Mal J Nutr 31(3): 365-379, 2025

Food-based recommendations for reproductive age women with hypertension: A preliminary study in a public health centre in Semarang, Indonesia

Heni Hendriyani*, Muflihah Isnawati & Dian Luthfita Prasetya Muninggar

Nutrition Department, Poltekkes Kemenkes Semarang, Semarang, Indonesia

ABSTRACT

Introduction: Hypertension is a major risk factor for cardiovascular disease, stroke, and kidney disease. The Indonesian Basic Health Research in 2018 showed that prevalence of hypertension reached 34.1%, whereas in Central Java province it was above the national figure of 37.6%. Prevalence of high blood pressure was higher in women than in men, at 40.2% and 34.8%, respectively. Therefore, this study aimed to develop food-based recommendations for women of reproductive age with hypertension in Semarang. **Methods:** This cross-sectional study included women aged 30–52 years (*n*=100) in Semarang City. Dietary intake was assessed by quantitative 24-hour diet recall. **Results:** Median frequency of fruit consumption was only four times per week, whereas median frequency of vegetable consumption was higher at nine times per week. Beverages had median frequency intake of 38 times a week. Consumption of high-sodium snacks was frequent, with median frequency of five times a week. Folate was identified as a problematic nutrient. Potential food subgroups and food items recommended for achieving dietary adequacy were rice, cassava, meat, chicken, tempeh, small shrimp, and fruits. Mean sodium intake was above recommendation, while mean magnesium intake was below recommendation. **Conclusion:** Women of reproductive age with hypertension reported poor dietary patterns, including low intake of fruits and vegetables, and high intakes of beverages and high-sodium snacks. This study shows that locally available foods have potential to improve diet quality of women of reproductive age with hypertension.

Keywords: food-based recommendation, hypertension, linear programming, Optifood, women

INTRODUCTION

Hypertension is a major risk factor for stroke, kidney, and heart diseases. Lifestyle changes like healthy diet, exercise, and weight loss could help lower blood pressure (Ndanuko *et al.*, 2016). Low- and middle-income countries account for 82% of the 16 million young fatalities and over 75% of all deaths from non-communicable diseases (NCDs) (WHO, 2019). The prevention and control of NCDs is a top priority in the 21st century because of the socioeconomic expenses associated with these illnesses (WHO, 2019). Additionally, increased blood pressure, high blood sugar, and obesity are signs of an unhealthy diet and insufficient exercise. The aforementioned factors are the three most significant causes

*Corresponding author: Dr Heni Hendriyani
Nutrition Department, Poltekkes Kemenkes Semarang
Wolter Monginsidi 115, Pedurungan, Semarang, Indonesia
Tel: (62)24-6710378; Fax: (62)246708597; E-mail: hendriyaniheni74@gmail.com
doi: https://doi.org/10.31246/mjn-2024-0015

of death, collectively referred to as metabolic risk factors (WHO, 2018).

According to a meta-analysis and systematic review, both adults with and without hypertension experience a significant drop in blood pressure after starting the Dietary Approaches to Stop Hypertension (DASH) diet, although the effect of the intervention was amplified by higher daily sodium intake and younger age groups (Filippou *et al.*, 2020). According to the 2018 Basic Health Survey, hypertension prevalence in Indonesia was 34.1%, with Central Java reporting a higher rate at 37.6%. Women were more affected than men, with prevalence rates of 40.2% and 34.8%, respectively. Urban areas in Central Java had slightly higher prevalence (38.1%) compared to rural areas (37.0%) (Kemenkes RI, 2018). The action plan is expected to be more targeted and locally relevant once Central Java-specific factors are identified. Nutritional counselling and local food recommendations are also highly beneficial for hypertension patients.

According to Weng *et al.* (2024), hypertension negatively affects the quality of life of reproductive-age women, complicates pregnancy outcomes, such as preterm birth and foetal growth restriction, and endangers newborns' health. While well-controlled chronic hypertension through treatment is beneficial, poorly controlled blood pressure in early pregnancy significantly increases the risk of low birth weight, pre-eclampsia, and organ damage in both mother and foetus (Weng *et al.*, 2024). Pregnancy-associated hypertension remains a significant cause of morbidity and mortality in both mothers and foetuses (James & Nelson-Piercy, 2004). Further research has demonstrated that it may contribute to early childhood cardiometabolic disorders (Geelhoed *et al.*, 2010; Davis *et al.*, 2015).

The quality of diets can be improved using linear programming (LP) to determine the optimal daily eating patterns for a population under various limitations. The goal of low-protein diet is to meet energy and nutritional needs while following certain guidelines, like minimising diet variation and lowering costs. Dietary recommendations based on contemporary food patterns are typically more practicable. In a community-based clustered randomised trial, LP was used to develop food-based recommendations (FBRs) for Minangkabau women with dyslipidaemia. The intervention promoted foods such as seafood, soy protein, and dark green leafy vegetables (Gusnedi *et al.*, 2022). Therefore, this study aimed to develop FBRs for women of reproductive age with hypertension in Semarang, Indonesia, using LP analysis through Optifood. This is the first study in Indonesia to apply this method for this target group, identifying problematic nutrient levels and determining optimal daily food combinations to guide dietary recommendations.

METHODOLOGY

Study site, design, and subjects

This cross-sectional observational study was conducted in Semarang City from June 2022 to September 2023. The study population consisted of women aged 30–52 years with hypertension. A total of 100 dietary recall data were collected using purposive random sampling. Participants were selected from women visiting public health centres in Semarang. They provided informed consent prior to participation. The variables of the study consisted of demographic characteristics (age, employment, education, and family income), nutrient intakes (energy, protein, fat, fibre, vitamin C, iron, folate, and zinc intakes), hypertension status, anthropometric data (weight, height, and BMI), and physical activity.

Data collection

Sociodemographic characteristics of subjects

Sociodemographic characteristics were obtained using a questionnaire during face-to-face interviews.

