Habitual Dietary Patterns of Patients on Hemodialysis Indicate Nutritional Risk

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ORIGINAL RESEARCH

Habitual Dietary Patterns of Patients on Hemodialysis Indicate Nutritional Risk

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Objective: This study aimed to (i) determine habitual dietary patterns of Malaysian patients on hemodialysis (HD) and (ii) examine their association with nutritional status.

Methods: An *à posteriori* approach examined 3-day dietary recalls of 382 multiethnic Malaysian patients on HD, leading to short-listing of 31 food groups. Dietary patterns were derived through principal component analysis. Sociodemographic and lifestyle characteristics together with nutritional parameters were examined for associations with specific dietary patterns.

Results: Four dietary patterns emerged, namely, "Home Food," "Eating Out (EO)-Rice," "EO-Sugar sweetened beverages," and "EO-Noodle." Younger patients, male gender, Malay, and patients with working status were more likely to follow "EO-Rice" and "EO-Sugar sweetened beverages" patterns, while Chinese patients were more likely to consume "EO-Noodle" pattern (all P values < .05). The EO frequency was directly associated with "EO-Rice" (P = .030), "EO-Sugar sweetened beverages" (P = .040), and "EO-Noodle" (P = .001) patterns. The highest tertile of the "Home Food" pattern related to higher handgrip strength (T3 = 21.3 ± 0.74 vs. 18.0 ± 0.73 kg, P = .006), higher serum albumin (T3 = 3.99 ± 0.04 vs. T1 = 3.84 ± 0.04 g/dL, P = .027), and lower Malnutrition-Inflammation Score (T3 = 4.9 ± 0.36 vs. T1 = 6.4 ± 0.34, P = .010), along with lower Diet Monotony Index (T3 = 29.0 ± 1.1 vs. T1 = 33.0 ± 1.0, P = .030). while "EO-Rice" and "EO-Sugar sweetened beverage" patterns were associated only with higher energy intake (all P values < .001).

Conclusions: These results indicated that a home-based diet inclusive of healthy food choices was associated with better nutritional status in this HD population.

Introduction

PATIENTS UNDERGOING MAINTENANCE hemodialysis (HD) are at high risk for malnutrition, which has an "iceberg effect" in increasing comorbidities and reducing life span.[1,2] Whether the form of malnutrition is defined as protein energy malnutrition or protein energy wasting (PEW),[3] the requirement for achieving nutritional adequacy for energy and protein is supreme to attaining nitrogen balance in a scenario of higher protein requirements to offset dialysis losses and energy insufficiency.[4,5] Diet, therefore, is a modifiable factor in maintaining good nutritional status and reducing the risk of morbidity and mortality

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in this population,[6] and expert dietary guidelines target achievement of energy and protein adequacies.[7] However, nutritional insufficiencies marked by energy and protein deficits concomitant with poor nutritional status are frequently reported in patients on HD, indicating inherent challenges in achieving dietary adequacy as recommended.[8-10]

In chronic patient-centered care, apart from medical issues, understanding behavioral and social facets contributing toward diminished nutritional intake should be central to dietary interventions.[11] Indeed, many studies report that patients on HD face difficulties in managing their diet when tracking nutrients and incorporating the various dietary restrictions along with a lack of general nutritional knowledge.[11-14] In addition, requiring assistance in social activities such as shopping and cooking further adds to nutritional inadequacies.[11] Traditional studies tend to focus on specific nutrients to report deficiencies, adequacies, and excessiveness. But the relationship of diet and disease is complex, and patient behaviors should be moderated in accordance with the nature of meal choices and practices, which are combinations of a variety of food, nutrients, and bioactive constituents. Factoring in the food environment would allow for the determination of food access and food choices separate from socioeconomic factors.[15]

Accumulating literature in non–chronic kidney disease (CKD) populations describes diet consumption as a mixture of foods falling into various dietary patterns, which are influenced by dietary habits, beliefs, cultural traditions, as well as geographical and socioeconomic factors.[16,17] Studying food behaviors in the renal population is emerging but limited to reporting association of dietary patterns with CKD health indicators.[18-20] In Malaysia, the annual *Malaysian Dialysis and Transplant Registry* reported 21% of patients on HD to be malnourished based solely on serum albumin levels <35 g/L or 60% based solely on the body mass index (BMI) < 25 kg/m^2.[21] Even though there are data on poor appetite and energy and protein insufficiencies,[8,22] the element of patient behaviors as a determinant of food selection related to poor nutritional status is scarcely reported. This study, therefore aimed to (i) identify dietary patterns of a multiethnic Malaysian HD patient population using an *á posteriori* approach with factor analysis and (ii) determine the associations of derived dietary patterns with nutritional status. We hypothesized that dietary patterns would be linked to nutritional risk in these patients.

Methods

Study Design and Patients

This cross-sectional study comprised patients initially screened for recruitment into the Palm Tocotrienols in Chronic Hemodialysis study.[23] Multiple dialysis providers (n = 11) inclusive of government hospitals, the National Kidney Foundation, and private dialysis units in the Klang Valley provided the setting for patient recruitment, which was conducted between October 2015 and March 2018. Ethical approval was obtained from the Medical Research and Ethics Committee, Ministry of Health, Malaysia (NMRR-15-865-25260). For inclusion, patients had to be 18 years of age and dialyzing for at least 3 months. Patients with poor adherence toward HD, unfit for assessment owing to physical or mental disability, and with terminal illness, such as HIV/AIDS or malignancy, were excluded. All patients gave informed consent before the study initiation.

Dietary Assessment

The dietary intake was assessed using the recommended 3-day dietary recalls (3-DDRs) method.[7] These recalls were single 24-hour records randomized for a dialysis, a nondialysis, and a weekend day, obtained through trained dietitians who conducted the assessment through face-to-face interviews with patients. Portion size recalls of patients were optimized using household measurement tools shown during dietary interviews.

