

Original Research



Can tailored home-delivered meal services alleviate self-rated frailty of the low-income older adults in Korea?

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Conflict of Interest

The authors declare no potential conflicts of interests.

ABSTRACT

BACKGROUND/OBJECTIVES: This study aimed to examine whether the tailored home-delivered meal (HDM) services included nutrition counseling impacts alleviating self-rated frailty among low-income older adults in Korea.

SUBJECTS/METHODS: Pre- and post-test were implemented on May 27 and on November 25 in 2019 during 3 weeks, respectively, before and after the 6 months intervention program. Participants completed a questionnaire measuring frailty, malnutrition, food security, depression, and underlying diseases. Initially, 136 older adults were selected as participants for this study, they were recipients of a free meal program from 2 senior welfare centers in Seoul, the final sample size of those who completed the intervention program was 117 (female 70.9%, male 29.1%). Statistical analyses were conducted with IBM SPSS package program, paired *t*-test and χ^2 test to validate the test.

RESULTS: There were statistically significant differences in the score of the Tilburg Frailty Indicator (TFI) before and after receiving the tailored HDM services (pre-test 9.46, post-test 2.8, $P < 0.01$). The differences in the score of TFI by 3 risk groups at the pre-test decreased as a result of receiving these services.

CONCLUSIONS: The tailored HDM services alleviated the self-rated frailty of low-income older adults with limited mobility in a community setting. Based on the positive outcomes this study could be applied to developing social services for aging in place.

Keywords: Aged; meals; malnutrition; poverty; frailty

INTRODUCTION

The number of elderly populations aged 65 and over in South Korea have reached 9 million, indicating 17.5% of the population in 2022. South Korea, is about to enter a super-aged society in 2025, is faced with setting the direction of its social policy based on an understanding of the aging population [1]. As the ratio of aging population in a society increases, the number of economically, physically, and emotionally vulnerable members of society increase [2]. Against this backdrop, community care has emerged as a policy agenda, with social interest in food security for low-income older adults growing in Korea [3]. Despite

Author Contributions

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the Korean government offering HDM services to poor older adults in the community for the past 20 years, there are still challenges to securing nutrition for the elderly [4]. According to the 2020 National Survey of Older Koreans, 27.8% of older Koreans aged 65 and over had more than 3 types of chronic diseases associated with nutritional problems, and Koreans aged 85 and over who live in poverty in were even worse conditions [5]. The results of the Korean National Health and Nutritional Survey in 2018 revealed that the prevalence of hypercholesterolemia and obesity have continued to increase, and the prevalence of obesity in men is 42.1%, much higher than that of women (25.5%). Meanwhile the prevalence of the hypercholesterolemia was similar in men and women, with 21.4% and 20.9%, respectively [6]. Considering Korea's high elderly poverty rate and the weakening of family care functions [7,8], meal services should be designed to ensure that low-income older adults with limited mobility living in the community have access to appropriate food.

Low-income older adults who have mobility issues and have difficulty in getting sufficient nutrition have a higher risk of becoming frail [4,9]. Frailty is a common geriatric condition that is vulnerable to disorders and diseases due to a decline in physical and cognitive function [10]. Frailty includes complex symptoms such as reduced muscle strength, fatigue, low physical activity, slow walking speed, and weight loss [11]. Without proper management, frailty is accelerated with aging and increases the risk of hospitalization, institutionalization, and mortality [10,12]. Especially, nutrition is important for maintaining physical function and preventing frailty in later life [13,14]. Malnutrition causes weight loss, muscle and bone impairment, and a decrease in physical activity [11,15-17].

