# Drivers of Fruit and Vegetable Intake Among Seniors in Bangkok, Thailand

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**Objectives:** Seniors are at high risk due to inadequate intake of fruit and vegetables. Manifold factors influence this, but psychological and environmental factors have been understudied. This study fills this gap by analyzing drivers of intake among Bangkok seniors, combining demographic, food environment, and psychological variables using the Health Action Process Approach. **Methods:** A questionnaire with self-reported measures was used to interview 201 seniors from across Bangkok. The analysis uses multivariate regression and path analysis. **Results:** Average daily intake was found to be 267 grams, far below the WHO recommendation of 400 grams. Age and household size were associated with lower intake, while intention to consume, home cooking, and home gardening were associated with higher intake. However, the lack of significant effects for dental issues, nutritional knowledge, and planning challenges expectations and warrant further exploration. The path analysis also showed that planning did not mediate intention and intake as hypothesized. Reliance on habitual eating patterns among seniors may make typical meal planning less relevant. **Conclusion:** As the population ages and urbanizes, behaviorally informed public health strategies are needed to improve seniors' diet quality. Practical behavioral nudges and interventions targeting food vendors could support higher intake.

**Keywords:** Health Action Process Approach, Food Choice, Food Environment, Aging, Urban Health Issues.

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A recent Lancet study estimated that more than half of the world's population consumes a diet lacking essential micronutrients like vitamins and minerals found in fruits and vegetables.[1] Micronutrients, particularly antioxidants, can help protect against chronic diseases like heart disease and cancer. They play a vital role in maintaining a healthy immune system. A higher deficiency in micronutrients has been a leading cause of illness and premature death worldwide, contributing to an estimated 11 million deaths annually.[2] Low intake of fruit and vegetables alone accounts for about 3 million of these deaths.[2] Increased mortality risk of cardiovascular disease, cancer, and respiratory disease is associated with low fruit and vegetable intake.[3] The World Health Organization (WHO) recommends that adults should eat at least five portions or 400 grams of fruit and vegetables daily.[4] Globally, few people have realized the need to consume fruit and vegetables.[5] In lower-income countries, it is estimated that 78% of people eat less than five portions a day.[6]

Thailand is no exception to this global situation. A 2009 National Health Examination Survey of 39,290 individuals revealed that three-quarters of the Thai population consumed insufficient vegetables.[7] In 2018, an empirical study sampled 6,991 people across Thailand and found inadequate fruit and vegetable consumption among 66% of the population.[8] In addition, low income and low education have been associated with suboptimal vegetable intake in Thailand[7-10] and elsewhere.[11,12]

Phulkerd et al.[8,10] identified senior citizens as one population group at risk of low vegetable intake in Thailand. They hypothesized that seniors may avoid eating vegetables because of dental problems but did not test this empirically. Another study measuring fruit and vegetable intake among 3,787 people aged 50 and above found that almost 80% consumed insufficient fruit and vegetables.[13] Chalermsri et al.[14] showed that dietary diversity

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among older Thais is worse when single than married. Other studies from outside Thailand have identified social influence and psychological factors associated with fruit and vegetable intake among older adults.[15,16] Previous studies have suggested associations between older age, living environment, home gardening, and other physical health issues and fruit and vegetable intake in Thai seniors.[7,8,10] The importance of childhood food habits has also been shown by a longitudinal study that collected data from children in 1930s and later followed up with the same participants in 1990s to gather adult data in England and Scotland. The result showed that childhood vegetable consumption was associated with higher Healthy Diet Scores later in life.[17] To validate this association, similar factors were incorporated in this study.

The Health Action Process Approach (HAPA) is model that studies patterns of related factors to identify appropriate interventions for health behavior change.[18] The HAPA model assumes that changing people's health behavior requires them to believe that they are capable of doing said behavior (self-efficacy), formulate an action plan (action planning), and come up with a solution in case any problem that prevents them from doing the behavior arises (coping planning). Previous studies have employed HAPA to study fruit and vegetable intake behavior. For instance, a study of pregnant Latinas in the United States by Hromi-Fiedler et al.[19], during in-depth interviews, found that participants were motivated internally to consume fruit and vegetables, driven by their own belief in their capability to act (self-efficacy) and a deliberate intention to do so. The study found that participants employed various action strategies to increase their consumption, such as altering meal preparation methods and disguising the taste of certain vegetables. Participants also planned ahead for coping with obstacles if their action plan cannot be achieved, for instance, by planning to eat more fruit if a meal included fewer vegetables than planned.

There is another study that applied HAPA to analyze the fruit and vegetable intake of long-haul truck drivers in Australia.[20] The study showed that action planning mediated and moderated fruit and vegetable intake while coping planning partially mediated and moderated it. Similarly, a HAPA study on fruit and vegetable intake among Chinese undergraduate students found that action planning significantly mediated the relationship between intention and intake.[21] Inspired by these studies, the psychological variables in the current study, with the application of the HAPA method, included intention, dietary self-efficacy, planning, and social influence.

More comprehensive studies are needed to identify factors associated with low fruit and vegetable intake among older people in Thailand. Existing studies on fruit and vegetable intake in Thailand lack an analysis of psychological and environmental factors affecting dietary behaviors.[7-10] Previous studies have also not examined the relationships between psychosocial variables, meal patterns, food environments, and demographic factors. To fill this critical research gap, this study aims to gain an in-depth understanding of why older people under-consume fruit and vegetables by incorporating psychological factors based on the Health and Action Process Approach (HAPA) alongside social, demographic, and environmental factors. This study thus analyzes how psychological drivers interact to influence fruit and vegetable intake in addition to other demographic, social, meal patterns, and food environment drivers among older adults in Bangkok, Thailand. Last, but not the least, the study also explores the current consumption pattern and explores structural relationships between personal, social, and environmental factors.

## MATERIALS AND METHODS

### Research Design

A quantitative research design guided this study, which employed a food environment framework developed by Stadlmayr et al.[12]. This framework comprised individual, social, physical, and macro-level factors. Individual factors referred to biological, demographic, cognitive, lifestyle, and behavioral factors. Social-level factors referred to the number of people living together and sharing meals, while physical-level factors included residential characteristics or neighborhood food environment. Macro-level factors may refer to urbanization or cultural norms. Most of these factors in this framework were overlooked by other food environment frameworks.