Food items in the 3-DDR data were transformed from household units to absolute weight (gm) and volume (mL), before data were computed referencing the *Malaysian Food Composition*[24] and the *Singapore Food Composition* database[25] available within the Nutritionist Pro™ (Axxya System LLC, Stanford, TX). Energy and protein adequacies were areas of principal interest.

We used the Goldberg's index for identification of misreporters to remove outliers.[26] Basal metabolic rate was calculated using the Harris-Benedict equation.[23,27,28] In accordance with the reported energy intake, patients with energy intake-to-basal metabolic rate ratio of <1.2, 1.2-2.4, and > 2.4 were considered as underreporting, acceptable reporting, and overreporting, respectively. Exclusion of misreporters based on implausible reported energy intakes is the standard protocol followed in dietary pattern analyses.[18,19,29]

Food Grouping

Food items relating to meals and beverages extracted from 3-DDRs were alphabetically rearranged, duplicates removed, and the final listing grouped according to similarity, culinary use, and nutrient content.[15,17,29] Food grouping aggregations were based on natural foods, processed foods, and beverages considering dietary recommendations for patients on HD.[7] Initially, this resulted in 47 food groups. After data entry for every subject's 3-DDR was completed, mean consumption for each food group was calculated. Food items consumed by less than 5% of participants were either excluded or merged with similar food groups, which narrowed the final food listing to 31 food groups, with foods within categories sharing a similar nutritional profile.[15,17,29]

Assessment of Dietary Monotony

The Diet Monotony Index (DMI), calculated from the serving size of 31 food groups, was used to examine dietary variety in this study.[30] The monotony index relies on the fact that the proportion close to zero becomes very small when squared (e.g., $0 \times 10^2 = 0.01$), while the proportion close to one remains relatively large, determined by foods that account for a high proportion of total servings. Therefore, higher points in the monotony index relate to higher diet monotony, while lower points were indicative of more variety.[30]

Nutritional Status Assessment

Anthropometry

Patients' height and postdialysis dry weight were measured using the seca digital scale (Model 220; seca, Hamburg, Germany). The BMI was calculated using the following formula: weight (kg)/height × height (m^2). Triceps skinfold (TSF) thickness was measured on the nonfistula arm by using the Harpenden skinfold caliper (HSK-BI; British Indicators, West Sussex, UK), while mid-arm circumference (MAC) was measured using a nonstretch Lufkin® metal measuring tape (Apex Tool Group, LLC, NC). Subsequently, mid-arm muscle circumference (MAMC) was calculated using the following formula[31]: $MAMC\ (cm) = MAC\ (cm) - [TSF\ (cm) \times \pi]$.

Bioimpedance Analysis

Lean tissue mass (LTM) and fat tissue mass (FTM) were measured by bioimpedance analysis as recommended by the manufacturer (Body Composition Monitor; Fresenius Medical Care, Bad Homburg, Germany).

Handgrip Strength Measurements

Handgrip strength (HGS) of patients was measured using the Jamar dynamometer (BK-7498; Fred Sammons, Inc., Burr Ridge, IL) on the nonfistula arm. The measurement was repeated thrice for each patient, and the median value was used.

Biochemistry

In-hospital data for serum urea, creatinine, albumin, phosphate, potassium, hemoglobin, and total iron binding capacity (TIBC) values for patients were retrospectively referred, and these measurements were performed within 2 weeks of the collection of 3-DDRs. All analyses were performed in accordance with standard operating procedures set by the Ministry of Health, Malaysia. Serum urea by the urease glutamate dehydrogenase method, creatinine by the Jaffe method, total iron-binding capacity and hemoglobin by the colorimetric method, and albumin by the bromocresol green method were analyzed by automated clinical chemistry (Roche/Hitachi 912 System; Roche Diagnostics, Tokyo, Japan). On the other hand, serum high-sensitivity C-reactive protein (hs-crp) was measured by nephelometric turbidimetric immunoassay at an independent laboratory.

Sociodemographic and Lifestyle Characteristics

Sociodemographic data and medical history were obtained from patients' medical records. Information about lifestyle factors such as occupational status and monthly income was obtained from patients through interviews. In addition, the frequency of eating out (EO) per week was also assessed in diet history.

Definitions in Assessment of Nutritional Status

Malnutrition-Inflammation Score

The Malnutrition-Inflammation Score (MIS) proposed by Kalanter-Zadeh et al.[32] is a 10-component nutritional screening tool which includes domains for patients' medical history, physical examination, BMI, and laboratory parameters. Each component is scored from 0 to 3, denoting normal to nutritional deficit. The sum of all components ranges from 0 to 30, with 0 denoting normal nutrition status and increasing scores denoting severity of malnutrition and inflammation. In addition, the scoring cutoff value ≥ 5 was used to identify the prevalence of malnourished patients[33] in this study, which has also been validated in a local study.[34]

PEW Assessment

The diagnostic criteria proposed by the International Society of Renal Nutrition and Metabolism Expert Group[3] were adopted to identify the presence of PEW. We chose serum albumin <3.8 g/dL, BMI <23 kg/m^2, reduction >10% in MAMC in relation to the 50th percentile of a reference population,[35] confirmed on 3 occasions within 2 weeks, and dietary energy intake (DEI) of <25 kcal/kg ideal body weight in line with our clinical practice.[8]

Statistical Analysis

Patient characteristics were described as means ± standard deviation for continuous data and as frequency (percentages) for categorical data. The non-normally distributed variable was presented as median (interquartile range) values and log-transformed before statistical analyses. Weight of food items in grams was used as the input variable for factor analysis.

Principal component analysis (PCA) with eigenvalue >1 was used to derive dietary patterns. The derived patterns were orthogonally rotated (varimax rotation) to enhance the difference between loading for easier interpretability.[17] Factors beyond the break point on the scree plot were retained. Dietary patterns were named in accordance with the highest factor loading on food groups in each pattern. Within each pattern, consumption data were further categorized into tertiles, where tertile 1 (T1) indicated the lowest consumption and tertile 3 (T3) the highest consumption.