Public or privately funded nutrition programs such as food vouchers, food banks, congregate meals, and home-delivered meals (HDMs) support food-insecure people in Korea [3,4,18-20]. Of these nutrition programs, some research has demonstrated that HDM is the most basic community-based service for older adults who have limited outdoor activities and cannot prepare their own meals [21-24]. Research are pointing out that HDM is effective for improving nutrition intake, especially energy and protein intake for the vulnerable elderly [4,24]. Regular contact offered through HDM also reduces community-dwelling older adults' loneliness and depressive symptoms which can increase the prevalence of frailty among them [25,26]. Furthermore, HDM not only improves frail older adults' nutrition but can also reduce social expenditures of hospitalization and nursing home care [11,13,14,27].

However, if HDM disregards the health status or dietary preferences of older adults it can limit positive effects in terms of frailty [18,28]. For instance, even if older adults are provided with HDM services, dental maladies or impaired senses of smell or taste among older adults can lead to malnutrition [27]. If the meals alleviate older adults' diseases but do not meet their dietary preferences, the amount of food intake will decrease [18]. From this perspective, the qualitative aspect of how well the HDM services are tailored to their preference can reflect the needs of the vulnerable older adults and should be considered to prevent food insecurity and to realize aging in place [28]. Although studies are proving positive effects on medically tailored meal intervention for patients with specific diseases [28,29], researches verifying the effectiveness of tailored HDM for community-dwelling older adults are limited.

Thus, this study aims to determine whether a tailored HDM service helps reduce the level of frailty among low-income older adults with limited mobility in the community. This study is to design a tailored HDM service including nutrition counseling for low-income older adults living in a community that can delay the deterioration of health and live longer in a familiar

place. The assumption of this study is that the degree of self-rated frailty among participants would decrease after the tailored HDM service.

SUBJECTS AND METHODS

Intervention program: tailored HDM service for older adults

Participants were recipients of HDM services from 2 senior welfare centers in Seoul. The eligibility requirements for HDM services are 60 years and older, community-dwelling, low income, and being challenged with mobility issues at home [4]. The tailored HDM service was a trial project which offered both need-based meals and home-visit nutrition counseling. To speculate on the participants' characteristics, HDM staffs including a dietitian visited the participants and conducted assessments on masticatory function, frailty, depression, nutritional status, and referred to diseases diagnosed by the doctors of the participants.

Each participant received a lunch box every day during weekdays from June 17th to December 16th, 2019 based on the budget plan of Seoul Metropolitan Government. The meals were planned in compliance with the guideline of the Korean Dietary Intake Reference [30]. The dietitians assessed the participants' dietary needs on whether they had chronic diseases or impaired oral/chewing functions. Thus, 4 types of therapeutic diets were prepared and offered: 1 normal diet, 1 diet for chronic diseases such as diabetes and hypertension, and 1 for a renal diet. All diets included 2 types of rice dishes such as cooked rice or rice porridge depending on their oral function ability, chewing status, and preference. The low sugar/sodium lunch box was constructed considering the chronic diseases to which 9 of 10 participants were exposed, such as hypertension or diabetes. The lunch box with protein restriction was provided to 11 participants with kidney disease.

With the tailored HDM, a dietitian at each senior welfare center provided on-site nutrition counseling services as well as food safety ensuring tips at home. The purpose of the counseling was to educate the importance of proper and hygienic food intake and to induce behavioral changes [31]. The counseling service included how to manage a dietary plan for health and how to properly handle delivered meals to prevent food poisoning. The frequency of nutrition counseling services was determined by a comprehensive consideration of the participants' health and nutrition status as well as the limited time and dietitians' manpower. The frequency of the counseling services provided by visiting the participants' home were based on each group's health conditions: once every 2 weeks for the higher risk group, once every 4 weeks for the medium group, and once every 6 weeks for the lower risk group. The duration of each visit lasted at a minimum of 20 minutes to a maximum of 40 minutes.