### Instrument and Data Collection

*Fruit and vegetable intake* was this study's primary

outcome variable. In accordance with the 2018 Health Examination Survey in Thailand[8], vegetable intake was measured by asking respondents number of times a week they typically ate vegetables; and number of vegetable servings they ate during those days. Respondents were also asked number of times a week they ate fruit and number of servings of fruit they ate on those days. Serving sizes were described to the participants by showing them images of serving sizes of raw and cooked vegetables and fruits, equaling 80 grams.[22] Self-reported measures often have a potential risk of recall bias and underreporting. Therefore, to minimize this risk, the purpose of the questions was carefully explained to the participants, and they were given sufficient time to respond. For ease of interpretation, the number of daily servings was converted to grams. To measure the primary outcome, five alternative specifications were provided: (1) frequency of fruit intake (days/week); (2) quantity of fruit intake (grams/day); (3) frequency of vegetable intake (days/week); (4) quantity of vegetable intake (grams/day); and (5) quantity of fruit and vegetable intake combined (grams/day). All variables were expressed for each individual.

The participants were asked to specify their age and household size, whether they had a home garden, whether they regularly ate fruit and vegetables as a child, and whether they had any chronic illnesses or dental issues that may affect their eating behavior. Respondents were also asked about their usual meal patterns. The questions included whether they typically had a meal companion and whether they cooked, bought, or consumed food prepared by others. They were also asked whether they had a refrigerator and kitchen at home, and which cooking method they often used (e.g., boil/soup, stir fry, fry, curry dish). Respondents' age, marital status, employment status, education level, and their mother's education were also recorded.

*Intention* to eat fruit and vegetables was measured by the question, "I intend to eat fruit/vegetables every day." All responses were rated on a 5-point Likert scale from "strongly disagree" (1) to "strongly agree" (5). The intention to eat fruit and the intention to eat vegetables had a Cronbach's alpha of 0.68, which shows a high consistency between these variables. Statements about fruit were used to analyze fruit intake, statements about vegetables were used to analyze vegetable intake, and a combined score was used to examine total fruit and vegetable intake.

*Dietary self-efficacy* was measured using a scale adapted from Pandey et al.[23]. The scale included four items each for fruit and vegetables, asking participants to indicate how much fruit and vegetables they thought they could eat. An example is "I think I can eat at least 2 servings of fruit/vegetables every day next week." All responses were rated on a 5-point Likert scale from "strongly disagree" (1) to "strongly agree" (5). Higher scores reflected more dietary self-efficacy. Cronbach's alpha was 0.85, indicating consistency between the items. Statements about fruit were used to analyze fruit intake and statements about vegetables were used to analyze vegetable intake.

Following Brown et al.[20], *planning* was measured using a scale that included planning strategies, action planning, and coping planning. Action planning items consisted of 3 items each for fruit and vegetables. Each item asked the participants to indicate their level of agreement with the statement, for example, "I have made a plan regarding when/where/how often to eat fruit/vegetables." Fruit and vegetable items were separately measured in this model to match the outcomes of each variable. The combined score was used to determine the combined outcome of both variables. Similarly, two coping planning statements were framed to assess how participants planned to deal with an unexpected situation affecting their plans to eat fruit and vegetables. For example, one statement said, "I have made a plan regarding what to do if something interferes with my plans." All responses were rated on a 5-point Likert scale from "strongly disagree" (1) to "strongly agree" (5). Higher scores reflected the presence of more planning. The Cronbach's alpha for all eight items of the planning measurement was 0.91, indicating high consistency. The regression model included action planning and coping planning as separate variables.

*Social influences* regarding fruit and vegetable consumption were assessed using a scale adapted from Pandey et al.[23]. Four items each for fruit and vegetables were incorporated to determine whether the participant's peers consumed fruit and vegetables and whether they encouraged the participant also to consume so. The statements run thus: "Other close ones eat at least two servings of fruit/vegetables

every day" and "Other close ones encourage me to eat at least two servings of fruit/vegetables every day." Cronbach's alpha was 0.88, indicating a high potential for social influence on fruit and vegetable intake. Fruit and vegetable items were separately included in the model to match individual score with their individual outcome, and the combined score with the combined outcome.

**Sampling and Data Collection**

Data were collected between January and June 2024, using a questionnaire-based survey. The questionnaire was developed in English, translated into Thai, and back-translated into English by another translator to ensure correct translation. The minimum sample size for a hierarchical regression analysis was calculated using the G*Power software. Assuming 18 predictors, an effect size of 0.15, a power of 0.95, and an alpha of 0.05, the minimum sample size obtained was 147 individuals. Therefore, a sample of 201 senior Thais, as those aged 60 years or above, was randomly selected. Each participant was required to sign a consent form and it was ensured that they acknowledged their rights to withdraw from any question or the entire interview anytime they wished. Both verbal and written consent were collected. Personal identifying information was removed before the data analysis. During data collection and analysis, hard copies of the surveys were made on paper or a tablet using KoboCollect.

Retirement homes are uncommon in Thailand as seniors tend to live independently or with their children. Due to the data protection issues, it was difficult to obtain a list of senior citizens from the local government authorities. Hence, participants of the study were randomly sampled from Buddhist and other community temples, which are common meeting places for senior citizens. Out of 359 temples in Bangkok's 50 districts, 50 temples were randomly selected. After obtaining permission from thirty abbots to interview people at their temples, interviews with about fifteen participants per temple were conducted. Enumerators visited nearby communities to find additional participants if needed. Five additional districts were randomly selected, and community leaders were approached for scheduling interviews with senior citizens. Individual interviews lasted approximately 30 minutes. Answers were recorded on paper or electronically on a tablet/laptop. After the interview, participants received a small compensation of 80 baht (USD 2.35) for their time.

**Data Analysis**

Hierarchical regression and path analysis techniques were used to examine the factors associated with fruit and vegetable intake among seniors. The hierarchical regression model, often neglected in food choice research. Two sequential blocks were employed for each outcome: the first block included demographic factors, while the second block included psychosocial variables. The demographic factors included age, marital status, household size, home gardening, childhood fruit and vegetable consumption habits, chronic illness, dental issues, food environment characteristics like home cooking, food preparation, and cooking method, and meal patterns.

## RESULTS

The sample of 201 seniors included 149 women (74%) and 52 men (26%), with an average age of 69.3 years. Of all respondents, 100 (50%) participants were married; 80 (39.8%) participants were employed, and 131 (65.2%) unemployed. Most participants (82%) had elementary or high school education; while only a few (15%) had undergraduate degrees or above. Their mothers' education was generally lower than their own, with 46% of their mothers having had no formal education. Most seniors self-reported physical illness (79%) and dental issues (58%). Regarding food environments and meal patterns, most seniors prepared their own meals (74%) and ate alone (69%). Regarding home cooking, 52% cooked their own breakfast, 41% cooked their own lunch, and 59% cooked their own dinner. Of all respondents, 93% had a kitchen, 96% had a refrigerator, and 40% had a home garden. Their most common cooking method was boiling soups (55%), followed by stir-frying (23%). Of the sample, 66% indicated that they had regularly eaten fruit and vegetables in their childhood.

