24.0, 24.9) | 0.301 |
| Carbohydrate (% energy) | 56.3 (55.6, 57.0) | 55.4 (54.7, 56.1) | 0.358 | 56.6 (55.9, 57.3) | 55.0 (54.4, 55.7) | 0.103 |
| **Other nutrients** |          |          |         |          |          |         |
| Salt equivalent (g/1,000 kcal) | 10.7 (10.6, 10.9) | 10.6 (10.4, 10.8) | 0.569 | 10.8 (10.6, 11.0) | 10.6 (10.4, 10.7) | 0.378 |
| Dietary fiber (g/1,000 kcal) | 13.4 (13.1, 13.7) | 13.1 (12.8, 13.5) | 0.560 | 13.5 (13.1, 13.8) | 13.1 (12.8, 13.4) | 0.435 |
| **Food groups** |          |          |         |          |          |         |
| Seafood (g/1,000 kcal) | 26.2 (24.8, 27.6) | 29.8 (28.4, 31.4) | 0.076 | 26.6 (25.2, 28.0) | 29.4 (27.9, 31.0) | 0.178 |
| Meat (g/1,000 kcal) | 16.7 (15.7, 17.8) | 14.5 (13.6, 15.4) | 0.109 | 16.1 (15.1, 17.2) | 15.0 (14.1, 16.0) | 0.429 |
| Vegetables (g/1,000 kcal) | 109 (104, 113) | 102 (97.7, 106) | 0.307 | 109 (104, 114) | 102 (97.5, 106) | 0.317 |
| Rice (g/1,000 kcal) | 90.8 (85.8, 96.1) | 87.4 (82.6, 92.4) | 0.628 | 92.0 (86.9, 97.5) | 86.3 (81.5, 91.2) | 0.429 |
| Bread (g/1,000 kcal) | 7.6 (6.9, 8.4) | 7.8 (7.1, 8.6) | 0.847 | 7.6 (6.9, 8.4) | 7.9 (7.1, 8.7) | 0.833 |
| Noodles (g/1,000 kcal) | 9.6 (8.8, 10.5) | 6.0 (5.5, 6.6) | <0.001** | 9.0 (8.2, 9.8) | 6.4 (5.8, 7.0) | 0.010* |

Is means±SE least square means (ls means ± standard error, ls means± standard error).

Fully adjusted geometric means of log-transformed value were calculated by employing a general linear model. The analysis of covariance was performed to investigate the association of self-reported difficulty of food access with nutritional status in Model 1 and Model 2 with possible covariance as below:

1 Model 1, crude model.
2 Model 2, age (40–49, 50–59, 60–69, or ≥70 y), body mass index (<18.5, 18.5–24.9, ≥25 kg/m², or unknown), light-to-moderate exercise (almost none, 1–4, ≥5 times/wk, or unknown), diet treatment (yes, no, or unknown), food cost (<20, 20–25, ≥26 thousand yen/month/person, or unknown), job status (fulltime and part-time job, self-employed worker, retired or others, or unknown), and number of family members (alone, 2, ≥3, or unknown).

* p-value<0.05, ** p-value<0.003 (Bonferroni correlation α=0.05/15).
energy from fat in 1970–1972, and 57.1–57.3% energy from carbohydrates in 1982–1985) (27, http://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/Overview.pdf). These ranges are similar to the current nutritional balance among men with the difficulty of food access. This trend of nutritional balance is also observed in other Asian countries; the Vietnamese diet is highly dominated by rice and its by-products, and the nutritional balance of the traditional diet is high in carbohydrates and low in fat (28). The present study showed that staple food intake, especially noodles and rice with difficulty of food access, was likely to be higher than that in the non-difficulty group in men. Our findings suggest that a diet dominated by staple foods may relate to the nutritional balance of lower fat and higher carbohydrates among residents with difficulty of food access. Nevertheless, the nutritional balance of low fat and high carbohydrates among men with difficulty of food access in the present study was within the tentative dietary goals to prevent the progression of lifestyle-related diseases in Japan (http://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/Overview.pdf). Therefore, the nutritional balance in difficulty of food access with health issues may be weakly associated in this study. Follow-up studies are required to clarify the health effect of self-reported food access on residents experiencing difficulty of food access.