Association of dietary pattern tertiles with sociodemographic and lifestyle characteristics was examined by one-way analysis of variance and the Pearson *Chi* Square test. Finally, one-way analysis of covariance with *Bonferroni* test adjusted for age, gender, ethnicity, working status, dialysis vintage, and kt/V was used to determine the association of dietary pattern tertiles with nutritional parameters.

An α of 0.05 was set to determine the significance of associations. All data analyses were performed using the SPSS®, version 23, (SPSS Inc., Chicago).

Results

After excluding misreporters, the final data analysis was based on dietary recalls of 382 patients (Fig. 1). Baseline characteristics and nutritional status of all patients (n = 433) and those excluded (n = 51) were provided as supplementary data (Table S1 and S2). This HD population's mean age was 54.4 years, with 54% comprising males with an ethnic mix of Malays, Chinese, and Indians. Almost 73% of the population was not working, and 61% reported an individual monthly income below MYR 1000 (USD 246). Eating foods away from home as indicated by the EO frequency per week was 9.1 ± 6.8. In terms of clinical characteristics, more than two-thirds of this population had hypertension (80%), followed by diabetes (43%) and cardiovascular disease (15%). The prevalence of malnourished patients as assessed by the MIS tool was 40%, while the prevalence of PEW was 20% as assessed by the International Society of Renal Nutrition and Metabolism criteria (Table 1).

Dietary Patterns

Four dietary patterns with a total of 31 food groups were identified through PCA (Table S3). The first factor labeled as "Home Food" pattern represented a high factor loading for white rice, starchy and nonstarchy vegetables, soybean and legumes, fish, pork, and poultry, along with a high negative loading for fried rice and traditional coconut milk rice. The second factor was labeled as "EO-Rice" pattern because it represented positive factor loading for fried rice, traditional coconut milk rice (*nasi lemak*), white rice, poultry, and sugar-sweetened beverages, with negative loading for noodles, *pau*, and *dim sum* dishes. The third factor carried high factor loadings for sugar-sweetened beverages; commercially prepared refined breads, buns, and rolls; and refined traditional cereal meals along with candies and deep-fried crackers and negative loading for pork, noodles, fried rice, and traditional coconut milk rice. This factor was labeled as "EO-Sugar sweetened beverages" pattern. The fourth factor named as the "EO-Noodle" pattern reflected the highest factor loading for all kinds of noodle dishes followed by fried rice, sugar-sweetened beverages, and white rice, with least likely choice for *chapati* which is an Indian flat bread. Pictorials for food groups with high positive and negative loading within each pattern are presented in Figure 2. All four patterns had eigenvalues >1.0 with EO-Noodle (17%) accounting for the highest variation, followed by EO-Sugar sweetened beverage (14%), EO-Rice (10.3%), and Home Food (5.8%) patterns.

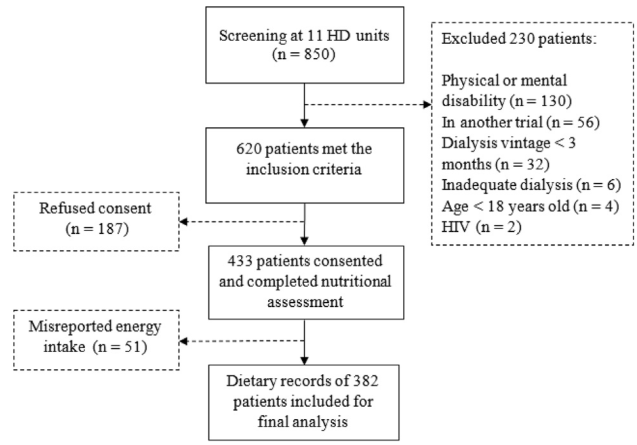

Figure 1. Flow chart representing screening, recruitment, and dietary recalls finalization. HD, hemodialysis.

Associations of Dietary Patterns with Sociodemographic and Lifestyle Characteristics

Sociodemographic and lifestyle characteristics according to tertiles of dietary patterns are presented in Table 2. It appeared that the Home Food pattern was homogenous across age, gender, and ethnicity (all $P_{trend} > .05$). In contrast, EO-Rice and EO-Sugar sweetened beverage patterns were associated with younger patients and male gender. Higher consumption of EO-Rice and EO-Sugar sweetened beverage patterns was associated with Malays, while higher consumption of EO-Noodle pattern was associated with Chinese patients.

In terms of lifestyle, patients most adherent (T3) toward EO-Rice and EO-Sugar sweetened beverages patterns were more likely to be working. Monthly income did not influence the choice of dietary patterns ($P_{trend} > .05$). Frequency of EO per week was not associated with the Home Food pattern, whereas it was directly associated with EO-Rice (P_{trend} = .030), EO-Sugar sweetened beverage (P_{trend} = .040), and EO-Noodle (P_{trend} = .001) patterns with significant differences observed between T3 and T1 comparisons (Table 2).

Association of Dietary Patterns with Nutritional Status

Nutritional parameters according to tertiles of dietary patterns are shown in Table 3. Patients' weight, BMI, MAC, TSF, MAMC, LTM, and FTM were not associated with any dietary pattern (all P values > .05). However, a higher HGS was associated with increasing tertiles of Home Food pattern (P_{trend} = .006), with a significant difference observed between T3 and T1. The HGS measures

Table 1. Baseline Characteristics of Patients (n = 382)