Table 1 presents the sample characteristics and the quantity of fruit and vegetable intake by respondents. The mean daily intake was 266.6 grams, equally split between fruit and vegetables. This is well below the recommended quantity of 400 grams per day; however, the variation around the mean was high (*SD*=190.8).

**Table 1**
**Sample Size, Means, and Standard Deviations of Fruit and Vegetable Intake for Categories of Covariates (N=201)**

| Variables | Total Sample N (%) | Fruit | Vegetables | Fruit and Vegetables |
|---|---|---|---|---|
| | | Mean Grams/Day (SD) | | |
| **All** | 201 (100) | 133.6 (133.1) | 132.9 (95.9) | 266.6 (190.8) |
| **Gender** | | | | |
| Male | 52 (25.9) | 122.9 (156.7) | 115.4 (89.4) | 238.2 (215.4) |
| Female | 149 (74.1) | 137.4 (124.2) | 139.1 (97.6) | 276.4 (181.2) |
| **Food Preparation** | | | | |
| Self | 148 (73.6) | 142.5 (141.8) | 138.0 (97.5) | 280.5 (202.5) |
| Others | 53 (26.4) | 108.7 (102.5) | 118.8 (90.7) | 227.5 (148.4) |
| **Meal Companion** | | | | |
| Eat alone | 139 (69.2) | 118.8 (105.4) | 132.5 (97.6) | 251.3 (167.9) |
| With companion | 62 (30.8) | 166.8 (177.1) | 134.0 (92.8) | 300.8 (232.1) |
| **Breakfast Source** | | | | |
| No breakfast | 19 (9.5) | 110.1 (107.8) | 119.1 (108.6) | 229.2 (165.3) |
| Buying | 74 (36.8) | 117.7 (126.4) | 96.4 (80.5) | 214.1 (170.7) |
| Cooking | 105 (52.2) | 148.9 (142.5) | 158.9 (94.7) | 307.8 (201.2) |
| Others | 3 (1.5) | 141.0 (33.0) | 213.3 (122.2) | 354.3 (99.6) |
| **Lunch Source** | | | | |
| No lunch | 42 (20.9) | 115.1 (103.7) | 120.8 (85.9) | 235.9 (146.0) |
| Buying | 70 (34.8) | 116.4 (104.1) | 111.3 (83.2) | 227.8 (144.1) |
| Cooking | 82 (40.8) | 158.5 (165.2) | 164.5 (104.8) | 322.9 (234.2) |
| Others | 7 (3.5) | 125.7 (98.8) | 52.2 (29.4) | 178 (110.4) |
| **Dinner Source** | | | | |
| No dinner | 16 (8.0) | 88.6 (84.3) | 129.3 (98.2) | 217.9 (167.4) |
| Buying | 62 (30.8) | 112.3 (97.6) | 94.7 (88.4) | 207.0 (147.6) |
| Cooking | 118 (58.7) | 151.5 (152.8) | 156.2 (94.4) | 307.7 (207.3) |
| Others | 5 (2.5) | 121.1 (80.2) | 68.6 (14.0) | 189.7 (72.6) |
| **Kitchen** | | | | |
| No | 13 (6.5) | 89.7 (81.5) | 75.6 (84.4) | 165.3 (155.3) |
| Yes | 188 (93.5) | 136.7 (135.6) | 136.9 (95.6) | 273.6 (191.4) |
| **Refrigerator** | | | | |
| No | 7 (3.5) | 99.6 (100.2) | 115.9 (103.4) | 215.5 (138.5) |
| Yes | 194 (96.5) | 134.8 (134.2) | 133.5 (95.9) | 268.4 (192.5) |
| **Cooking Method** | | | | |
| Boil/soup | 109 (54.2) | 135.6 (119.6) | 134.6 (93.5) | 270.2 (175.1) |
| Stir fry | 47 (23.4) | 138.6 (153.4) | 141.5 (89.3) | 280.1 (200.3) |
| Fry | 15 (7.5) | 74.4 (75.8) | 83.0 (69.7) | 157.7 (123.9) |
| Curry | 18 (9.0) | 171.4 (197.2) | 169.5 (121.9) | 341.0 (276.8) |
| Other | 12 (6.0) | 113.3 (91.1) | 91.4 (105.6) | 204.8 (157.8) |
| **Education Level** | | | | |
| None | 6 (3.0) | 66.7 (53.3) | 62.9 (69.2) | 129.5 (118.9) |
| Elementary-Highschool | 164 (81.6) | 132.1 (137.6) | 129.3 (91.4) | 261.4 (190.5) |
| Undergraduate and above | 31 (15.4) | 154.8 (115.8) | 165.5 (114.2) | 320.4 (190.8) |
| **Mother's Education Level** | | | | |
| None | 93 (46.3) | 119.8 (130.7) | 116.1 (83.3) | 235.9 (173.7) |
| Elementary-Highschool | 106 (52.7) | 146.8 (135.5) | 149.4 (103.7) | 296.3 (201.8) |
| Undergraduate and above | 2 (1.0) | 74.3 (24.2) | 40.0 (8.1) | 114.3 (32.3) |
| **Home Garden** | | | | |
| No | 120 (59.7) | 125.6 (132.9) | 114.1 (93.1) | 239.7 (189.9) |
| Yes | 81 (40.3) | 145.5 (133.3) | 160.8 (93.8) | 306.3 (186.2) |
| **Childhood FV Habit** | | | | |
| No | 69 (34.3) | 126.2 (117.0) | 121.2 (93.2) | 247.5 (168.3) |
| Yes | 132.65.7) | 137.5 (141.1) | 139.0 (97.1) | 276.5 (201.5) |
| **Illness** | | | | |
| No | 43 (21.4) | 161.6 (174.9) | 132.6 (88.9) | 294.2 (219.0) |
| Yes | 158 (78.6) | 126.0 (118.8) | 133.0 (98.0) | 259.0 (182.5) |
| **Dental Issue** | | | | |
| No | 85 (42.3) | 142.7 (162.6) | 128.3 (102.5) | 270.9 (223.6) |
| Yes | 116 (57.7) | 127.0 (106.7) | 136.4 (91.1) | 263.3 (163.6) |
| **Marital Status** | | | | |
| Not currently married/cohabiting | 101 (50.2) | 136.7 (130.1) | 131.1 (99.2) | 267.8 (195.3) |
| Married | 100 (49.8) | 130.5 (136.7) | 134.7 (93.0) | 265.3 (187.2) |
| **Employment Status** | | | | |
| No | 131 (65.2) | 120.0 (111.8) | 135.3 (98.4) | 255.2 (172.7) |
| Yes | 80 (39.8) | 154.3 (158.6) | 129.4 (92.5) | 283.7 (215.4) |