Study design

This study used a 1 group pretest-posttest study design. The participants were selected from a pool of clients that were already receiving HDM services. HDM staff visited the participants and conducted assessments 2 weeks prior to the first receipt of HDM services and again 2 weeks after the last service check-up on the participants' health status, nutritional status, and socio-demographic characteristics. HDM staffs were trained for each questionnaire before the assessments. Due to the characteristics of the older participants, responses were collected by HDM staffs through in-person interviews. Questionnaires about service satisfaction were only added in the post-survey. A total of 136 participants were selected for this study, but only 117 participants remained in the end because of moving, death, or refusal

of the participants. This study was approved by the Institutional Review Board at Dankook University (IRB number: 2019-09-041) and was compliant with all guidelines.

Instrument for measurements

To estimate the impact of the tailored HDM services, the study assessed changes in the participants' health status from before and after the services were rendered. With frailty [12,32] the instruments determining the dietary status and health risks of the participants are as follows: depression [33,34], malnutrition [35,36], dietary hygiene safety [37], food security [38], and diagnoses of disease from doctors.

Frailty

To verify changes in frailty, participants were asked to respond to 15 items from Tilburg Frailty Indicator (TFI) part B which consists of user-friendly questionnaires used for assessing frail community-dwelling older adults. Participants completed 11 items with yes/no categories and 4 items with yes/no/sometimes categories. All 15 items were scored one or zero. The instrument consisted of 3 domains: a physical domain (items 1–8), a psychological domain (items 9–12), and a social domain (items 13–15). The scores range from 0 to 15, higher scores mean a higher level of frailty. Scores 5 or higher indicated that people were frailer [12,32]. Cronbach's alpha scores for the total of 15 items is 0.79 and from 0.67 to 0.78 for each domain.

Depression

To measure depressive symptoms, this study used the Korean version of the Short Form Generic Depression Scale (SGDS-K) [33,34] the questionnaires consisted of 15 items. Participants answered "yes" or "no" for each of the 15 items. The total score ranges from 0 to 15. The higher the scores show the more severe the depressive symptoms are. An older adult who scores 8 or more on the SGDS-K is defined as a depression case [34]. The reliability of SGDS-K is strong (Cronbach's alpha of 0.90) [39].

Malnutrition

Nutritional status was quantified with the Minimal Nutrition Assessment (MNA) which consists of 6 screening items and 12 assessment items [35]. The total score ranges from 0 to 30 and less than 17 means malnourished; 17 to 23.5 means at risk of malnutrition; and more than 24 points means normal nutrition [36].

Dietary hygiene safety

Dietary hygiene safety status was quantified with 7 items related to personal hygiene, food stores, and food preparation in meal management at home [37]. The total score ranges from 0 to 10, categorized by the distribution of samples into 3 groups: less than 7.5 means poor dietary hygiene safety; 7.5 to 9.0 means improving; and 7.5 to 10 means great.

Food security

Food security is the ability of households and individuals to access sufficient and nutritious food. To measure the adequacy of participants' access to food, the Food Insecurity Experience Scale (FIES) was used, which is an 8-item questionnaire with dichotomous yes/no responses. The total score of the FIES items is 8. This study considered participants who scored one or more on FIES as food insecure [38].

Disease diagnosed by doctor

To find out what kind of diseases the participants were suffering from; this study investigated the disease that was diagnosed and treated or managed by their family doctors. Participants responded that they were diagnosed and treated by their doctors for hypertension, diabetes, stroke, kidney diseases, arthritis, dysuria, cancers, cardiovascular diseases, and respiratory diseases. If there was a diagnosed disease other than the 9 diseases aforementioned, the participants were asked to name the disease in detail.

Statistical analysis

This study designed a one-group pre/post-test and employed a paired *t*-test. To examine effect sizes, this study used Cohen's *d* statistic calculated by the pooled mean and divided by the SD for the independent samples *t*-test [40]. Also, the χ^2 test was used to compare the difference in frailty among the risk groups before and after receiving the HDM service. The IBM SPSS for Windows 24.0 (SPSS Inc., Chicago, IL, USA) was used to analyze statistical data.