Food consumption pattern

Subject's dietary intake was assessed through non-consecutive 24-hour diet recalls on both weekdays and weekends. Data were used to describe the median and range of weekly food consumption. Serving sizes were estimated using local utensils and real food models. Participants reported all foods and beverages consumed the previous day, including frequency and time of consumption.

Food composition database

The Indonesia food composition database (Ministry of Health Indonesia, 2018) was applied for all nutrients except vitamins B6 and B12.

Hypertension status

Hypertension status was obtained from the patient's medical records at the public health centre. Systolic BP (SBP) and diastolic BP (DBP) were repeatedly measured at 1-minute intervals after at least a 5-minute rest in a seated position. The average of two measurements was used. Hypertension was defined as SBP ≥ 140 mmHg, DBP ≥ 90 mmHg, or current treatment with BP-lowering medications (Muntner *et al.*, 2019).

Body mass index (BMI)

BMI was calculated by dividing body weight (kg) by height squared (m^2). Weight and height were measured using a digital scale and a stadiometer, respectively. BMI was categorised into four groups according to the Asian-Pacific cut-off points: underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23–24.9 kg/m^2), and obese (≥25 kg/m^2) (Pan & Yeh, 2008).

Physical activity

Physical activity was assessed by measuring the type and intensity of activities, as well as sitting time, to estimate total physical activity in metabolic equivalents of task (MET)-minutes per week and sedentary duration. The International Physical Activity Questionnaire was used to measure performance in MET. The following MET scores were utilised in the calculation: walking = 3.3 MET, moderate activity = 4.0 MET, and vigorous exercise = 8.0 MET; these values were multiplied by the intensity in minutes and days, then added to determine the overall physical activity score (Oyeyemi *et al.*, 2011).

Preparation of the linear programming model parameters

The dietary assessment data were used to set the linear programming (LP) model parameters and were processed in Microsoft® Office Excel 2007 (Impressa Systems, Santa Rosa, California, United States). The model parameters consisted of a list of foods consumed by the participants (from the mean 2-day 24-hour diet recall assessment), a median serving size for each food (g/day for consumers only), and the number of servings per week for individual foods, food groups, and food subgroups (Tables 2 and 3).

The range of weekly food pattern consumption frequencies (minimum, average, and maximum) was defined as the 5^{th}, 50^{th}, and 95^{th} percentiles of the frequency distribution for each food item, food group, and subgroup.

For nutrient-dense foods for which the 90th percentile value was 0 (i.e., <10% of participants consumed it), the maximum frequency of consumption was defined at the 95th percentile with the aim to promote the consumption of these nutrient-dense foods. These LP parameters were used to set up the LP models for the analyses in the World Health Organization (WHO) Optifood Software (version 4.0.14.0). The WHO Optifood Software (version 4.0.14.0) was developed by WHO in collaboration with the London School of Hygiene and Tropical Medicine, FANTA, and Blue-Infinity (Fahmida, Pramesthi & Kusuma, 2020). The following 12 nutrients were analysed in Optifood: protein, calcium, vitamin C, thiamine, riboflavin, niacin, vitamin B6, folate, vitamin B12, vitamin A, iron, and zinc. The mean body weight of subjects was 56.0 kg, which was used in the LP models to calculate the average energy requirements for the women (30–55 years old), based on the Indonesian recommended daily allowance for energy requirements.

Development of food-based recommendations

Diet recall data were analysed using NutriSurvey 2007 (SEAMEO-TROPMED RCCN-University of Indonesia) and then processed in Microsoft® Office Excel 2007 to be entered into Optifood. Microsoft® Office Excel 2007 produced datasets for food items, food subgroups, and food groups, as well as frequency and median portions. These data were used for the Optifood analysis and the development of food-based recommendations (FBRs).

FBR can be established using WHO Optifood in four analytical modules, according to Daelmans *et al.* (2013). The model parameters were checked in Module I, while analyses were carried out in Modules II and III. The optimal nutritional diets were identified in Module II analysis. The "best diet (food pattern)" was defined by the average of the target population's food patterns, while the "best diet (no food pattern)" was defined as food patterns that deviated from the average food patterns but remained within the observed food pattern ranges. In Module III, diets with the lowest and highest nutrient contents were first delivered without FBR to provide baseline levels for comparison. Those with the lowest nutrient contents were minimised to identify the worst-case nutrients, whereas those with the highest nutrient contents were maximised to identify the best-case scenarios. Further analysis in Module III specified the worst-case nutrient levels for each tested FBR.

FBR was set up based on problem nutrients (PN) of the participant population. PN was assigned if the nutrient did not achieve 100.0% of its recommended nutrient intake (RNI) in the Module III model, which had the upper tail of the model nutrient intake distribution. Besides, it was necessary to define dietary adequacy (DA), shown by ≤65.0% of its RNI in the "worst-case scenario" in Module III, which had the lower tail of the model nutrient intake distribution. DA was defined as the accepted percentage of the population at risk of inadequate nutrient intake. FBR was evaluated if the DA for each nutrient was >65.0% of RNI in the "worst-case scenario" (minimised).

Data analysis

Data obtained from the previous step were entered into Microsoft® Office Excel 2007 according to name and food code. Data processing began with preparing Excel files for the Food Composition Table (FCT), research data input, and nutritional adequacy references. The files included information such as food name, food group and subgroup, serving size, minimum and maximum servings, average serving, and food type. In addition to Excel, 24-hour diet recall data were also analysed using NutriSurvey to determine the nutritional content of individual foods and recipes.

The next step in data processing involved using LP software to identify nutrient intake from local diets and develop population-specific FBRs. This optimisation analysis helps public health professionals determine the most affordable combinations of local foods to meet the nutritional needs of the target group.