Characteristics	Mean ± SD	n (%)
Age (year)	54.4 ± 13.9	
Gender (male)		206 (54)
Ethnicity		
Malay		138 (36)
Chinese		172 (45)
Indians		72 (19)
Working status		
Yes		102 (27)
No		280 (73)
Monthly income (MYR)		
<1,000		233 (61)
>1,000		149 (39)
EO frequency/week	9.1 ± 6.8	
Comorbidities		
Hypertension		302 (80)
Diabetes		164 (43)
CVD		59 (15)
Urea (mg/dL)	54.6 ± 15.1	
Dialysis vintage (years)	4.6 (2.1-8.7)*	
Kt/V	1.6 ± 0.4	
Creatinine (mg/dL)	9.4 ± 2.3	
hs-CRP (mg/L)	3.5 (1.7-8.3)*	
Potassium (mEq/L)	5.2 ± 3.8	
Phosphate (mg/dL)	5.4 ± 1.5	
BMI (kg/m^2)	24.5 ± 4.4	
<23		144 (38)
≥23		238 (62)
MAMC (cm)	23.6 ± 3.5	
Reduction >10%		153 (40)
Reduction ≤ 10%		229 (60)
Albumin (g/dL)	3.9 ± 0.4	
< 3.8		113 (30)
≥ 3.8		268 (70)
DEI (kcal/kg IBW)	24.9 ± 5.2	
< 25		198 (52)
≥ 25		184 (48)
DPI (gm/kg IBW)	0.90 ± 0.29	
< 0.8		153 (40)
≥ 0.8		229 (60)
DMI	31.6 ± 10.1	
Malnutrition classification		
MIS	5.4 ± 3.1	
Well nourished < 5		229 (60)
Malnourished ≥5		153 (40)
PEW criteria		
PEW		77 (20)
Non-PEW		305 (80)

BMI, body mass index; CVD, cardiovascular disease; DEI, dietary energy intake; DMI, Diet Monotony Index; DPI, dietary protein intake; EO, eating out; hs-CRP, high-sensitivity C-reactive protein; IBW, ideal body weight; Kt/V, dialysis dose; MAMC, mid-arm muscle circumference; MIS, Malnutrition-Inflammation Score; MYR, Malaysian Ringgit; PEW, protein energy wasting.

*Data are expressed as median with interquartile range (IQR).

were not significantly different across tertiles of EO-Rice, EO-Sugar sweetened beverage, and EO-Noodle patterns.

We noted an increasing significant trend for only serum albumin (P_{trend} = .027) as a nutritional biomarker associated with increasing tertiles within the Home Food pattern, with significant difference between T3 and T1. In contrast, EO-Rice, EO-Sugar sweetened beverage, and EO-Noodle patterns were not associated with any nutritional biomarker (Table 3).

Nutritionally, Home Food and EO-Noodle patterns were associated with neither energy nor protein adequacies. Contrarily, EO-Rice and EO-Sugar sweetened beverage patterns were associated with higher total energy intake ($P_{trend} < .001$) and DEI ($P_{trend} < .001$) with significant difference between T3 versus T1 values (Table 3).

An inverse trend for MIS was observed with increasing tertiles of the Home Food pattern (P_{trend} = .010), which also indicated significance between T3 and T1 comparisons (Fig. 3A). In contrast, neither tertile trends nor T3 versus T1 comparisons for MIS were significantly different for the other dietary patterns (all $P_{trend} > .05$). The prevalence of PEW in patients was not significant across tertiles within dietary patterns (all $P_{trend} > .05$) (Fig. 3B).

A significant inverse trend for the DMI was observed with increasing tertiles of Home Food pattern (P_{trend} = .030), with significance between T3 and T1 comparisons (Fig. 3C).

Discussion

This is, to our knowledge, one of the first studies to report on dietary patterns in the Malaysian HD population. We used an *á posteriori* assessment approach and identified four dietary patterns practiced by our study population. These were the Home Food, EO-Rice, EO-Sugar sweetened beverages, and EO-Noodle patterns. The EO-Rice, EO-Sugar sweetened beverages, and EO-Noodle patterns represented a high factor loading for fried rice and traditional coconut milk rice (factor = 0.66), sugar sweetened beverages (factor = 0.80), and noodles (all kinds) (factor = 0.65), respectively. These food groups are commonly consumed when EO rather than at home. We therefore labeled these three dietary patterns as EO patterns to distinguish them from the Home Food pattern. In fact, the frequency of EO within these 3 dietary patterns was significantly higher for patients in tertile 3. This further confirms our assumption that these dietary patterns are associated with EO behavior.

The major outcome of this analysis was that patients highly adherent to the Home Food pattern (T3) had significantly higher HGS and serum albumin levels than those least adherent (T1) within this dietary pattern group. The Home Food pattern was also associated with the lowest MIS scores and DMI values which represented better nutritional status and greater dietary variety in patients most adherent to this pattern. At this time, there are no studies with CKD patient population reporting on the nature of dietary pattern behaviors related specifically to these nutrition assessment parameters. Therefore, our study by addressing this research gap importantly demonstrates an association of dietary patterns with nutritional status of patients on HD. Prospective cohorts indicate that patients on