## Regression Results

Table 2 lists the means of continuous covariates in the regression. Robust data handling procedures were employed by verifying the validity, consistency, anonymity, and completeness of the data while adjusting for confounders to ensure the integrity and validity of the results. All variables were checked for linearity through regression analysis, normality using Sapir-Wilk's tests, homoscedasticity through visual examination, and multicollinearity using correlational analysis. All assumptions were passed except for normality. Daily fruit and vegetable intake had the highest correlation with intention ($r$=0.36), followed by home-cooked meal consumption frequency ($r$=0.34) and cooking frequency ($r$=0.27), as well as nutritional knowledge. The Cronbach's alpha of the psychosocial measurements was above 0.70, signifying high reliability. The only exception was the 2-item intention measure (Cronbach α=0.68), representing moderate reliability.

**Table 2**
**Means and Cross-correlations of Continuous Variables used in the Analysis**

| Variables | *m (SD)* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Outcomes** | | | | | | | | | | | | |
| 1. Fruit and vegetable intake (gram/day) | 266.6 (190.8) | 1.00 | | | | | | | | | | |
| **Meal Patterns** | | | | | | | | | | | | |
| 2. Home-cooked meals/week | 8.5 (6.7) | 0.34 | 1.00 | | | | | | | | | |
| 3. Bought meals/week | 5.5 (5.7) | -0.10 | -0.56 | 1.00 | | | | | | | | |
| 4. Cooking frequency/week | 4.9 (4.3) | 0.27 | 0.58 | -0.41 | 1.00 | | | | | | | |
| **Psychosocial Factors (1-5)** | | | | | | | | | | | | |
| 5. Dietary self-efficacy | 3.9 (0.6) | 0.27 | 0.12 | -0.04 | 0.08 | (.77) | | | | | | |
| 6. Intention | 4.4 (0.9) | 0.36 | 0.23 | -0.11 | 0.11 | 0.68 | (.68) | | | | | |
| 7. Planning | 3.3 (1.2) | 0.14 | 0.09 | -0.14 | -0.01 | 0.26 | 0.36 | (.89) | | | | |
| 8. Social influence | 3.7 (0.9) | 0.20 | 0.12 | -0.13 | 0.08 | 0.46 | 0.42 | 0.47 | (.88) | | | |
| 9. Nutritional knowledge (1-10) | 6.3 (1.8) | 0.26 | 0.06 | -0.03 | 0.11 | 0.15 | 0.22 | 0.15 | 0.16 | 1.00 | | |
| **Demographics** | | | | | | | | | | | | |
| 10. Age (yrs) | 69.3 (8.6) | -0.15 | 0.11 | -0.16 | -0.09 | -0.04 | 0.05 | -0.08 | 0.05 | -0.17 | 1.00 | |
| 11. Household size (persons) | 3.7 (2.3) | 0.02 | 0.03 | -0.06 | -0.04 | -0.05 | -0.09 | 0.00 | 0.00 | 0.12 | -0.07 | 1.00 |

Note.
Cronbach's alpha values are in parentheses.

**Table 3**
**Comparison of Step 1 Unstandardized Coefficients and Standard Errors in Parentheses between the 5 Hierarchical Regression Models (N=201)**

| Predictors/Outcomes | Fruit | | Vegetables | | Fruit and Vegetable Quantity |
|---|---|---|---|---|---|
| | Frequency | Quantity | Frequency | Quantity | |
| **Demographics** | | | | | |
| Age (yrs) | -0.03 (0.02)† | -3.16 (1.28)** | -0.01 (0.02) | -1.05 (0.88) | -4.22 (1.76)** |
| Household size (persons) | -0.13 (0.07)† | -8.62 (4.05)** | -0.11 (0.06)† | -6.88 (2.78)* | -15.51 (5.56)** |
| Childhood FV habit (=1) | 0.47 (0.34) | 11.39 (19.43) | 0.85 (0.29)** | 10.78 (13.30) | 22.16 (26.71) |
| Illness (=1) | -0.04 (0.39) | -24.96 (22.40) | -0.05 (0.34) | -0.99 (15.34) | -25.94 (30.79) |
| Dental issue (=1) | 0.46 (0.32) | -12.34 (18.19) | 0.32 (0.27) | 8.02 (12.45) | -4.32 (25.00) |
| **Food Environment** | | | | | |
| Home garden (=1) | 0.73 (0.34)* | 5.41 (19.48) | 0.79 (0.29)** | 36.19 (13.34)** | 41.61 (26.78) |
| Kitchen (=1) | 0.48 (0.66) | 33.07 (37.65) | 0.92 (0.56)† | 32.47 (25.78) | 65.54 (51.75) |
| Refrigerator (=1) | -0.25 (0.88) | 31.02 (50.16) | 0.34 (0.75) | -9.59 (34.34) | 21.43 (68.95) |
| **Meal Pattern** | | | | | |
| Meal companion (=1) | 0.34 (0.35) | 44.58 (19.94)* | -0.01 (0.29) | -4.70 (13.66) | 39.88 (27.41) |
| Home-cooked meals/week | 0.05 (0.03)† | 5.93 (1.65)*** | 0.06 (0.02)* | 5.76 (1.13)*** | 11.69 (2.27)*** |
| Bought-meals/week | 0.01 (0.03) | 3.61 (1.69)* | -0.00 (0.03) | 0.69 (1.15) | 4.30 (2.31)† |
| **Constant** | 5.63 (1.98)** | 254.38 (112.23)* | 3.71 (1.68)* | 133.21 (76.85)† | 387.59 (154.27)* |
| **R-squared** | 0.10* | 0.15** | 0.19*** | 0.23*** | 0.22*** |
| **Adjusted R-squared** | 0.05 | 0.10 | 0.14 | 0.19 | 0.17 |

*Note.*
†$p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

A 2-step hierarchical regression was used for each of the five outcomes. Table 3 presents the findings of the first step of each outcome. The comparison reveals that models show varying levels of explanatory power, with demographics, food environment, and meal patterns contributing differently across models. Since the predictors have different units,

In Step 1, home-cooked meal consumption was a significant positive predictor across all outcomes, including fruit frequency (β=0.14, $p$<0.10), fruit quantity (β=0.30, $p$<0.001), vegetable frequency (β=0.21, $p$<0.05), vegetable quantity (β=0.40, $p$<0.001), and combined fruit and vegetable intake (β=0.41, $p$<0.001). This suggested that cooking meals at home is associated with increased fruit and vegetable intake. In contrast, household size was a significant negative predictor for both vegetable frequency (β=−0.12, $p$<0.10), vegetable quantity (β=−0.16, $p$<0.05), and the combined quantity (β=−0.19, $p$<0.01) but not for fruit alone. Hence, this makes it evident that seniors in larger households appear to eat vegetables less frequently and in smaller amounts than those in smaller households.