RESULTS

Background characteristics

The average age of the 117 participants was 80.98 years old. Approximately 87.18% of participants (*n* = 102) lived alone and 70.94% (*n* = 83) were female. About 33.33% of the participants (*n* = 39) had never received formal education or did not graduate from elementary school. The average monthly income of the participants was 10% of the average monthly urban wage in Korea (Table 1) [5].

Nutritional, psychological, functional and dietary health status of participants

Table 2 represents the characteristics of the nutritional, psychological, functional, and dietary health status of the participants. All participants were at risk of malnutrition: malnutrition 30.77%, and risk of malnutrition 69.23%. The prevalence of frailty among participants was 91.45%. More than half of the participants (54.70%, *n* = 64) had depressive symptoms. About 69.23% of the participants (*n* = 81) did not have access to adequate food. Prevalence of diabetes, hypertension, and arthritis were all 29.91%, respectively. That of dysuria was also high at 27.35%.

Table 1. Sample characteristics (*n* = 117)

Characteristic	Values
Mean age (yrs)	80.98 ± 6.24
Sex	
Female	83 (70.94)
Male	34 (29.06)
Living arrangement	
Living alone	102 (87.18)
Living with other	15 (12.82)
Education	
None	39 (33.33)
Elementary school	35 (29.91)
Middle school	17 (14.53)
High school	17 (14.53)
College	9 (7.69)
Monthly income (1,000 w)	502.92 ± 195.45 K

Values are presented as mean ± SD or number (%).

Table 2. Baseline status for classifying participants into 3 risk groups (n = 117)

Selected background variable	Values
Frailty (range: 0–15)	
Yes (5–15)	107 (91.45)
No (0–4)	10 (8.55)
Depression (range: 0–15)	
Yes (8–15)	64 (54.70)
No (0–7)	53 (45.30)
Nutritional status (range: 0–30)	
Malnutrition (0–17)	36 (30.77)
Risk of malnutrition (17.1–23.5)	81 (69.23)
No malnutrition (23.6–30.0)	0 (0.00)
Dietary hygiene safety (range: 0–10)	
Poor (0–7.5)	24 (20.51)
Improving (7.6–9.0)	54 (46.15)
Great (9.1–10.0)	39 (33.33)
Food security (range: 0–8)	
Unsecured (1–8)	81 (69.23)
Secured (0)	36 (30.77)
Disease diagnosed from doctor (multiple choices)	
Diabetes	35 (29.91)
Hypertension	35 (29.91)
Arthritis	35 (29.91)
Dysuria	32 (27.35)
Cardiovascular disease	21 (17.95)
Stroke	14 (11.97)
Kidney disease	10 (8.55)
Respiratory disease	8 (6.84)
Dementia	4 (3.42)
Etc ¹⁾	65 (55.56)
Risk group ²⁾	
High	29 (24.79)
Medium	51 (43.59)
Low	37 (31.62)

Values are presented as numbers (%).

¹⁾Liver cirrhosis, thyroiditis, hyperlipidemia, osteoporosis, asthma, fracture, glaucoma, panic disorder, hyperlipidemia, sleep disorder, spinal stenosis, pancreatitis, gout, hematologic malignancy.

²⁾Classified 3 groups by dietitian's nutrition assessment based on frailty, depression, malnutrition from Minimal Nutrition Assessment, food security and health indicators of the participants.

To deliver appropriate and effective counseling services in a timely schedule, participants were classified into high, medium, and low dietary risk groups based on the comprehensive diagnosis from the above results of the severity of frailty, depression, malnutrition, hygiene safety, food insecurity, and diseases they had. Participants who were classified “poor” in all 6 areas were classified as a high-risk group (24.79%); 3 to 5 were classified as the medium-risk group (43.59%); 2 or fewer risk areas were classified as the low-risk group (31.62%). Dietitians visited the participants in the high-risk group once every 2 weeks, the medium-risk group once every 4 weeks, and the low-risk group once every 6 weeks to offer counseling services.