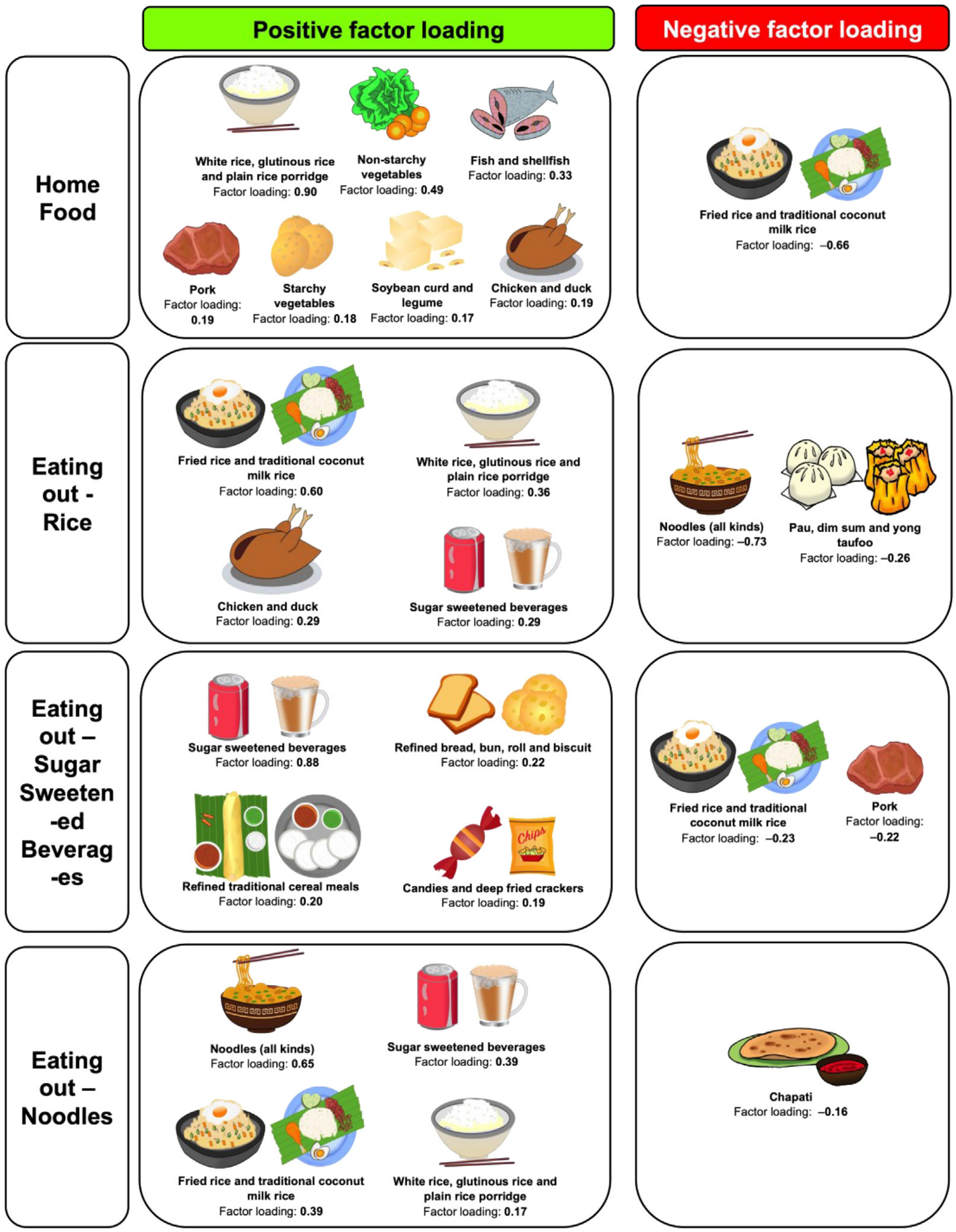

Figure 2. Food groups within dietary patterns with positive and negative factor loadings >0.15. Four dietary patterns were identified in factor analysis. Some foods loaded positively in one dietary pattern and negatively in another. For example, "fried rice and traditional coconut milk rice" loaded positively onto "Eating out-Rice" pattern (0.60) but negatively onto "Home Food" pattern (−0.66). This means a person who eats "fried rice and traditional coconut milk rice" regularly is highly likely to be associated with "Eating out-Rice" pattern and least likely to be associated with "Home Food" pattern.

HD with higher HGS[36] and serum albumin[37] and lower malnutrition-related inflammation[38,39] had greater survival opportunities. A good nutritional status in dialysis population is often attributed to adequate energy and protein intake. However, in this study, the Home Food pattern represented by white rice, meat, fish, poultry, starchy, and non-starchy vegetables along with beans and legumes was associated with neither energy nor protein adequacy. There is a possibility that a higher HGS and serum albumin and lower MIS values linked with this home-based diet might be attributed to the micronutrients and polyphenols intake.[40] Further studies are required to explore the underlying mechanism of association between dietary patterns and nutritional status in dialysis population.

Essentially, it is evident from our study that the greatest adherence to Home Food pattern was observed with

Table 2. Association of Sociodemographic and Lifestyle Characteristics With Tertiles of Dietary Patterns

	Home Food				EO-Rice				EO-Sugar sweetened beverages				EO-Noodle			
Variables	T1	T2	T3	*P*-trend	T1	T2	T3	*P*-trend	T1	T2	T3	*P*-trend	T1	T2	T3	*P*-trend
Age (Year)	54.2 ± 13.3	53.7 ± 13.7	55.3 ± 14.7	.65	57.4 ± 13.1†	55.1 ± 11.6	49.9 ± 15.1†	**<.001**	58.2 ± 12.8†	54.4 ± 13.3	50.6 ± 14.5†	**<.001**	52.2 ± 14.7	56.3 ± 12.4	55.5 ± 13.8	**.036**
Gender																
Male	60 (47)	77 (57)	69 (58)	.18*	81 (47)	42 (51)	83 (65)	**.006***	56 (44)	60 (47)	90 (71)	**<.001***	85 (57)	48 (46)	73 (57)	.14*
Female	67 (53)	58 (43)	51 (42)		91 (53)	41 (49)	44 (35)		72 (56)	67 (53)	37 (29)		65 (43)	57 (54)	54 (43)	
Ethnicity																
Malay	50 (39)	48 (35)	40 (33)		35 (20)	35 (42)	68 (54)		35 (27)	39 (31)	64 (50)		75 (50)	37 (35)	26 (20)	
Chinese	53 (42)	59 (44)	60 (50)	.70*	102 (59)	34 (41)	36 (28)	**<.001***	75 (59)	59 (46)	38 (30)	**<.001***	33 (22)	50 (48)	89 (70)	**<.001***
Indians	24 (19)	28 (21)	20 (17)		35 (20)	14 (17)	23 (18)		18 (14)	29 (23)	25 (20)		42 (28)	18 (17)	12 (10)	
Working status																
Working	32 (25)	40 (30)	30 (25)	.63*	32 (19)	20 (24)	50 (39)	**<.001***	23 (18)	31 (24)	48 (38)	**.001***	47 (31)	24 (23)	31 (24)	.25*
Nonworking	95 (75)	95 (70)	90 (75)		140 (81)	63 (76)	63 (76)		105 (82)	96 (76)	79 (62)		103 (69)	81 (77)	96 (76)	
Monthly income																
<1000	71 (56)	88 (65)	72 (60)	.31*	111 (65)	53 (64)	67 (53)	.09*	82 (64)	80 (63)	69 (54)	.22*	86 (57)	67 (64)	78 (61)	.56*
>1000	56 (44)	47 (35)	48 (40)		61 (35)	30 (36)	60 (47)		46 (36)	47 (37)	58 (46)		64 (43)	38 (36)	49 (39)	
EO frequency/ week	8.7 ± 6.9	9.9 ± 7.1	8.6 ± 6.3	.29	8.2 ± 6.7†	9.0 ± 6.5	10.6 ± 7.1†	**.030**	8.4 ± 6.4†	8.5 ± 6.6	10.5 ± 7.2†	**.040**	7.9 ± 6.3†	8.4 ± 6.5	11.0 ± 7.1†	**.001**

ANOVA, analysis of variance; EO, eating out; SD, standard deviation.
Data are expressed as mean ± SD or frequency (percentage).
Significant values are highlighted in bold.
*Pearson's Chi square test was used for categorical variables. One-way ANOVA with Bonferroni test was used for pairwise comparisons.
†Indicates significant difference between T3 and T1.