The first step in Optifood was to create a new target group and fill in all the required data correctly. The FCT and Indonesian RDA were imported into the reference data. After creating a new group, Optifood directed the process to the "food" menu. In this menu, results of the Excel food data were imported and frequency per week was calculated. The next step was automatically completed if the "food" section was entered correctly, as well as steps 4–5. After the five steps had been completed, the diet was continually checked to ensure the accuracy of the data. Following an analysis, nutrition problems were identified in this menu and solutions were created (SEAMEO RECFON, 2020).

The detailed operational framework of the Optifood procedures is shown in Figure 1. The analysis starts with an

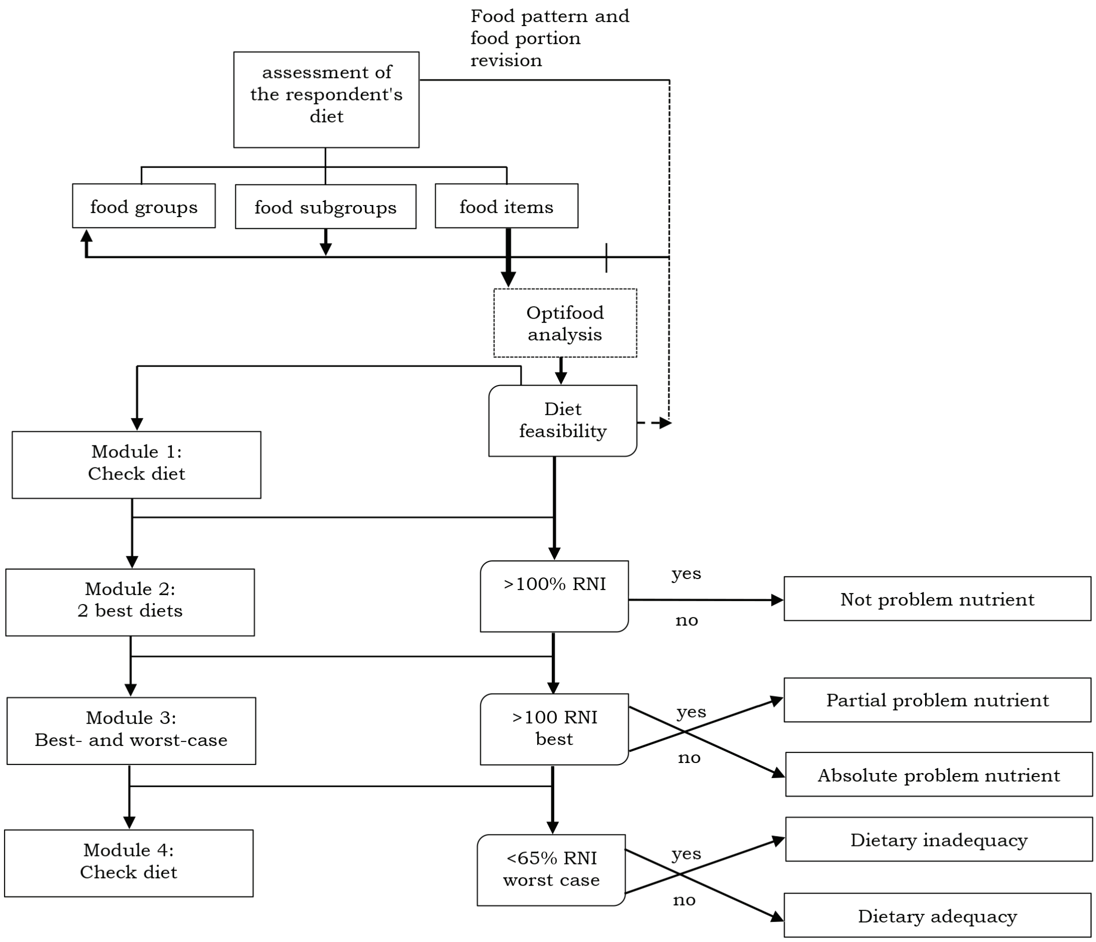

Figure 1. Operational framework of Optifood

Table 1. Baseline characteristics of participants (*N*=100)

Variables	*n*	%
Age (years)		
30–40	18	18.0
41–52	82	82.0
BMI		
Normal	9	9.0
Overweight	14	14.0
Obese	77	77.0
Physical activity		
Mild	34	34.0
Moderate	66	66.0
Sodium intake		
<2000 mg	40	40.0
≥2000 mg	60	60.0
Magnesium intake		
<500 mg	100	100.0
≥500 mg	0	0.0
Education attainment		
No schooling	3	3.0
Elementary level	46	46.0
Middle level	45	45.0
Higher level	6	6.0
Employment		
Housewife	49	49.0
Civil servant	6	6.0
Entrepreneur	26	26.0
Labour	7	7.0
Others	12	12.0
Family income per month		
<IDR 500.000 (<USD 32.7)	2	2.0
IDR 500.000-2.000.000 (USD 32.7–<130.8)	42	42.0
IDR 2.000.000-4.000.000 (USD 130.8–261.6)	47	47.0
> IDR 4.000.000 (>USD 261.6)	9	9.0
Hypertension onset		
<1 year	10	10.0
>1 year	90	90.0
Check-up frequency		
<1 once/month	14	14.0
Once a month	68	68.0
Seldom	18	18.0
Place of seeking healthcare services		
Public health centre (PHC)	76	76.0
Hospital	6	6.0
General practitioner	5	5.0
Midwife	1	1.0
None	12	12.0

1 US dollar = 15,291 IDR (as of October 7, 2022)

assessment of the respondent's diet, which is then grouped into food groups, food subgroups, and food items. The next step is to apply the Optifood analysis, beginning with diet feasibility and then performing module 1 (check diet), module 2 (2 best diets), module 3 (best- and worst-case scenario), and module 4 (check diet). From the activities of Modules 1 and 2, information regarding nutrient problems and DA will be obtained.