Changes in participants' frailty 6 months before and after tailored HDM services

As shown in **Table 2**, the number of frail participants decreased after receiving tailored HDM services. The proportion of frail participants decreased from 91.5%, before receiving the tailored HDM service, to 68.4%, after using the service. In other words, 23.1% of frail participants became normal after receiving the services. As presented in **Table 3**, the tailored HDM service shows a statistically significant influence on the total TFI score of participants ($P < 0.01$). After receiving the services, the total TFI score of participants decreased by half from a mean of 9.46 to 6.62 out of the possible maximum 15 points, meaning that improvement in

frailty was observed in the participants. A stratified analysis of TFI domains such as physical, psychological, and social frailty proved that tailored HDM services significantly influenced the participants' ratings on 13 of 15 items on the scale. The range of estimates of Cohen's *d* was wide and it proved a moderately medium effect size ($0.28 < d < 2.96$, $M(d) \approx 0.72$) (Table 3).

In the physical domain, all 8 items of TFI showed statistically significant differences between the pre-test and the post-test among the participants (pre-test 4.74 out of 8 points, post-test 3.31, difference 1.33, $P < 0.001$). After receiving tailored HDM services, participants felt healthier (item 1, pre-test 0.74, post-test 0.61, $P < 0.05$) and less tired (item 8, pre-test 0.74, post-test 0.50, $P < 0.001$) than before receiving the services. The degree of disturbance in daily life due to physical function decline in terms of walking (item 3, pre-test 0.83, post-test 0.63, $P < 0.001$), maintaining balance (item 4, pre-test 0.79, post-test 0.61, $P < 0.001$), hearing (item 5, pre-test 0.38, post-test 0.18, $P < 0.01$), vision (item 6, pre-test 0.50, post-test 0.25, $P < 0.01$), and strength in hand (item 7, pre-test 0.62, post-test 0.46, $P < 0.001$), meaning there was significant improvement of their frailty. Unexplained weight loss also declined (item 2, pre-test 0.15, post-test 0.08, $P < 0.001$). For the participants, there were statistically significant differences in 3 of 4 psychological domains (pre-test 2.29 out of 4 points, post-test 1.55, difference 0.74, $P < 0.001$). Participants' experiencing problems with memory (item 9, pre-test 0.31, post-test 0.15, $P < 0.01$) were less frequent than before receipt of the HDM services. Participants feeling depressed (item 10, pre-test 0.82, post-test 0.52, $P < 0.001$) and anxious (item 11, pre-test 0.79, post-test 0.55, $P < 0.001$) also decreased. However, there were no statistically significant differences in coping with daily issues before and after HDM services (item 12, pre-test 0.37, post-test 0.33, $P > 0.05$). Statistically significant changes were also found in 2 of the 3 social domain items after 6 months of receiving the tailored HDM services (pre-test 2.43 out of 3 points, post-test 1.77, difference 0.66, $P < 0.001$). After receiving the services, participants wanted to socialize more with

Table 3. Pretest and posttest results on TFI 6 months before and after tailored HDM service (n = 117)