Table 3. Association of Nutritional Parameters With Tertiles of Dietary Patterns

	Home Food				EO-Rice				EO-Sugar sweetened beverages				EO-Noodle			
Variables	T1	T2	T3	*P*-trend*	T1	T2	T3	*P*-trend*	T1	T2	T3	*P*-trend*	T1	T2	T3	*P*-trend*
Weight (kg)	60.6 ± 1.16	60.7 ± 1.07	61.4 ± 1.18	.87	60.3 ± 0.96	62.6 ± 1.38	60.6 ± 1.25	.36	61.1 ± 0.96	61.5 ± 1.38	59.7 ± 1.25	.57	60.4 ± 1.08	60.7 ± 1.23	61.5 ± 1.13	.77
BMI (kg/m^2)	24.2 ± 0.41	24.6 ± 0.38	24.0 ± 0.41	.58	23.8 ± 0.35	25.3 ± 0.49	24.4 ± 0.44	.05	24.3 ± 0.34	24.5 ± 0.49	23.9 ± 0.44	.60	24.4 ± 0.38	23.9 ± 0.43	24.4 ± 0.40	.64
MAC (cm)	28.7 ± 0.42	29.6 ± 0.39	29.3 ± 0.42	.31	29.2 ± 0.35	29.7 ± 0.50	28.8 ± 0.46	.24	29.2 ± 0.41	29.5 ± 0.41	28.8 ± 0.42	.49	29.0 ± 0.38	29.2 ± 0.44	29.4 ± 0.40	.81
TSF (mm)	18.1 ± 0.87	18.9 ± 0.80	17.6 ± 0.88	.56	17.2 ± 0.71	19.9 ± 1.02	18.6 ± 0.93	.10	18.2 ± 0.72	18.4 ± 0.71	17.9 ± 0.74	.91	18.7 ± 0.80	17.3 ± 0.91	18.4 ± 0.84	.48
MAMC (cm)	23.0 ± 0.34	23.7 ± 0.32	23.8 ± 0.35	.23	23.7 ± 0.28	23.7 ± 0.41	23.0 ± 0.37	.25	23.5 ± 0.35	23.7 ± 0.32	23.1 ± 0.36	.51	23.1 ± 0.31	23.8 ± 0.36	23.6 ± 0.33	.32
LTM (kg)	32.0 ± 0.72	31.0 ± 0.66	33.2 ± 0.73	.09	32.1 ± 0.60	32.8 ± 0.86	32.1 ± 0.78	.96	31.9 ± 0.74	32.1 ± 0.68	31.8 ± 0.77	.95	31.6 ± 0.67	31.6 ± 0.76	32.6 ± 0.70	.54
FTM (kg)	20.9 ± 0.86	21.7 ± 0.79	20.5 ± 0.87	.60	20.6 ± 0.71	22.4 ± 1.02	20.8 ± 0.92	.31	21.2 ± 0.77	21.3 ± 0.77	20.4 ± 0.79	.74	21.0 ± 0.80	21.1 ± 0.91	20.9 ± 0.84	.98
HGS (kg)	18.0 ± 0.73†	19.3 ± 0.67	21.3 ± 0.74†	**.006**	19.6 ± 0.61	20.4 ± 0.88	18.7 ± 0.80	.35	20.2 ± 0.61	19.4 ± 0.88	18.8 ± 0.80	.43	18.6 ± 0.69	20.1 ± 0.78	19.9 ± 0.72	.29
Albumin (g/dL)	3.84 ± 0.04†	3.94 ± 0.03	3.99 ± 0.04†	**.027**	3.93 ± 0.03	3.94 ± 0.04	3.91 ± 0.03	.88	3.97 ± 0.03	3.92 ± 0.04	3.87 ± 0.04	.33	3.96 ± 0.03	3.95 ± 0.04	3.86 ± 0.04	.16
Hemoglobin (g/dL)	10.6 ± 0.19	10.7 ± 0.17	11.0 ± 0.19	.27	10.8 ± 0.16	10.9 ± 0.22	10.7 ± 0.20	.73	10.8 ± 0.16	10.6 ± 0.22	10.8 ± 0.20	.71	10.6 ± 0.17	11.1 ± 0.19	10.6 ± 0.18	.16
hs-CRP (mg/L)	3.84 (1.87-8.95)	3.80 (1.73-9.49)	3.37 (1.48-7.24)	.90	3.52 (1.67-7.60)	4.32 (2.12-9.24)	3.32 (1.71-9.45)	.52	3.64 (1.44-7.89)	3.42 (1.91-7.97)	4.09 (1.82-10.52)	.60	4.27 (1.79-10.22)	3.48 (1.63-6.86)	3.33 (1.74-8.12)	.10
Energy (Kcal)	1,487 ± 31.2	1,530 ± 28.8	1,539 ± 31.5	.47	1,429 ± 25.3†	1,546 ± 36.6	1,622 ± 33.0†	**<.001**	1,473 ± 31.8†	1,536 ± 29.7	1,639 ± 33.2†	**<.001**	1,488 ± 28.7	1,492 ± 32.5	1,576 ± 30.0	.09
DEI (kcal/kg IBW)	24.7 ± 0.55	25.0 ± 0.51	25.0 ± 0.56	.66	23.7 ± 0.45†	25.6 ± 0.65	26.7 ± 0.59†	**<.001**	23.9 ± 0.56†	24.9 ± 0.51	26.9 ± 0.58†	**.001**	24.2 ± 0.51	25.0 ± 0.58	25.5 ± 0.53	.20
Protein (gm)	52.3 ± 2.01	55.0 ± 1.84	57.7 ± 2.02	.73	53.9 ± 1.65	54.5 ± 2.38	56.7 ± 2.15	.88	56.0 ± 2.02	56.2 ± 1.85	50.8 ± 2.11	.19	51.6 ± 1.84	54.5 ± 2.08	57.7 ± 1.92	.74
DPI (gm/kg IBW)	0.86 ± 0.03	0.89 ± 0.03	0.94 ± 0.03	.76	0.89 ± 0.03	0.89 ± 0.04	0.90 ± 0.03	.93	0.90 ± 0.31	0.91 ± 0.29	0.84 ± 0.33	.22	0.85 ± 0.02	0.89 ± 0.03	0.93 ± 0.30	.16