The study was approved and granted ethical clearance by the Health Research Committee (KEPK) of Semarang Health Polytechnic of the Ministry of Health (No. 0405/EA/KEPK/2022).

RESULTS

General characteristics of the target group

A total of 100 recall data from women aged 30–52 years, with a mean age of 45 years, were obtained. In Indonesia, the reproductive age for women is between 30 and 49 years. However, according to the Ministry of Health Indonesia (2024), women still have menstruation until the age of 53 years (Kemenkes RI, 2024). Table 1 presents the sociodemographic characteristics of the participants. Most women in this study were aged 41–51 years old (81.0%). Forty-six out of 100 women had an elementary education level. Most women were housewives (49.0%) and had an income of between IDR 2,000,000 – 4,000,000 (USD 132.2 - 264.5) a month (47.0%). In addition, most women (90.0%) had hypertension more than 1 year ago. Regarding check-up frequency, a large proportion of participants (68.0%) reported performing it once a month. Majority (76.0%) visited the public health centre to obtain health services. More than half of the participants (77.0%) were obese and had moderate physical activity (66.0%). Moreover, 60 participants (60.0%) had a sodium intake of more than 2000 mg per day. All participants had a magnesium intake of 500 mg per day (100.0%).

Table 2 presents the distribution of food consumption and their median portion sizes. The participants consumed a total of 129 food items, categorised into 15 food groups. These included grains and grain products (5 items); starchy roots and other starchy plant foods (4); bakery and breakfast cereals (6); meat, fish, and eggs (5); dairy products (4); legumes, nuts, and seeds (5); vegetables (8); fruits (8); added fats (3); added sugars (3); miscellaneous (6); savoury snacks (1); sweetened snacks and desserts (3); beverages (3); and composite foods (6). Rice (milled) from the grains and grain products food group was consumed by 99.0% of participants, with a median serving size of 27 g and a range of 8–83 g. Starchy roots and other starchy plant food items that were consumed by 24.0% of participants were potatoes, with a median serving size of 20 g and a range of 10–239 g.

Meanwhile, chicken egg and chicken meat were consumed by 58.0% and 42.0% of participants, respectively, with median serving sizes of 42 g and 39 g and ranges of 2–81 g and 20–121 g, respectively. Tempeh and tofu were the most consumed foods in the legumes, nuts, and seeds food group, at 63% and 43%, respectively, with median serving sizes of 45 g and 39 g each and ranges of 5–200 g and 10–216 g each. Cabbage and carrot were consumed by 37% and 33% of participants, with median serving sizes of 10 g and 17 g each and ranges of 2–50 g and 4–50 g each. The types of fruits that most participants consumed were bananas (24.0%) and sweet oranges (12.0%), with median serving sizes of 100 g and 60 g each and ranges of 10-150 g and 22-110 g each. Many participants consumed soy sauce (27.0%), with a median serving size of

Table 2. Distribution of food consumption and median portion size

Food items	*n (%)*	*Serving size, g (median)*
Grains and grain products		
Noodle, dried	12 (12.0)	43 (5–90)
Rice, milled	99 (99.0)	27 (8–83)
Yellow noodles (wet)	2 (2.0)	69 (38–100)
Rice flour	12 (12.0)	12 (4–50)
Wheat flour	33 (33.0)	15 (5–40)
Starchy roots and other starchy plant foods		
Potato	21 (21.0)	20 (10–239)
Tapioca, fresh tuber	14 (14.0)	57 (28–250)
Cassava flour	10 (10.0)	2 (2–8)
Sweet potato white, raw	1 (1.0)	120 (120–120)
Bakery and breakfast cereals		
Traditional food, *"Gemblong"*	2 (2.0)	40 (40–40)
Traditional food, *"Gethuk Singkong"*	4 (4.0)	100 (30–120)
Cake, modern	3 (3.0)	40 (20–65)
Lumpur cake	1 (1.0)	120 (120–120)
Bread roll	3 (3.0)	80 (40–80)
Traditional food, *"Wingko Babat"*	2 (2.0)	38 (25–50)
Meat, fish, and eggs		
Egg, hen, whole, raw	58 (58.0)	42 (2–81)
Fish, fresh water	4 (4.0)	108 (60–144)
Chicken, meat	42 (42.0)	39 (20–121)
Beef meatballs	19 (19.0)	30 (5–167)
Beef, medium	12 (12.0)	39 (10–78)
Dairy products		
Cheddar cheese	3 (3.0)	15 (7–30)
Chocolate milk powder	3 (3.0)	28 (20–40)
Sweetened condensed milk	2 (2.0)	25 (10–40)
Fresh milk	3 (3.0)	10 (2–20)
Legumes, nuts, and seeds		
Melinjo chips	1 (1.0)	7 (7–7)
Mungbean dried *(Kacang Ijo Kering)*	2 (2.0)	40 (20–60)
Peanuts	17 (17.0)	14 (5–52)
Tofu	46 (46.0)	39 (10–216)
Tempeh, raw	63 (63.0)	45 (5–200)
Vegetables		
Yardlong beans, mature seeds, raw *(Biji Kacang Panjang)*	23 (23.0)	25 (9–63)
Chayote	14 (14.0)	20 (9–40)
Soybeans, mature seeds, sprouted, raw	25 (25.0)	10 (2–25)
Spinach	20 (20.0)	32 (5–110)
Bok choy	13 (13.0)	17 (10–50)
Chinese convolvulus, raw (*Kangkung*)	12 (12.0)	50 (10–99)
Cabbage	37 (37.0)	10 (2–50)
Carrot	33 (33.0)	17 (4–50)

to be continued...