The present study indicated a significant association between self-reported difficulty of food access and nutritional balance in men but not in women. This relationship between self-reported difficulty of food access and nutritional balance may have a stronger association in middle-aged men due to their poorer cooking skills (29) and lack of dietary variety (5) compared to those of women.

The present study showed no significant association of self-reported difficulty of food access with vegetables and dietary fiber consumption among men and women, except for women aged 65 y or older. In contrast, a Japanese cross-sectional study showed that having low subjective food access was associated with infrequent intake of fruits and vegetables in both sexes over a wide range, from northern to southern areas of Japan and from urban cities to rural areas (11). Some studies in the United States and New Zealand have provided evidence that poor geographical accessibility to grocery stores was associated with a low intake of vegetables and fruits among younger and middle-aged people and even older adults (15–17, 28). Residents of Japanese rural areas may have easier access to vegetables through non-market exchanges or home gardens (30, 31). Moreover, residents in the present study may be able to consume vegetables regardless of difficulty of food access in their rural areas.

Although this cross-sectional study has not demonstrated a causal effect, an association between self-reported difficulty of food access and nutrient intake may be linked to transportation and self-rated health. A review article has suggested that decreased availability of fresh foods, higher food prices, and greater risks of food insecurity due to limited access to supermarkets were not just an individual problem but a rural infrastructure issue (32). Regarding health status, the present study found some common characteristics among residents who experienced difficulty of food access. Specifically, frailty of IADL in women and poor self-rated health in both sexes were observed more in residents who reported difficulty of food access than in residents without difficulty. Hanibuchi et al. (33) showed a significant association between a geographically short distance to fast-food and convenience stores and higher BMI among older people. A previous study by Hanibuchi et al. (33) showed a discrepancy between self-reported and geographical food accessibility, as well as types of stores (i.e., fast food outlets or convenience stores), which are linked to the diet-mediated physical status. Nevertheless, self-reported difficulty of food access may have a multifactorial background in the light of the findings relating to difficulty of food access in the present study. For example, people may have difficulty of food access because of adverse socioeconomic factors, such as low educational status, low income (12, 16, 17, 34), or poor dietary knowledge.

This study has several limitations. First, it may present selection bias in terms of gender, age, and socioeconomic status (i.e., job status, number of family members, and income). The recruitment methodology was limited due to this study being performed by a previously established policy concerning research projects (5). In addition, non-response bias may exist because the sample size was limited due to a low response rate (24.6%) in the present survey. Although the sample size is small, its statistical power is at an appropriate level when we use analysis of covariance: statistical power (1−β)=0.85 in 145 men and (1−β)=0.99 in 329 women (effect size=0.25, α error=0.05, number of covariates=5). Second, all results were derived from self-administered data. Although self-reports are often used in observational studies, there is a possibility that inaccurate information will be included (35). These two limitations may be associated with limitations of mail surveys (36). Third, this study did not consider examples of food access other than retail stores that may affect dietary habits in a rural area; for example, social networks of food sharing among neighbors and having kitchen gardens in households. Fourth, we did not perform a validated and reproducibility analysis for self-reported food access. In addition, using a single question regarding the difficulty of food access may induce a misclassification (i.e., over- or under-stated) due to inaccurate responses. Although there is still no accepted "gold standard" for assessing the validity of self-reported food access (13), we should investigate reproducibility in the future. Fifth, although the present analysis adjusted for possible confounding factors, the multifactorial background with regard to self-reported difficulty of food access may lead to residual confounding. Finally, caution is required in making generalizations about the present findings as the results were derived from neighbors living in a Japanese rural area.
Conclusion

This cross-sectional study found self-reported difficulty of food access was associated with nutritional balance, such as lower fat and higher carbohydrate intake, than non-difficulty of food access among middle-aged and older men in a Japanese rural area.

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Supplemental Information

Supplemental On-line Material is available on J-STAGE.

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