In Step 2, psychosocial variables were added to each model. This affected the strength of certain predictors. For instance, childhood fruit and vegetable consumption and home-cooked meals were no longer significant ($p$>0.10) as predictors of vegetable frequency. Overall, the expanded model explained more of the outcome variation than the simpler model. N R-squared) by 28% for fruit frequency, 14% for fruit quantity, 29% for vegetable frequency, 6% for vegetable quantity, and 10% for fruit and vegetable quantity combined. Table 4 shows unstandardized coefficients ($B$) for ease of interpretation, while the results adequately report the standardized coefficients (β) for a more coherent comparison of the predictors' strength. The full models also reveal several shared positive and negative predictors across the five outcomes, reflecting distinct fruit and vegetable intake drivers.

**Table 4**
**Comparison of Step 2 Unstandardized Coefficients and Standard Errors in Parentheses between the Full Regression Models (N=201)**

| Predictors/Outcome | Fruit | | Vegetables | | Fruit and Vegetable Quantity |
|---|---|---|---|---|---|
| | Frequency | Quantity | Frequency | Quantity | |
| **Demographics** | | | | | |
| Age (years) | -0.04 (0.02)† | -3.49 (1.24)** | 0.00 (0.02) | -0.73 (0.87) | -4.10 (1.73)* |
| Household size (persons) | -0.11 (0.06)† | -7.75 (3.83)* | -0.10 (0.05)* | -6.73 (2.74)** | -15.28 (5.36)** |
| Childhood FV habit (=1) | 0.18 (0.29) | -0.31 (18.40) | 0.36 (0.25) | -0.18 (13.63) | 1.78 (26.14) |
| Illness (=1) | 0.09 (0.34) | -17.95 (21.06) | 0.13 (0.28) | 0.82 (15.24) | -17.96 (29.58) |
| Dental issue (=1) | 0.18 (0.28) | -27.04 (17.56) | 0.11 (0.23) | 5.93 (12.55) | -19.82 (24.57) |
| **Food Environment** | | | | | |
| Home garden (=1) | 0.52 (0.30)† | -9.70 (18.74) | 0.60 (0.25)** | 30.85 (13.50)** | 22.49 (26.23) |
| Kitchen (=1) | 0.48 (0.57) | 24.15 (35.65) | 0.79 (0.47)†† | 25.82 (25.55) | 46.21 (49.89) |
| Refrigerator (=1) | -0.25 (0.75) | 10.57 (47.24) | 0.50 (0.62) | -10.63 (33.93) | -0.62 (66.11) |
| **Meal Pattern** | | | | | |
| Meal companion (=1) | 0.07 (0.30) | 38.26 (18.94)* | 0.06 (0.25) | -4.01 (13.56) | 37.16 (26.43) |
| Home-cooked meals/week | 0.03 (0.02) | 5.10 (1.55)** | 0.02 (0.02) | 4.79 (1.14)*** | 9.89 (2.19)*** |
| Bought-meals/week | -0.00 (0.02) | 3.39 (1.57)* | -0.00 (0.02) | 0.54 (1.13) | 3.99 (2.20)† |
| **Psychosocial Factors** | | | | | |
| Nutritional knowledge | 0.13 (0.08) | 4.97 (5.02) | -0.01 (0.06) | 4.97 (3.53) | 11.30 (6.95) |
| Dietary self-efficacy (F/V) | 0.31 (0.22) | 12.38 (14.06) | 0.42 (0.22)†† | 15.07 (12.01) | 16.61 (25.66) |
| Intention (F/V) | 0.90 (0.15)*** | 25.36 (9.58)** | 0.87 (0.14)*** | 13.95 (7.68)† | 40.28 (17.58)** |
| Action planning (F/V) | -0.16 (0.12) | 9.48 (7.69) | 0.15 (0.09)†† | 1.06 (4.86) | 3.13 (11.19) |
| Coping planning (F/V) | -0.10 (0.11) | -17.96 (6.60)** | -0.14 (0.09) | -3.34 (4.78) | -18.69 (9.39)** |
| Social influence (F/V) | 0.03 (0.18) | 11.50 (11.05) | -0.09 (0.13) | -1.43 (7.34) | 17.01 (16.10) |
| **Constant** | 1.90 (1.93) | 128.16 (121.30) | -1.13 (1.61) | -5.27 (87.54) | 136.16 (172.86) |
| **R-squared** | 0.39**** | 0.29**** | 0.47**** | 0.30** | 0.32**** |
| **Adjusted R-squared** | 0.33 | 0.23 | 0.42 | 0.23 | 0.26 |

*Note.*
†$p$ < 0.1, *$p$ < 0.05, **$p$ < 0.01, ***$p$ < 0.001

Among psychological factors, *Intention* was found to be the strongest significant predictor across every outcome, including fruit frequency (β=0.47, $p$<0.001), vegetable frequency (β=0.46, $p$<0.001), fruit quantity

(β=0.23, $p$<0.01), combined fruit and vegetable intake (β=0.21, $p$<0.05), and vegetable quantity (β=0.16, $p$<0.10). The significant role of *Intention* across all outcomes suggests that even a modest increase in intention to consume significantly increases fruit and vegetable intake. *Home-cooked meal* consumption also emerged as a significant positive predictor for quantity-based outcomes, such as fruit quantity (β=0.26, $p$<0.01), vegetable quantity (β=0.33, $p$<0.01), and combined fruit and vegetable intake (β=0.34, $p$<0.01). Hence, home-prepared meals and fruit and vegetable intake have a clear positive association.

Additionally, the presence of a *home garden* was positively associated with both vegetable intake frequency (β=0.15, $p$<0.05) and quantity (β=0.17, $p$<0.05). It also marginally predicted fruit frequency (β=0.11, $p$<0.10). *Household size* also consistently emerged as a significant negative predictor across all outcomes, ranging from combined intake (β=−0.19, $p$<0.01), vegetable quantity (β=0.17, $p$<0.05), fruit quantity (β=−0.14, $p$<0.05), vegetable intake frequency (β=−0.12, $p$<0.05), and fruit frequency (β=−0.11, $p$<0.10). This suggests that individuals in larger households consume fewer fruits and vegetables. The results also revealed *age* as a consistent negative predictor across all fruit outcomes, reflecting its influence on fruit intake. For fruit quantity, *age* negatively predicted consumption (β=−0.18, $p$<0.05). At the same time, it also significantly influenced combined fruit and vegetable intake (β=−0.15, $p$<0.05). Age also negatively affected fruit frequency, although the effect was only marginally significant (β=−0.12, $p$<0.10). Hence, this suggests that fruit and vegetable intake declines with age.