Table 2. Distribution of food consumption and median portion size *(continued)*

Food items	*n (%)*	*Serving size, g (median)*
Fruits		
Young coconut meat	8 (8.0)	6 (5–15)
Melon, green	5 (5.0)	100 (40–200)
Pineapple	6 (6.0)	100 (40–200)
Jackfruit, ripe	3 (3.0)	20 (10–175)
Banana, Ambon var.	24 (24.0)	100 (10–150)
Watermelon (*Semangka*)	3 (3.0)	100 (100–100)
Mango, fresh	4 (4.0)	75 (40–150)
Sweet oranges	12 (12.0)	60 (22–110)
Added fats		
Margarine	6 (6.0)	5 (4–7)
Coconut milk, raw (liquid)	43 (43.0)	10 (4–30)
Cooking oil	98 (98.0)	5 (1–21)
Added sugars		
Syrup	3 (3.0)	20 (15–40)
Palm sugar	21 (21.0)	7 (3–30)
White sugar	56 (56.0)	10 (3–25)
Miscellaneous		
Ginger	2 (2.0)	28 (23–33)
Celery	1 (1.0)	50 (50–50)
Sweet soy sauce *(Kecap)*	27 (27.0)	10 (1–50)
Mayonnaise *(Mayones)*	1 (1.0)	5 (5–5)
Sauce	6 (6.0)	13 (5–20)
Peanut butter	1 (1.0)	5 (5–5)
Savoury snacks		
Plain tapioca crackers *(Kerupuk)*	42 (42.0)	10 (5–32)
Sweetened snacks and desserts		
Seaweed jelly	1 (1.0)	15 (15–15)
Chunky bar, mixed nuts, and chocolate-coated	4 (4.0)	7 (7–14)
Candy Blaster: Chocolate-filled hard candy	2 (2.0)	17 (9–25)
Beverages (non-dairy or blended dairy)		
Coffee powder	7 (7.0)	20 (7–200)
Beverages, tea, Jasmine, and brewed	44 (44.0)	2 (2–2)
Water, bottled, generic	99 (99.0)	333 (133–1,500)
Composites (mixed food groups)		
Traditional foods (*Bakwan)*	9 (9.0)	50 (25–150)
Sweet flour cake *Butter (Martabak Manis)*	1 (1.0)	130 (130–130)
Martabak (Egg, Meat)	2 (2.0)	60 (50–70)
Traditional foods and *Risoles*	1 (1.0)	75 (75–75)
Noodle, chicken	2 (2.0)	200 (200–200)
Dumplings (*Siomay*)	3 (3.0)	50 (50–60)

10 g and a range of 1–50 g and savoury snacks that were high in sodium, namely plain tapioca crackers (42.0%), with a median serving size of 10 g and a range of 5–32 g. Meanwhile, almost all participants consumed cooking oil, with a median serving size of 5 g, ranging from 1 to 21 g. More than half of the

Table 3. Median, minimum, and maximum consumption frequency per week of food groups

Food group	*Consumed frequency per week*		
	Median	*Minimal*	*Maximal*
Added fats	36	14	70
Added sugars	8	3	19
Bakery and breakfast cereals	2	1	3
Beverages (Non-dairy or blended dairy)	38	21	71
Composites (mixed food groups)	2	1	4
Dairy products	1	1	2
Fruits	4	1	9
Grains and grain products	21	11	34
Legumes, nuts, and seeds	12	3	33
Meat, fish, and eggs	10	3	23
Miscellaneous	4	1	13
Savoury snacks	5	5	15
Starchy roots and other starchy plant foods	3	2	8
Sweetened snacks and desserts	1	1	2
Vegetables	9	2	30

participants consumed white sugar (56.0%), with a median serving size of 10 g and a range of 3–25 g.

Food group consumption frequency

Table 3 showed that grains, as Indonesia's staple food, were consumed three times daily (21 times per week). Protein sources such as legumes, nuts, seeds, meat, fish, and eggs were consumed 10–12 times weekly (1–2 times per day). Fruit intake was low, with a median of four times per week, while vegetables were consumed more frequently at nine times per week. Beverages and fats, particularly cooking oil, were consumed about five times daily, indicating frequent intake. High-sodium snacks were consumed nearly every day, with a median of five times per week.

Problem nutrients

Table 4 presents the LP analysis results for Modules II and III. Folate was identified as a problem nutrient in Optifood Module II (two best diets). Dietary inadequacy included all nutrients – protein, fat, calcium, vitamin C, thiamine, riboflavin, niacin, vitamin B_6, vitamin B_{12}, vitamin A (RE), iron, and zinc. The potential food subgroups and food items identified in Module II that could be promoted to achieve DA were rice, cassava, meat, chicken meat, tempeh, small shrimp, and fruits. These food subgroups and food items were used either separately or combined with other foods to establish the optimised FBR alternatives in Module 3. Folate was considered an absolute problem nutrient because 100% of its RNI could not be achieved with the best diet (Module II) or in the best-case scenario (Module III). The analysis for sodium and magnesium is not available in Optifood; therefore, they were analysed using NutriSurvey.

Table 4 also shows the three alternative FBRs determined based on identified food groups, subgroups, and food items, as well as a comparison of their worst-case scenario nutrient levels in Module III. Among these alternatives, the last FBR was the most promising, as it could demonstrate the highest RNI percentage for all the problem nutrients on the list.

DISCUSSION

To the best of our knowledge, this is the first study to identify PN and develop FBRs using the LP approach in a specific population of reproductive-age women with hypertension. This study described current feeding patterns, as well as modifications to increase the weekly consumption of specific, nutrient-dense foods to ensure DA among women aged 30–52 years with hypertension in Semarang, Indonesia. It is speculated that gaps in the intake adequacy of several nutrients will remain, even when FBRs are adopted. These were minimised by considering the types, frequency, and portion sizes of foods consumed in existing dietary patterns. The current study aimed to close nutrient gaps by promoting healthy foods for women with hypertension.

Up-to-date recommendations in dietary guidelines have the potential to inform a range of policy action developments, such as identifying specific foods for labelling, restrictions, and procurement, as well as providing financial incentives for healthy and sustainable foods, while imposing taxes on unhealthy, unsustainable dietary patterns. Identifying indices that effectively measure the health and sustainability of diets can also be used to monitor and evaluate policy actions against these recommendations in a timely manner (Machado *et al.*, 2023).