Items	Frailty	Pre-test	Post-test	PMD \pm SD (95% CI)	Two-tailed t-statistic, effect size
		Mean \pm SD	Mean \pm SD		
1–15	Total ¹⁾	4.46 \pm 2.96	3.31 \pm 2.19	2.84 \pm 3.02, (2.29, 3.39)	t(116) = 10.17 ^{***} , d = 0.92
1–8	Physical domain ²⁾	4.74 \pm 2.20	3.31 \pm 2.27	1.33 \pm 2.16, (1.04, 1.83)	t(116) = 7.19 ^{***} , d = 0.64
1	Poor physical health	0.74 \pm 0.44	0.61 \pm 0.49	0.14 \pm 0.54, (0.04, 0.24)	t(116) = 2.74 [*] , d = 0.28
2	Unexplained weight loss	0.15 \pm 0.36	0.08 \pm 0.27	0.07 \pm 0.42, (0.00, 0.15)	t(116) = 2.00 ^{***} , d = 0.22
3	Difficulty in walking	0.83 \pm 0.38	0.63 \pm 0.48	0.20 \pm 0.49, (0.11, 0.28)	t(116) = 4.45 ^{***} , d = 0.46
4	Difficulty maintaining balance	0.79 \pm 0.41	0.61 \pm 0.49	0.18 \pm 0.52, (0.08, 0.27)	t(116) = 3.74 ^{***} , d = 0.40
5	Poor hearing	0.38 \pm 0.49	0.18 \pm 0.39	0.21 \pm 0.48, (0.12, 0.29)	t(116) = 4.59 ^{**} , d = 0.45
6	Poor vision	0.50 \pm 0.50	0.25 \pm 0.43	0.25 \pm (0.57), (0.14, 0.35)	t(116) = 4.70 ^{***} , d = 0.53
7	Strength in hands	0.62 \pm 0.49	0.46 \pm 0.50	0.15 \pm (0.58), (0.05, 0.26)	t(116) = 2.86 ^{***} , d = 0.32
8	Physical tiredness	0.74 \pm 0.44	0.50 \pm 0.50	0.24 \pm (0.52), (0.14, 0.33)	t(116) = 4.98 ^{***} , d = 0.32
9–12	Psychological domain ³⁾	2.29 \pm 1.08	1.55 \pm 1.29	0.74 \pm (1.42), (0.48, 1.00)	t(116) = 5.68 ^{***} , d = 0.62
9	Problems with memory	0.31 \pm 0.46	0.15 \pm 0.35	0.16 \pm (0.53), (0.07, 0.26)	t(116) = 3.35 ^{**} , d = 0.39
10	Feeling down	0.82 \pm 0.39	0.52 \pm 0.50	0.30 \pm (0.56), (0.20, 0.40)	t(116) = 5.77 ^{***} , d = 0.67
11	Feeling nervous or anxious	0.79 \pm 0.41	0.55 \pm 0.50	0.25 \pm (0.57), (0.14, 0.35)	t(116) = 4.70 ^{***} , d = 0.52
12	Able to cope with problems	0.37 \pm 0.48	0.33 \pm 0.47	0.03 \pm (0.56), (–0.07, 0.14)	t(116) = 0.67, d = 0.08
13–15	Social domain ⁴⁾	2.43 \pm 0.65	1.77 \pm 0.50	0.66 \pm (0.66), (0.54, 0.78)	t(116) = 10.81 ^{***} , d = 1.14
13	Living alone	0.88 \pm 0.33	0.85 \pm 0.35	0.03 \pm (0.24), (–0.02, 0.07)	t(116) = 1.14, d = 0.09
14	Social relations	0.71 \pm 0.46	0.90 \pm 0.31	–0.19 \pm (0.51), (–0.28, –0.10)	t(116) = –4.00 ^{***} , d = 0.49
15	Social support	0.84 \pm 0.37	0.02 \pm 0.13	0.82 \pm (0.41), (0.75, 0.90)	t(116) = 21.80 ^{***} , d = 2.96

Effect size: Cohen's *d* (N/A means homogeneity of variance was not assumed).

TFI, Tilburg Frailty Indicator; HDM, home-delivered meal; PMD, paired mean differences; CI, confidential interval (lower limit, upper limit). Effect size: Cohen's *d* (N/A means homogeneity of variance was not assumed).

* $P < 0.05$ ** $P < 0.01$; *** $P < 0.001$

¹⁾Possible maximum score of 15 points; ²⁾Possible maximum score of 8 points; ³⁾Possible maximum score of 4 points; ⁴⁾Possible maximum score of 3 points; higher score means higher.