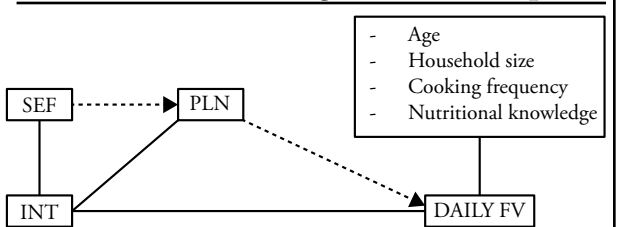
In conclusion, the hierarchical regression shows that adding psychosocial factors helps explain more of the variation in fruit and vegetable intake. There are also varying levels of impact of key fruit and vegetable intake predictors. While *intention* consistently emerged as the strongest predictor across all outcomes, *home-cooked* meal consumption positively influenced quantity-based outcomes; *home gardens* were associated with higher vegetable intake frequency and quantity. A significant finding was that *household size* and *age* were consistent negative predictors, with larger households and older individuals consuming fewer fruits and vegetables. These findings highlight the importance of the different predictor patterns that shape each intake outcome.

**Path Analysis**

Path analysis was used to examine the direct and indirect relationships between intention, self-efficacy, social influence, and combined planning on daily fruit and vegetable intake to provide a deeper understanding of the relationships between constructs in the model. Control variables, including age, household size, cooking frequency, and nutritional knowledge, were added to the model. The model included paths from intention to daily fruit and vegetable intake and planning, from planning to daily fruit and vegetable intake, and from social influence to daily fruit and vegetable intake. Additionally, self-efficacy was placed as a predictor of intention and planning to investigate its potential influence on the variables. The model fit was evaluated using multiple indices: $\chi^2(9)$ =19.61, p<0.05, *RMSEA*=0.08, 90% *CI* [0.03, 0.12], *CFI*=0.95, *TLI*=0.91, and *SRMR*=0.05. These indicate an acceptable overall fit.

All loadings are displayed in Figure 1. The results indicate that *intention* had a significant direct effect on combined fruit and vegetable intake (*B*=53.92, β=0.28, $p$<0.01) and on planning (*B*=0.40, β=0.34, $p$<0.01). However, planning did not significantly predict daily fruit and vegetable intake (*B*=−4.45, β=−0.07, $p$=0.67). However, self-efficacy significantly predicted intention (*B*=1.02, β=0.68, $p$<0.01) but did not significantly predict planning (*B*=0.72, β=0.04, $p$=0.65).

**Figure 1**
**Results of the Path Coefficients for Combined Fruit and Vegetable Consumption**




Note
SEF = dietary self-efficacy, INT = intention, PLN = planning, DAILY FV = daily fruit and vegetable intake (gram/day) †p < 0.1, *p < 0.05, **p < 0.01, ***p < 0.001.

These results thus reveal that *intention* significantly predicted daily fruit and vegetable intake and planning, emphasizing its key role in consumption and preparation. Self-efficacy though strongly influenced *intention* (β=0.68, p<0.01) but not planning. As a result, planning did not significantly

predict combined fruit and vegetable intake. This suggests that *intention* and self-efficacy are critical drivers of fruit and vegetable consumption, while planning may play a less important role.

## DISCUSSION

This study focused on describing fruit and vegetable consumption and exploring the relationships among psychosocial factors while considering demographics, meal patterns, and food environment factors in a sample of elderly adults in Bangkok, Thailand. The HAPA method was used to understand the psychological processes at play. The descriptive statistics reveal that fruit and vegetable intake among the elderly Thais was considerably lower than recommended for good health. This finding is consistent with past research in various populations.[7-10,13] Inadequate fruit and vegetable intake remains a concern affecting the health of the Thai population.

The significant predictors from the regression analysis revealed a mix of factors like intention, home-cooked meals, home gardens, age, and household size that affect fruit and vegetable intake. Previous studies also found that home cooking contributed significantly to more vegetable intake in the United Kingdom[24] and better dietary quality in the United States.[25] This suggests that food vendors typically prepare meals with a lot of rice and animal proteins but fewer vegetables. Therefore, many popular street foods in Thailand contain little or no vegetables. Future research should assess differences in the nutritional quality of purchased *versus* home-cooked food in the urban context and how it affects the quality of diets of people of varying ages. The presence of a home garden was another significant predictor in this study. This is consistent with Phulkerd et al.[10] for Thailand and other studies with older adults elsewhere.[26] There are several possible pathways to show how gardening can increase vegetable intake. Home gardens can increase the tendency to acquire enough vegetables to meet the recommendation level, thereby stimulating consumption.[27] Regular engagement with vegetables in a garden can also raise people's awareness and interest in healthy eating.[28]

Additionally, the study presented age and household size as negative predictors, confirming past research conducted in Thailand and elsewhere.[7,13,29,30] Elderly seniors may eat less fruit and vegetables as their physical activity levels decline with age. They may also prefer softer foods that are easier to swallow and require less chewing as muscle mass and strength are reduced in old age.[31] Cichero[31] noted that people over 65 years are seven times more likely to choke on food than 1-4-year-old children. Moreover, the negative influence of household size and age on fruit and vegetable intake may be related to the cost of fruit and vegetables.[32] Low income is a key challenge to afford healthy foods for seniors with specific health limitations, especially in a three-generation household where only a few members earn a stable income. Future studies could examine potential interventions to boost fruit and vegetable consumption in multigenerational households by alleviating their financial strain, such as providing food vouchers to enhance the affordability of various food options. Interestingly, these results suggested that intention, an individual-level factor, may play a more significant role in elderly people's diets than previously thought.

This study employed three HAPA predictor constructs. First, the positive relationship between intention and behavior highlights that those who intend to act on a specific behavior will be more likely to achieve it. Possible explanations are cultural factors like social norms and economic factors like access to infrastructure enabling the intended food behavior. The positive relationship between self-efficacy and intention suggests that individuals with greater belief in their ability to adopt healthy consumption behaviors are more likely to form strong intentions to engage in those behaviors. This relationship aligns with HAPA, which states that self-efficacy is a critical pre-intentional predictor. Nevertheless, self-efficacy does not statistically predict planning in this study, suggesting that believing in oneself does not always translate into a conscious decision or attempt to plan out how to consume healthy food in detail.