The Optifood analysis determined that the median frequency of fruit consumption was only four times per week, indicating that fruit was not consumed every day. The median frequency of vegetable consumption was higher than that of fruit consumption (9 times per week or 1–2 times per day), but still below the recommendation. A study found that very few women ate dark green leafy vegetables rich in vitamin A (around 30%). In general, few

Table 4. Comparison of nutrient levels between two best diets (Module II) and worst-case and best-case scenario diets (Module III), worst-case and best-case scenario diets without food-based recommendations (FBRs) (Module III), and alternative sets of FBR tested (Module III; worst-case scenarios only)

Analysis	*Achievement in nutrients (% RNI)*													
	Energy	*Protein*	*Fat*	*Calcium*	*Vitamin C*	*Thiamine*	*Riboflavin*	*Niacin*	*Vitamin B_6*	*Folate*	*Vitamin B_{12}*	*Vitamin A (RE)*	*Iron*	*Zinc*
Best diet (food patterns)	100	108.1	86.7	101.4	81.4	152.7	118.9	119.9	91.4	34.9	100.0	187.0	83.5	57.0
Best diet (no food pattern)	100	135.8	116.3	106.3	101.1	154.5	185.4	134.4	140.7	72.6	100.0	332.8	100.0	101.1
Best-case scenario	144	169.8	162.8	160.3	146.4	223.3	224.7	229.0	167.3	72.8	137.1	372.5	142.5	113.9
Worst case scenario	25	54.6	40.5	44.4	0.3	63.2	19.1	32.9	18.2	1.2	3.9	0.9	38.8	9.8
Optimised diets without FG	-	135.8	116.3	106.3	101.1	154.5	185.4	134.4	140.7	72.6	100.0	332.8	100.0	101.1
Optimised diets with FG	-	108.1	86.7	101.4	81.4	152.7	118.9	119.9	91.4	34.9	100.0	187.0	83.5	57.0
WORSTBESTSCENARIO	-	54.6	40.5	44.4	0.3	63.2	19.1	32.9	18.2	1.2	3.9	0.9	38.8	9.8
FBR1	-	113.0	66.5	82.9	65.7	115.4	112.6	106.4	93.6	36.3	87.9	118.4	75.5	61.6
FBR2	-	112.7	66.5	82.7	61.4	115.3	112.3	105.9	93.4	35.3	87.9	118.4	75.4	60.7
FBR3	-	112.8	67.3	82.8	63.0	115.7	113.4	107.1	95.3	37.2	88.0	120.7	75.8	61.4

FG : Food groups

women consume fruits and vegetables (21.7% and 6.6% in rural areas; 8.6% and 2.5% in urban areas). Fruits are seasonal; their high off-season prices may make them unaffordable for women from low-income households. A study conducted by Ndanuko *et al.* (2016) suggested that healthy dietary patterns, such as the DASH diet, Nordic diet, and Mediterranean diet, which are high in fruits and vegetables, significantly lowered systolic and diastolic BP by 4.3 mmHg and 2.4 mmHg, respectively (Ndanuko *et al.*, 2016).

The median consumption frequency of beverages, such as tea and coffee, was 38 times a week. Consumption of snacks high in sodium was frequent, with a median frequency of five times a week. Based on the NutriSurvey analysis, sodium and magnesium intake patterns were consistent with the findings from the Optifood analysis. Over half of the respondents reported a sodium intake exceeding 2000 mg per day. Sources of sodium contributing to high intakes were beef meatballs, condiments such as sweet soy sauce (*kecap*), savoury snacks such as plain tapioca crackers (*kerupuk*), coffee powder, and traditional foods such as bakwan (Table 2). In contrast, all participants had a magnesium intake of 500 mg per day. These combined findings indicated an unhealthy dietary pattern characterised by low fruit and vegetable intake, with excessive sodium and insufficient magnesium intakes. Accordingly, recommendations emphasising sodium reduction and increased consumption of fruits and vegetables were incorporated into the message.

Across all food groups, there was a general trend towards higher intake among rural women than urban women (Otunchieva, Smanalieva & Ploeger, 2022). In a study by Awoke *et al.* (2022), pre-pregnancy women born in Australia were less likely to have an optimal intake of grains/cereals. Aside from that, those with higher education and the least socioeconomically disadvantaged were more likely to meet physical activity. On the other hand, postpartum women with higher education and in socioeconomically advantaged areas were more likely to meet the recommended vegetable and fruit intakes and recommended levels of physical activity (Awoke *et al.*, 2022).

LP analysis found that folate was an absolute problem nutrient. Using the LP approach, FBRs can help achieve the recommended intakes of protein, fat, calcium, thiamine, riboflavin, niacin, vitamin B_6, vitamin B_{12}, vitamin A (RE), and iron for women aged 30–49 years, but not for vitamin C, folate, and zinc (nutrient gaps). Even after increasing the intake of PN from approximately 30% RNI in the non-optimised diet to 50%–70% RNI in the optimised diet, the intake was still below 65% RNI (nutrient gaps).

Based on LP analysis, several recommendations that could help increase nutritional needs were obtained, but each of them was inadequate. The FBR recommends diversifying staple foods by including cassava in addition to rice. Animal protein sources, such as chicken meat, chicken liver, and small shrimp are suggested. For plant-based proteins, tempeh and tofu, are highly recommended due to their nutrient density, with tempeh advised to be consumed twice as often as tofu on a weekly basis. Recommended vegetables include green cultivated types like cassava leaves, cabbage, and long beans, which were the most frequently consumed. For fruits, bananas and papayas are suggested, as they are affordable, accessible, rich in nutrients, especially potassium, and beneficial for hypertensive patients.