Table 4. Results from χ^2 analyses of frailty by risk group baseline and 6 months after the tailored HDM services (n = 117)

Risk group	Pre-test	Post-test	PMD \pm SD, (95% CI)	Two-tailed <i>t</i> -statistic, effect size	Pre-test	Post-test
	Mean \pm SD	Mean \pm SD			χ^2	χ^2
Low	8.14 \pm 3.26	5.92 \pm 3.18	2.22 \pm 3.20, (1.15, 3.29)	<i>t</i> (36) = 4.22***, <i>d</i> = 0.69	7.869***	1.065
Medium	9.63 \pm 2.91	6.51 \pm 2.76	3.12 \pm 2.75, (2.34, 3.89)	<i>t</i> (50) = 8.080***, <i>d</i> = 1.10		
High	10.86 \pm 1.77	7.00 \pm 3.23	3.86 \pm 2.89, (2.76, 4.96)	<i>t</i> (28) = 7.20***, <i>d</i> = 2.92		

Effect size: Cohen's *d* (N/A means homogeneity of variance was not assumed).

HDM, home-delivered meal; PMD, paired mean differences; CI, confidential interval (lower limit, upper limit).

****P* < 0.001.

people than before and felt that they were getting the necessary amount of help from others (item 14, pre-test 0.71, post-test 0.9, difference -0.19, *P* < 0.001).

Changes in participants' frailty by risk group 6 months before and after tailored HDM services

Table 4 shows subjective frailty improved, showing the decreased mean score of frailty in all risk groups after using the tailored HDM services. The results of χ^2 analyses also prove that the tailored HDM services offset a difference in TFI scores among the 3 risk groups. For instance, there was a significant difference in TFI scores among the risk groups before using the HDM services. The mean of TFI in the low-risk group was the lowest (pre-test 8.14 out of 15 points) and the mean of TFI in the high-risk group was the highest (pre-test 10.86 out of 15 points), indicating that statistically these groups were different according to the χ^2 test (*P* < 0.01). After the end of the HDM services, there were no statistically significant differences in TFI scores within the 3 risk groups (post-test 5.96 out of 15 points for the low-risk group, 6.51 for the medium risk group, and 7.00 for the high-risk group, *P* > 0.05). It meant that the degree of the frailty of all 3 groups were alleviated through the tailored HDM services, although 68.4% of participants were still frail.

DISCUSSION

Nutrition is a critical factor that allows the older adults to stay healthy. Previous studies have tried to investigate the association between frailty and nutrition [14,41,42]. But there is limited study testing the effectiveness of a 6-month-long HDM service on frailty. Thus, this study investigated whether the tailored HDM services with nutrition counseling influence frailty among socioeconomically vulnerable older adults in Korea. The main impact of the 6-month tailored HDM service revealed that the participants' frailty scores decreased, thus the proportion of frailty decreased to 68.4% at the post-test from 91.5% at the beginning of the service. Following the tailored HDM service, participants tend to get lower scores in the physical, psychological, and social domain of TFI questionnaires than before receiving the services, meaning that the improvement in frailty is possible. These results are consistent with the findings of previous studies proving that the effects of HDM services are positive [14,41-43]. HDM improve dietary intakes and has influenced in keeping the independence of older adults in their home settings [24]. Especially, it increases energy and protein intakes, nutritional status, and functional outcome such as handgrip strength [24]. A study tested the community-based integrated service model including emotional support and tailored services, the model has been proven effective in improving frailty, loneliness and health-related quality of life of older adults living alone [44].