ANCOVA, analysis of covariance; BMI, body mass index; DEI, dietary energy intake; DPI, dietary protein intake, EO, eating out; FTM, fat tissue mass; hs-CRP, high-sensitivity C-reactive protein; HGS, handgrip strength; LTM, lean tissue mass; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference; SD, standard deviation; T1; Tertiles 1, T2; Tertile 2; T3, Tertile 3; TSF, triceps skinfold.

Data are expressed as mean ± SD or median (IQR).

Significant values are highlighted in bold.

*One-way ANCOVA with Bonferroni test was used for pairwise comparisons. Data were adjusted for age, gender, ethnicity, working status, dialysis vintage, and kt/V.

†Indicates significant difference between T3 and T1.

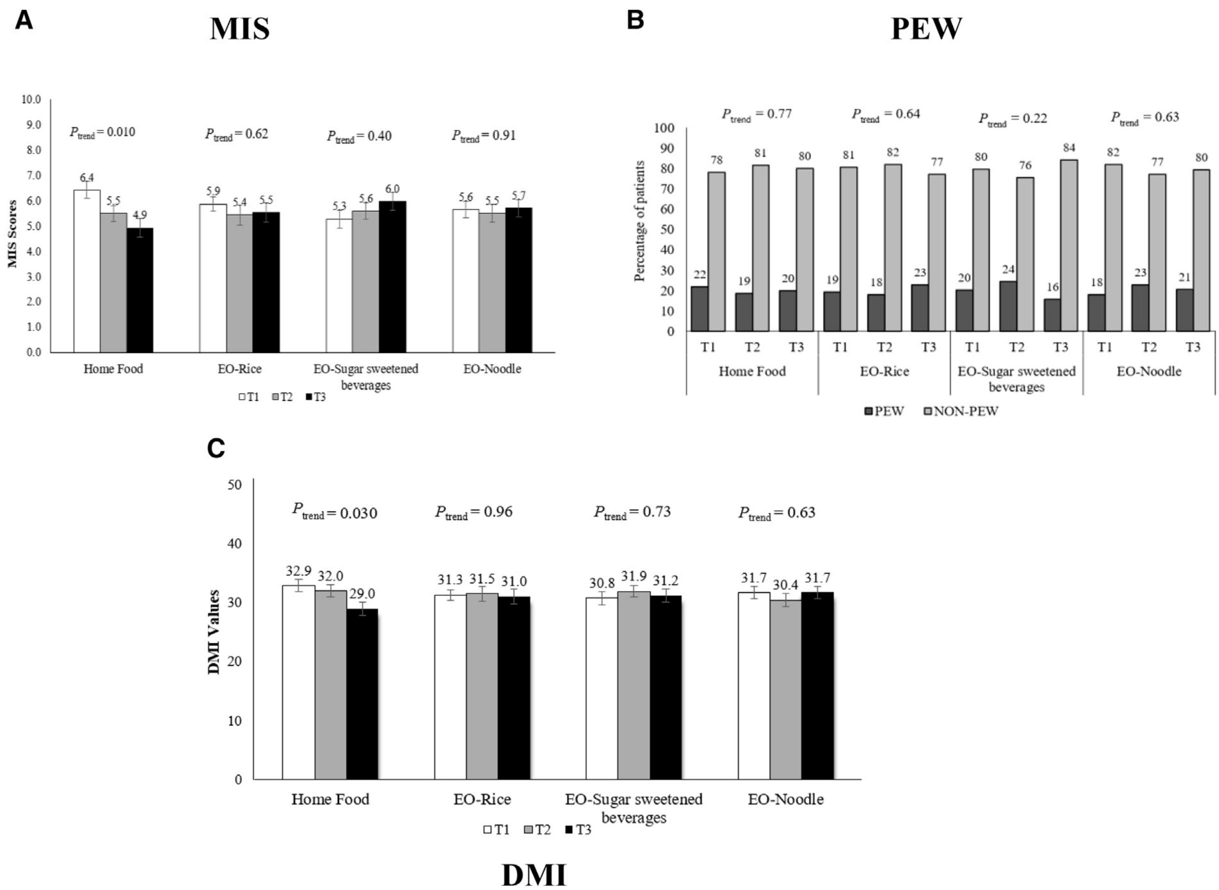

Figure 3. Association of dietary pattern tertiles with nutritional screening tools: (A) MIS, (B) PEW status, and (C) DMI. One-way ANCOVA with *Bonferroni* test for pairwise comparisons was used to compare dietary pattern tertiles with MIS and DMI values. Data were adjusted for age, gender, ethnicity, working status, dialysis vintage, and kt/V. The Pearson *Chi* square test was used to determine association between dietary pattern tertiles and PEW status. Significance at $P < .05$. ANCOVA, analysis of covariance; DMI, diet monotony index; EO, eating out; MIS, Malnutrition-Inflammation Score; PEW, protein energy wasting; T1, Tertile 1; T2, Tertile 2; T3, Tertile 3.

patients having the significantly lowest DMI score compared with the least adherent group. Zimmerer et al.[30] while investigating the association of the DMI with nutritional intake of 48 patients on HD revealed that a more varied dietary consumption was linked with higher intakes of energy and protein which was not observed in this study. A lower DMI may indicate greater dietary variety, but it cannot be assumed from our study that a lower monotony index is reflective of healthy food choices. For instance, rice within the cereal group does not differentiate between white rice, fried rice, and traditional coconut milk rice, which are individually characteristic of the dietary patterns emerging for this HD population. Therefore, association of dietary patterns with nutritional status depends solely on factor loadings rather than healthier food choices.