Potassium can prevent blood pressure increase caused by excessive sodium intake. This treatment is known to have a positive effect on controlling blood pressure in patients (Lee *et al.*, 2020). In addition to increasing the variety of foods consumed, women with hypertension are advised to limit salt intake and reduce consumption of high-sodium foods, including preserved and long-shelf-life products such as sausages, meatballs, and nuggets. Although women with hypertension know that they should reduce their sodium intake, many do not follow these dietary guidelines (Shim *et al.*, 2020).

Health education interventions regarding hypertension-related knowledge are effective in increasing knowledge about hypertension and influencing the implementation of self-care practices. Although knowledge may not be sufficient to produce behavioural change, it is an important component for motivating behavioural change. A study showed that systolic and diastolic blood pressures decreased after 12 weeks of nutrition education, suggesting that the duration of education may influence blood pressure outcomes (Lee, Rhee & Lee, 2020).

To date, LP analysis using Optifood software has been primarily used to address undernutrition in infants, young children, women of reproductive age, and adolescent girls (Zahra *et al.*, 2023). This study provided evidence of LP modelling in a public health centre setting (Fahmida *et al.*, 2015). As recommendations of local foods were formed based on the most frequently consumed foods and within the observed frequency of servings, the study could provide valuable information for health workers in designing education messages for this target group (Oy *et al.*, 2019). Furthermore, the recommendation of food groups or subgroups was chosen instead of specific food items to facilitate ease in implementation. This study also identified several important food sources for the diet of women aged 30–52 years with hypertension, which could be promoted through agricultural interventions, such as increasing production and accessibility (Hlaing *et al.*, 2015).

There will be challenges to the implementation and adoption of the developed local-specific FBRs. Firstly, the recommendations were developed at high constraint levels, which were the high number of servings per week from the food/food subgroup according to the target groups' dietary patterns, with the purpose of ensuring nutritional adequacy. Secondly, to ensure that the diet provides ≥70% of all micronutrient RNIs, the recommendation should include the number of FBRs, set at their highest constraint. Another barrier to dietary compliance is people's difficulty in changing eating habits formed throughout life. The relatively high cost of healthy foods, limited availability of suitable foods, problems in choosing more appropriate foods when eating out, and the complexity of preparing a low-salt diet when cooking meals for family members without hypertension are known barriers to changing dietary patterns (Shim, Heo & Kim, 2020).

The Indonesian balanced dietary guidelines include the concept of a balanced and nutritious diet, which is not very different from the DASH diet. Therefore, the guidelines for hypertensive patients are a modification of the Indonesian balanced diet concept, which is adjusted by increasing the amount of vegetables and fruits and reducing salt intake (Kemenkes, 2024). This food-based recommendation has a similar concept to Indonesia's balanced nutrition guidelines and serves as an explanation of the types of food that come from local areas.

CONCLUSION

Women of reproductive age with hypertension showed poor dietary patterns – low fruit and vegetable intake and high consumption of tea, coffee, and high-sodium snacks. This study showed that locally available foods have the potential to improve the diet quality of women of reproductive age (30–52 years) with hypertension, provided that consumption frequency is increased. Given the persistent folate deficiency, fortified folate-rich foods are needed. This food-based recommendation is in accordance with Indonesia's balanced nutrition guidelines and serves as an explanation of the types of food that come from the local area. Therefore, the message delivered to the target audience will be more acceptable. We suggest that future studies should investigate the effect of FBRs on dietary adherence in community-based interventions. FBR study could be implemented in different areas throughout the country.

Acknowledgment

We are grateful to the Ministry of Health of the Republic of Indonesia and the Health Service of the City of Semarang (Public Health Centres of Tlogosari Wetan, Tlogosari Kulon, Lebdosari, Lamper and Bandarharjo) for their support and participation in this study.

Authors' contributions

Hendriyani H, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; Isnawati M, advised on the data analysis and interpretation, and reviewed the manuscript; Muninggar DLP, conducted the study, assisted in data collection and data analysis.

Conflict of interest

The authors declare that they have no conflicts of interest.

References

Awoke MA, Wycherley TP, Earnest A, Skouteris H & Moran, LJ (2022). The profiling of diet and physical activity in reproductive age women and their association with body mass index. *Nutrients* 14(13):2607.

Daelmans B, Ferguson E, Lutter CK, Singh N, Pachón H, Creed-KanashiroH, Woldt M, Mangasaryan N, Cheung E, Mir R, Pareja R, & Briend A (2013). Designing appropriate complementary feeding recommendations: tools for programmatic action. *Maternal & Child Nutrition* 9 (Suppl 2): 116–130.

Davis EF, Lewandowski AJ, Aye C, Williamson W, Boardman H, Huang RC, Mori TA, Newnham J, Beilin LJ & Leeson P (2015). Clinical cardiovascular risk during young adulthood in offspring of hypertensive pregnancies: insights from a 20-year prospective follow-up birth cohort. *BMJ Open* 5(6):e008136.

Fahmida U, Kolopaking R, Santika O, Sriani S, Umar J, Htet MK & Ferguson E (2015). Effectiveness in improving knowledge, practices, and intakes of "key problem nutrients" of a complementary feeding intervention developed by using linear programming: Experience in Lombok, Indonesia. *Am J Clin Nutr* 101(3):455–461.

Fahmida U, Pramesthi IL & Kusuma S (2020). Linear programming approach using optifood. SEAMEO RECFON, Jakarta, Indonesia

Filippou CD, Tsioufis CP, Thomopoulos CG, Mihas CC, Dimitriadis KS, Sotiropoulou LI, Chrysochoou CA, Nihoyannopoulos PI & Tousoulis DM (2020). dietary approaches to stop hypertension (DASH) diet and blood pressure reduction in adults with and without hypertension: A systematic review and meta-analysis of randomised controlled trials. *Adv Nutr* 11(5):1150–1160.