Second, the connection between intention and planning highlights that once individuals develop an intention to act on behavior, they are more likely to engage in detailed planning to achieve their health-related goals, supporting the transition from intention to action. However, the absence of the impact of planning on behavior suggests that specific structured planning does not always result in enacting this particular behavior. Third, the study observes deviations from previous HAPA studies, signifying context-specific differences in health behavior determinants among seniors regarding fruit and vegetable consumption. This relationship is evident in the additional volitional factors beyond

planning, which play a crucial role in bridging the intention-behavior gap. Other cognitive factors in the volitional phase include action control, maintenance self-efficacy, and recovery-efficacy. Their relationships suggest that once people form an action plan, they need to feel in control to execute the plan (action control), feel confident in their ability to maintain the behavior (maintenance self-efficacy), and recover from setbacks (recovery self-efficacy). Other external factors that act as barriers or resources may hinder the effect of other psychological variables in the model. For example, limited physical mobility can stop seniors from accessing a wider range of food options, making them reliant on fewer food outlets like mobile food trucks.

The results of the HAPA model in this study show an adequate fit overall, consistent with previous works that demonstrate a good fit with the data.[33,34] This is also consistent with a recent trend in health behavior research, which suggests that intention would predict health behavior through conscious planning following the HAPA model.[18] These HAPA factors could better identify which aspects can help seniors eat sufficient fruit and vegetables. This relationship provides an initial understanding of how seniors differ from other populations and how healthy food consumption differs from other healthy behaviors. More studies are needed to understand what better means can be used by older adults to achieve what they intend to eat. Specific factors that influence seniors more than other groups, such as limited mobility, habit retention, social isolation, specific dietary requirements for medical purposes, and social interactions, could influence their dietary behavior.



## CONCLUSION

This study shows low fruit and vegetable consumption among elderly seniors in Bangkok, Thailand. It offers valuable insights into factors associated with low fruit and vegetable consumption behavior, highlighting the interplay of demographics, meal patterns, food environment, and psychosocial factors. As populations age and societies become more urbanized, there is a growing need for targeted policies to encourage healthy dietary behaviors among senior citizens. City governments and non-governmental organizations can use this finding, for example, by organizing cooking classes, gardening workshops, or small goal-setting training programs for senior citizens. These activities can be organized through existing clubs for seniors. Providers must ensure that such activities are accessible for seniors, given their limited mobility and physical strength. Collaborations with local food vendors to improve meal quality could also be considered. Such interventions are worth considering because poor dietary behavior is associated with enormous and rapidly increasing health costs. The study has strong evidence that initiatives to promote healthy food behavior, particularly increased fruit and vegetable intake, are needed to reduce the pressure on national health systems and improve the quality of life of senior citizens.

This study sheds light on often-overlooked senior individuals, filling a critical research gap. Previous studies did not examine the relationships between psychosocial variables, meal patterns, food environments, and demographic factors. To fill this research gap, this study aimed to reexamine the current consumption pattern and explore structural relationships between personal, social, and environmental factors. During the conduct of the study, the study faced several limitations. First, the measure of fruit and vegetable intake relied on self-reported serving sizes. This method only provided a rough estimation of actual consumption, which could produce certain inaccuracies. As a result, recall bias, social desirability bias, and underreporting may introduce inaccuracies in the fruit and vegetable intake measurement. Second, differences in how fruits and vegetables are typically consumed may also impact responses, as fruit is more commonly eaten as a snack or dessert, while vegetables are usually part of meals. These differences could influence consumption patterns and reporting. The single-item intention measures for each fruit and vegetable showed only moderate reliability, which may be prone to errors. Third, planning scores in this study combine action and coping into a single measure, potentially obscuring nuanced differences between these constructs in the path analysis. Notably, many participants expressed that they do not consciously plan their dietary choices, viewing their intake as a habitual behavior rather than one that requires detailed conscious planning. In this case, habits could be a confounding variable that needs further research to identify its unique role in Thai seniors' dietary behavior. Future research will benefit from longitudinal designs to track dietary patterns and changes while triangulating different dietary measurements.

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**Human Subject Approval Statement**

The study plan was approved by the World Vegetable Center's Institutional Review Board (registration ID 2023-17). Participation in the study was virtually risk-free. Verbal and written consent were collected.

**Conflict of Interest**

The authors declare no conflict of interest.

**REFERENCES**

1. Passarelli S, Free CM, Shepon A, et al. Global estimation of dietary micronutrient inadequacies: a modelling analysis. *Lancet Glob Health*. 2024;12(10):e1590-e99. https://doi.org/10.1016/s2214-109x(24)00276-6
2. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2019;393(10184):1958-72. https://doi.org/10.1016/s0140-6736(19)30041-8
3. Wang DD, Li Y, Bhupathiraju SN, et al. Fruit and Vegetable Intake and Mortality: Results From 2 Prospective Cohort Studies of US Men and Women and a Meta-Analysis of 26 Cohort Studies. *Circulation*. 2021;143(17):1642-54. https://doi.org/10.1161/circulationaha.120.048996
4. WHO. *Diet, Nutrition and the Prevention of Chronic Diseases: Report of a Joint WHO/FAO Expert Consultation*. World Health Organization 2003. https://www.who.int/publications/i/item/924120916X
5. Kalmpourtzidou A, Eilander A, Talsma EF. Global Vegetable Intake and Supply Compared to Recommendations: A Systematic Review. *Nutrients*. 2020;12(6):1558. https://doi.org/10.3390/nu12061558
6. Hall JN, Moore S, Harper SB, et al. Global variability in fruit and vegetable consumption. *Am J Prev Med*. 2009;36(5):402-09.e5. https://doi.org/10.1016/j.amepre.2009.01.029
7. Satheannoppakao W, Aekplakorn W, Pradipasen M. Fruit and vegetable consumption and its recommended intake associated with sociodemographic factors: Thailand National Health Examination Survey III. *Public Health Nutr*. 2009;12(11):2192-8. https://doi.org/10.1017/s1368980009005837
8. Phulkerd S, Thapsuwan S, Thongcharoenchupong N, et al. Sociodemographic differences affecting insufficient fruit and vegetable intake: a population-based household survey of Thai people. *J Health Res*. 2020;34(5):419-29. https://doi.org/10.1108/JHR-07-2019-0150
9. Hong SA, Piaseu N. Prevalence and determinants of sufficient fruit and vegetable consumption among primary school children in Nakhon Pathom, Thailand. *Nutr Res Pract*. 2017;11(2):130-38. https://doi.org/10.4162/nrp.2017.11.2.130
10. Phulkerd S, Thapsuwan S, Soottipong Gray R, et al. Characterizing Urban Home Gardening and Associated Factors to Shape Fruit and Vegetable Consumption among Non-Farmers in Thailand. *Int J Environ Res Public Health*. 2020;17(15):5400. https://doi.org/10.3390/ijerph17155400
11. Miller V, Yusuf S, Chow CK, et al. Availability, affordability, and consumption of fruits and vegetables in 18 countries across income levels: findings from the Prospective Urban Rural Epidemiology (PURE) study. *Lancet Glob Health*. 2016;4(10):e695-703. https://doi.org/10.1016/s2214-109x(16)30186-3
12. Stadlmayr B, Trübswasser U, McMullin S, et al. Factors affecting fruit and vegetable consumption and purchase behavior of adults in sub-Saharan Africa: A rapid review. *Front Nutr*. 2023;10:1113013. https://doi.org/10.3389/fnut.2023.1113013
13. Silarak K, Chompikul J, Mongkolchati A. Prevalence of Insufficient Fruit and Vegetable Intake and Associated Factors in Older Adults in Thailand. *J Public Health Dev*. 2017;15(1):81-99. https://he01.tci-thaijo.org/index.php/AIHD-MU/article/view/92822
14. Chalermsri C, Herzig van Wees S, Ziaei S, et al. Exploring the Experience and Determinants of the Food Choices and Eating Practices of Elderly Thai People: A Qualitative Study. *Nutrients*. 2020;12(11):3497. https://doi.org/10.3390/nu12113497