Malnutrition is reported to accelerate frailty which is characterized by exhaustion, weakness, slow walking, and lower levels of physical activity [8,45]. Frailty is not only a state of

increased vulnerability to stressors but also a predictor of disability and mortality in the aging population [8]. In this study, the prevalence of frailty was 91.5% at the pre-test, which decreased to 68.4% at the post-test, which is fairly higher compared with the prevalence of frailty in the 65 and over aged population of Korea that was reported as 14.3 in 2018 [8]. Although 27.3% of 65 years old and above are reported to be malnourished (19.0%) or at risk of malnutrition (8.8%) in Korea [5], our study showed that 30.8% of the participants were diagnosed with malnutrition and 69.2% at the baseline of being at the risk of malnutrition. The reason of a higher prevalence in malnutrition and frailty observed in our study sample is due to the characterization of older adults aged over 65 with low-income and limited mobility. From the study, it is likely to observe that malnutrition is linked with frailty. The result is in line with the study that suggested malnutrition is associated with a high risk of being frail [46]. In other words, frailty is also associated with depression. From the system review study using meta-analysis [47], the prevalence of frailty in 2,167 older people with depression was 40.4%. Older adults with depression had an increased the risk of having frailty (odds ratio = 4.07), when taking reference as participants without depression [47].

This study has some implications. First, it develops tailored HDM services considering the needs and characteristics of participants, away from only delivering free meals to the socioeconomically low-income older adults in the local community. The tailored HDM service delivered 3 different types of meals (e.g., normal diet including rice porridge, diabetic diet, and low-sodium diet) applicable to the community setting according to the health and nutritional status of the participants. Secondly, participants were also classified into 3 risk groups based on their ability to manage health and nutrition, and it was through this criterion that dietitians could more efficiently organize the frequency and contents of nutrition counseling. An accurate assessment of the health and nutritional status of low-income older adults is a prerequisite for the success of the tailored HDM service [28,48]. Lastly, the tailored HDM service integrated with nutrition and hygiene counseling is found to be effective for alleviating the frailty of older adults after a 6 month-long intervention. The provision of different frequencies of home-visits to the elderly depending on the severity of frailty, depression, nutrition, hygiene of kitchen, and food insecurity was found to be effective and efficient in improving self-rated frailty. Especially through face-to-face counseling, the low-income older adults living alone feel more likely to get social support from their community and feel less depressed. Thus, this study supports that tailored HDM services can be a solution to improving poor diet quality, insufficient nutrient intake, and alleviation of frailty to older adults. These implications consist of the Zhu and An [43] finding that HDM services led to a reduction of food insecurity, the nutritional risk among older adults, and improvement of social isolation from the interaction of meal deliverers.

Also, it is worth noting that the tailored HDM service delivered both free meals and one-on-one nutritional counseling services. In this study, 8 of 10 participants used to get a significant portion of their daily meals from the HDM service. The effect on health, nutrition, and eating habits might be bigger because a dietitian provided home-visit nutritional counseling/education and was well aware of what a low-income older adult ate [48]. Nutrition counseling for socioeconomically the low-income older adults should be offered in an easy-to-understand manner, such as what to eat and what not to eat, hygienic food storage and maintaining health, as this study focused on, rather than prescribing nutritional supplements.

This study had a few limitations such as a restricted sample and instrument. The pool was limited, and the participants were recruited from limited senior welfare centers in

Seoul, Korea. Zhu and An [43] pointed out research quality indicators as inclusion of the control group, at least 4 weeks of intervention periods, use of a reliable measuring tool, and randomly recruited participants for assessing the effectiveness of the HDM service. However, this study could not employ the control group due to a limited budget and manpower resources. Future studies need to design research with a control and intervention group, and target more frail older adults in a wider area to secure more representative samples.

Despite these limitations, this study demonstrated the feasibility of implementing tailored HDM services integrated with nutrition and food safety counseling by dietitians were effective in alleviating frailty among socioeconomically low-income older adults in a community setting. The tailored meals covered both the participants' needs on disease and impaired oral function. The meals were also provided to the low-income older adults for a longer period of 6 months long, far more than 4 weeks as recommended [43]. Nutrition and food safety related counseling services were provided depending on the severity of the risk of dietary life. Through such a well-designed study, it is found that tailored HDM services alleviated the self-rated frailty of low-income older adults in a community setting. Based on the positive outcomes this study could be applied to developing social services for aging in place.

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