Gusnedi G, Fahmida U, Witjaksono F, Nurwidya F, Mansyur M, Djuwita R, Dwiriani CM & Abdullah M (2022). Effectiveness of optimized food-based recommendation promotion to improve nutritional status and lipid profiles among Minangkabau women with dyslipidemia: A cluster-randomized trial. *BMC Public Health* 22(1):21.

Geelhoed JJ, Fraser A, Tilling K, Benfield L, Davey Smith G, Sattar N, Nelson SM & Lawlor DA (2010). Preeclampsia and gestational hypertension are associated with childhood blood pressure independently of family adiposity measures: the Avon longitudinal study of parents and children. *Circulation* 122(12):1192–1199.

Hlaing LM, Fahmida U, Htet MK, Utomo B, Firmansyah A & Ferguson EL (2015). Local food-based complementary feeding recommendations developed by the linear programming approach to improve the intake of problem nutrients among 12–23- month-old Myanmar children. *Br J Nutr* 116(S1):S16–S26.

James PR & Nelson-Piercy C (2004). Management of hypertension before, during, and after pregnancy. *Heart (British Cardiac Society)* 90(12):1499–1504.

Kemenkes RI (2018) Hasil Riset Kesehatan Dasar Tahun 2018. *Kementrian Kesehatan RI* 53(9):1689–1699.

Kemenkes RI (2024). *Saat Menopause Datang Lebih Awal*. From https://sehatnegeriku.kemkes.go.id/baca/blog/20240110/1844721/saat-menopause-datang-lebih-awal/ [Retrieved December 26 2024]

Lee YS, Rhee MY & Lee SY (2020). Effect of nutrition education in reducing sodium intake and increasing potassium intake in hypertensive adults. *Nutr Res Pract* 14(5):540–552.

Machado P, McNaughton SA, Livingstone KM, Hadjikakou M, Russell C, Wingrove K, Sievert K, Dickie S, Woods J, Baker P & Lawrence M (2023). Measuring adherence to sustainable healthy diets: A scoping review of dietary metrics. *Adv Nutr* 14(1):147–160.

Ministry of Health of the Republic of Indonesia (2018). Indonesian Food Composition Database (TKPI 2017). Jakarta: Directorate of Community Nutrition, Directorate General of Public Health, Ministry of Health of the Republic of Indonesia

Muntner P, Shimbo D, Carey RM, Charleston JB, Gaillard T, Misra S, Myers MG, Ogedegbe G, Schwartz JE, Townsend RR, Urbina EM, Viera AJ, White WB & Wright JT Jr (2019). Measurement of blood pressure in humans: A scientific statement from the American Heart Association. *Hypertension (Dallas, Tex. : 1979)* 73(5):e35–e66.

Ndanuko RN, Tapsell LC, Charlton KE, Neale EP & Batterham MJ (2016). Dietary patterns and blood pressure in adults: A systematic review and meta-analysis of randomized controlled trials. *Adv Nutr* 7(1):76–89.

Otunchieva A, Smanalieva J & Ploeger A (2022). Dietary Quality of women of reproductive age in low-income settings: A cross-sectional study in Kyrgyzstan. *Nutrients* 14(2):289.

Oy S, Witjaksono F, Mustafa A, Setyobudi SI & Fahmida U (2019). Problem nutrients in adolescent girls with anemia versus nonanemic adolescent girls and the optimized food-based recommendations to meet adequacy of these nutrients in adolescent school girls in east Java, Indonesia. *Food Nutr Bull* 40(3):295-307.

Oyeyemi AL, Oyeyemi AY, Adegoke BO, Oyetoke FO, Aliyu HN, Aliyu SU & Rufai AA (2011). The short international physical activity questionnaire: cross-cultural adaptation, validation and reliability of the Hausa language version in Nigeria. *BMC Med Res Methodol* 11(1):1–11.

Pan WH & Yeh WT (2008). How to define obesity? Evidence-based multiple action points for public awareness, screening, and treatment: an extension of Asian-Pacific recommendations. *Asia Pacific J Clin Nutr* 17(3):370–374.

Schröders J, Wall S, Hakimi M, Dewi FST, Weinehall L, Nichter M, Nilsson M, Kusnanto H, Rahajeng E & Ng N (2017). How is Indonesia coping with its epidemic of chronic noncommunicable diseases? A systematic review with meta-analysis. *PLoS One* 12(6):e0179186.

SEAMEO RECFON (2020). *Pengembangan Panduan Gizi Seimbang Berbasis Pangan Lokal Bagi Anak Bawah Lima Tahun (Balita) di 37 Kabupaten Prioritas Stunting di Indonesia*. From https://www.seameo-recfon.org/wp-content/uploads/2020/09/Laporan-PGSPL-37Kab-INDONESIA-submitted-30Juni2020-1.pdf [Retrieved September 5, 2023].

Shim JS, Heo JE & Kim HC (2020). Factors associated with dietary adherence to the guidelines for prevention and treatment of hypertension among Korean adults with and without hypertension. *Clin Hypertens* 26:5.

Weng X, Woodruff RC, Park S, Thompson-Paul AM, He S, Hayes D, Kuklina EV, Therrien NL & Jackson SL (2024). Hypertension prevalence and control among U.S. women of reproductive age. *Am J Prev Med 66*(3):492–502.

WHO (2018). *Noncommunicable diseases country profiles 2018*. From https://www.who.int/publications/i/item/9789241514620. [Retrieved October 20, 2023].

WHO (2019) *Noncommunicable diseases and their risk factors*. From https://www.who.int/health-topics/noncommunicable-diseases#tab=tab_1 [Retrieved November 15, 2023].

Zahra NL, Chandra DN, Mansyur M & Fahmida U (2023). Designing optimal food-based recommendations and nutrient-dense canteen menu for oil and gas workers using linear programming: A preliminary study in oil and gas worksite in east Kalimantan, Indonesia. *Nutrients* 15(19):4132.