15. Nicklett EJ, Kadell AR. Fruit and vegetable intake among older adults: a scoping review. *Maturitas*. 2013;75(4):305-12. https://doi.org/10.1016/j.maturitas.2013.05.005
16. Sawyer ADM, van Lenthe F, Kamphuis CBM, et al. Dynamics of the complex food environment underlying dietary intake in low-income groups: a systems map of associations extracted from a systematic umbrella literature review. *Int J Behav Nutr Phys Act*. 2021;18(1):96. https://doi.org/10.1186/s12966-021-01164-1
17. Maynard M, Gunnell D, Ness AR, et al. What influences diet in early old age? Prospective and cross-sectional analyses of the Boyd Orr cohort. *Eur J Public Health*. 2006;16(3):316-24. https://doi.org/10.1093/eurpub/cki167
18. Schwarzer R. Modeling Health Behavior Change: How to Predict and Modify the Adoption and Maintenance of Health Behaviors. *Appl Psychol*. 2008;57(1):1-29. https://doi.org/10.1111/j.1464-0597.2007.00325.x
19. Hromi-Fiedler A, Chapman D, Segura-Pérez S, et al. Barriers and Facilitators to Improve Fruit and Vegetable Intake Among WIC-Eligible Pregnant Latinas: An Application of the Health Action Process Approach Framework. *J Nutr Educ Behav*. 2016;48(7):468-77.e1. https://doi.org/10.1016/j.jneb.2016.04.398
20. Brown DJ, Hagger MS, Morrissey S, et al. Predicting fruit and vegetable consumption in long-haul heavy goods vehicle drivers: Application of a multi-theory, dual-phase model and the contribution of past behaviour. *Appetite*. 2018;121:326-36. https://doi.org/10.1016/j.appet.2017.11.106
21. Zhou G, Gan Y, Miao M, et al. The role of action control and action planning on fruit and vegetable consumption. *Appetite*. 2015;91:64-8. https://doi.org/10.1016/j.appet.2015.03.022
22. Siriraj Diabetes Center. *Food Exchange Lists*. 2015. https://www.si.mahidol.ac.th/th/division/diabetes/admin/knowledges_files/11_44_1.pdf
23. Pandey S, Budhathoki M, Yadav DK. Psychosocial Determinants of Vegetable Intake Among Nepalese Young Adults: An Exploratory Survey. *Front Nutr*. 2021;8:688059. https://doi.org/10.3389/fnut.2021.688059
24. Mills S, Brown H, Wrieden W, et al. Frequency of eating home cooked meals and potential benefits for diet and health: cross-sectional analysis of a population-based cohort study. *Int J Behav Nutr Phys Act*. 2017;14(1):109. https://doi.org/10.1186/s12966-017-0567-y
25. Wolfson JA, Leung CW, Richardson CR. More frequent cooking at home is associated with higher Healthy Eating Index-2015 score. *Public Health Nutr*. 2020;23(13):2384-94. https://doi.org/10.1017/s1368980019003549
26. Sommerfeld AJ, McFarland AL, Waliczek TM, et al. Growing Minds: Evaluating the Relationship between Gardening and Fruit and Vegetable Consumption in Older Adults. *Horttechnology*. 2010;20(4):711-17. https://doi.org/10.21273/HORTTECH.20.4.711
27. Robinson-Oghogho JN, Thorpe RJ, Jr. Garden Access, Race and Vegetable Acquisition among U.S. Adults: Findings from a National Survey. *Int J Environ Res Public Health*. 2021;18(22):12059. https://doi.org/10.3390/ijerph182212059
28. Palar K, Lemus Hufstedler E, Hernandez K, et al. Nutrition and Health Improvements After Participation in an Urban Home Garden Program. *J Nutr Educ Behav*. 2019;51(9):1037-46. https://doi.org/10.1016/j.jneb.2019.06.028
29. Boukouvalas G, Shankar B, Bruce Traill W. Determinants of fruit and vegetable intake in England: a re-examination based on quantile regression. *Public Health Nutr*. 2009;12(11):2183-91. https://doi.org/10.1017/s1368980009005175
30. Pessoa MC, Mendes LL, Gomes CS, et al. Food environment and fruit and vegetable intake in a urban population: a multilevel analysis. *BMC Public Health*. 2015;15:1012. https://doi.org/10.1186/s12889-015-2277-1
31. Cichero JAY. Age-Related Changes to Eating and Swallowing Impact Frailty: Aspiration, Choking Risk, Modified Food Texture and Autonomy of Choice. *Geriatrics (Basel)*. 2018;3(4):69. https://doi.org/10.3390/geriatrics3040069
32. Rao M, Afshin A, Singh G, et al. Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. *BMJ Open*. 2013;3(12):e004277. https://doi.org/10.1136/bmjopen-2013-004277
33. Parkinson J, Hannan T, McDonald N, et al. Health action process approach: promoting physical activity, and fruit and vegetable intake among Australian adults. *Health Promot Int*. 2023;38(4):daad095. https://doi.org/10.1093/heapro/daad095
34. Zhang CQ, Zhang R, Schwarzer R, et al. A meta-analysis of the health action process approach. *Health Psychol*. 2019;38(7):623-37. https://doi.org/10.1037/hea0000728