Other studies featuring the *á posteriori* approach report a dietary pattern consistent with food groups inclusive of fruits, vegetables, whole grain cereals, fish, and poultry, often referred as either "*Prudent*" or "*Healthy*" patterns.[15] These patterns closely resembled the matrix of food groups emerged in Home Food pattern. The EO-Sugar sweetened beverage pattern, for instance, carried a high positive factor loading for sugar-sweetened beverages; bakery products such as refined breads, buns, and rolls; refined traditional cereal meals, as well as candies and deep-fried crackers which perhaps closely resembled the "*Western style*" or "*Unhealthy*" patterns reported in other cohorts.[15] Conclusively, both "Home Food" and "EO-Sugar sweetened beverage" patterns are consistent dietary patterns cited for both CKD[19,20] and non-CKD populations.[29,41] Conversely, we note that a rice-based and noodle-based dietary patterns specific to Asian culture were uniquely discerned in our patient population. These traditional style dietary patterns with regional foods have been reported in non-CKD Chinese populations in China[42] and Singapore.[43]

We observed that the Home Food pattern was not associated with any sociodemographic or lifestyle factor. This could be attributed to the high positive factor loading (0.88) for "white rice" within the Home Food pattern which is a major staple food for Malaysians[44] and consumed as a traditional home meal balanced with gravy-based dishes, meat, and vegetables. On the other hand, EO-Rice and EO-Sugar sweetened beverage patterns were away-from-home meals consumed by patients who were likely to be younger, Malay, males, and with working status. These results agree with the findings from the REasons for Geographic and Racial Differences in Stroke (REGARDS) study that showed younger males were more likely to consume a convenient-style dietary pattern consisting of mixed dishes, take-out meals, sugar-sweetened beverages, and fried snacks.[19] The EO-Noodle pattern in contrast was associated with older patients, who were more likely to be Chinese. There is a growing body of literature indicating that sociodemographic and lifestyle aspects that influence dietary patterns within a population would eventually implicate health indicators.[20,29]

In our study, neither EO-Rice nor EO-Sugar sweetened beverage pattern was associated with any nutritional parameter except for energy adequacy. Drawing a parallel, we note that "*Western style*" or "*Unhealthy*" dietary patterns that resembled the EO-Sugar Sweetened beverage pattern in our study have been persistently associated with adverse clinical outcomes and increased risk for mortality in both CKD[19] and non-CKD population.[45] A greater disadvantage was understood from the REGARDS study with 3,972 patients with CKD with estimated glomerular filtration rate (eGFR) ≥60 ml/min. Those following a "Southern style" dietary pattern with high factor loadings for organ meats, fried foods, and sugar-sweetened beverages had significantly greater risk of mortality over time than those following a plant-based dietary pattern.[19] The Jackson Heart Study, a prospective follow-up study of 3,003 African Americans in the United States, used a targeted approach on beverage consumption to empirically derive patterns using PCA implicated in the development of reduced eGFR function and accordingly concluded that a beverage pattern of soda, sweetened fruit drinks, and water was associated with incident CKD (eGFR < 60 ml/min per 1.73 m^2).[45] Further research is needed to explore the association of dietary patterns in terms of nutritional adequacy and excessiveness with clinical events such as hospitalization and mortality in patients on HD.

Our study has several strengths. To our knowledge, it is the first study on patients undergoing dialysis examining the association of dietary patterns with parameters indicative of nutritional status. Unlike an *á priori* dietary assessment approach that only targeted certain aspects of diet, dietary patterns derived through an *à posteriori* approach define interrelationships of dietary components based on existing dietary data[16] and therefore depict a broader spectrum of eating behaviors. Importantly, the *á posteriori* approach enabled understanding of untargeted dietary behaviors within our population which is culturally and ethnically diverse, as indicated by the ethnic make-up of Malays, Chinese and Indians. In addition, we opted to assess dietary intake with 3-DDRs representative of a dialysis, a nondialysis, and a weekend days because a single 24-hr dietary recall may fail to elucidate habitual dietary behaviors,[7] with dialysis sessions *per se* reported to influence dietary intake of patients.[46]

However, some limitations in this study are also acknowledged. First, the *á posteriori* approach to derive dietary patterns requires subjective decisions including the aggregation of food items into food groups, the number of factors to retain, the method of rotation, and naming of patterns which could influence the derivation of patterns due to researcher bias. The global CKD dietary guidelines suggest 3-DDR as a preferred method for dietary assessment.[7] However, dietary recalls are also subject to measurement and recall bias. We minimized error in data collection by using trained dietitians. Furthermore, we excluded patients who misreported energy intake, which further reduces the probability of recall bias. Although we excluded misreporters as outliers in data treatment, this is necessary to enable dietary pattern analyses. This exclusion did not affect the overall nutritional and sociodemographic characteristics of the population. Finally, eating patterns specific to the population being studied are identified through the dietary patterns derived through the *á posteriori* approach. This may reduce the generalizability of patterns identified in this study to HD populations of other countries, specifically outside the Asian region.

Practical Implication

This clinical study observes different dietary patterns among Malaysian HD population which are specific to their sociodemographic and lifestyle characteristics. In addition, we observed that a good nutritional status in this patient population was indicated by a home-based diet. Most importantly, this study will help develop food-based dietary guidelines for this population. However, it remains to be established how these dietary patterns impact clinical outcomes in patients on HD.

Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1053/j.jrn.2019.09.010.

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