Context-specific food-based dietary guidelines for managing diabetes among hospitalized patients in Tanzania.

Happyness Kisighii A[1]*, Jofrey Raymond[1], Musa Chacha[2]

[1]Department of Food Sciences and Technology, Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania
[2]Department of Sustainable Agriculture Biodiversity and Ecosystem Management, The Nelson Mandela African Institution Science and Technology, Arusha, Tanzania

Abstract

Food-based dietary guidelines for managing diabetes among inpatients are currently not well established in Tanzania. This significantly contributes to delayed recovery of patients and increased burden to families and communities. This study aimed at developing context-specific food-based dietary guidelines to guide healthcare professionals make rational decisions in planning diets for patients. A cross-sectional study was conducted to collect data on dietary intake among diabetic inpatients to inform the formulation of food-based dietary guidelines. A 7-days weighed food record was used to assess dietary intake among 100 diabetic patients. Data on prices of common foods were obtained from hospitals' requisition books and nearby markets. Findings showed that there are inadequate intakes of existing food plans. Linear goal programming was used to optimize dietary intake for diabetic inpatients by developing food-based dietary guidelines. Optimal dietary guidelines that are context-specific for managing diabetes for hospitalized patients can be formulated using culturally acceptable foods.

Keywords: Optimal dietary pattern, Linear programming, Diabetes mellitus, Food-based dietary guidelines.

Introduction

Diabetes is now one of the stressing public health concerns in Tanzania. The prevalence was estimated at 3.7% for adults aged 20-79 years in 2020 and is expected to triple by 2045 with linked health, social, and economic costs [1]. The country is currently spending about $2.7 for insulin supply only to manage diabetes. Urgent solutions for slowing, or even reversing, this trend is needed, especially from investment in modifiable factors including diet, physical activity, and body weight [2]. Dietary management of diabetes has a vital role in helping diabetic patients achieve and maintain optimal glycaemic control, the benefits of which have been demonstrated particularly in diet interventions that are context-specific [3].

Dietary management aims to complement medical treatment for diabetes in various roles [4]. Some of these roles include; maintaining blood glucose levels within and /or as close to the normal range as is safely possible to reduce or prevent the risk of diabetic complications, together with optimal nutrition, activity and appropriate medication; minimizing the risk of hypoglycemia for those taking insulin or oral hypoglycaemic agents; adjusting energy intake to achieve reasonable weight, normal growth and development; achieving blood pressure and lipid levels that reduce the risk for micro-and macrovascular disease or complications; reducing the risk of long-term complications; maintaining the quality of life; and addressing individual nutritional needs, taking into consideration personal, ethnic and cultural preferences and lifestyle while respecting the individual's requirements and willingness to change [3].

Executing dietary management of diabetes is usually smoothened out when dietary guidelines that take into account local socio-cultural factors and personal preferences are in place [5]. This is particularly important in hospital settings [6]. Dietary guidelines form the basis for designing advice on healthy eating patterns that link nutrients to food intake and ensure overall dietary quality for health [7,5]. Dietary guidelines for managing diabetes do not exist in many Tanzanian hospital settings [8]. Besides, the existing guidelines are outdated or adapted from developed countries and therefore may not apply to the local situation [3]. The high-quality research to inform the development of food-based dietary guidelines that are context-specific are also not available in the country [3]. This makes it difficult for healthcare professionals to make a rational decision on diet planning to help people with diabetes achieve and maintain optimal metabolic and physiological outcomes during treatment.

***Correspondence to:** Happyness Kisighiia A, Department of Food Sciences and Technology, Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania, E-mail: amanihappy9@gmail.com

Received: *13-Jan-2022, Manuscript No. AAJPHN-22-51666;* Editor assigned: *17-Jan-2022, Pre QC No. AAJPHN-22-51666(PQ);* Reviewed: *01-Feb-2022, QC No. AAJPHN-22-51666;* Revised: *18-Apr-2022, Manuscript No. AAJPHN-22-51666(R);* Published: *25-Apr-2022, DOI: 10.35841/aajphn-5.4.117*

***Citation:** Kisighii HA, Raymond J, Chacha M. Context-specific food-based dietary guidelines for managing diabetes among hospitalized patients in Tanzania. J Pub Health Nutri. 2022;5(4):117*

This study aimed at formulating food-based dietary guidelines that take into account healthy dietary patterns, socio-cultural factors and personal preferences to complement medical treatment for patients with diabetes in Tanzanian hospital settings. We believe that accessibility of these guidelines-both physical availabilities (e.g., through a website or clinic) and comprehensibility for patients and healthcare professionals will enhance early recovery, reduce hospital readmission and mortality and consequently reduce the economic burden of diabetes in the country.

Materials and Methods

Site description

This study was conducted in 5 hospitals located in the Northern zone of Tanzania. Inclusion criteria were that a hospital must be currently attending diabetic patients and providing food catering services to hospitalized patients.

Study participants

A cross-sectional survey was conducted from April to August 2021 to assess the dietary intake of 100 (50 each gender) hospitalized patients with diabetes in 5 hospitals located in Northern Tanzania. Inclusion criteria was that an inpatient is receiving food services from the hospital. Ethical approval for this study was obtained from the Ethics Review Committee of the School of Life Sciences and Bioengineering at The Nelson Mandela African Institution of Science and Technology (NM-AIST). The written informed consent was obtained from each hospital's administration.

Anthropometric measurements

Anthropometric measurements such as the height and weight of the patients were recorded from the patients' profile form for admission. Then, the obtained height and weight were used to calculate the Body Mass Index (BMI) of each patient included in the study. The BMI is calculated by dividing the weight in kilogram by height in meters squared (kg/m2). Obtained BMI was classified according to World Health Organization (WHO) standards for adults to understand the nutritional status of hospitalized diabetic patients included in the study.

Dietary assessment

Dietary assessment was used to estimate food intake (type and amount of food), nutrient intake and dietary patterns of hospitalized diabetic patients during the study period. Dietary assessment was also used to assess energy intake for each patient. Observed food intake, nutrient intake, and dietary patterns data were used for diet optimization.

Food intake

The amount and type of food and beverage consumed by inpatients at the hospital were assessed using Weighed Food Records (WDR) for 7 days to include the distribution of intakes provided in hospitals per schedule. Foods and beverages were weighed using a digital electronic weighing scale. Food weighing utensils such as plates and cups were supplied to all research assistants to assist with food weighing. The raw ingredients of all foods and beverages available in the hospitals' kitchen were weighed before cooking, followed by weighing the final cooked dish and the remaining uneaten foods from patients. Food intake data were subsequently converted into daily energy and nutrient intake using Tanzania, Kenya and Uganda Food Composition Tables. Data were then entered into an Excel sheet 2016 for nutrient analysis.

Dietary pattern

Diet index-based pattern was used to assess quantities, proportions, variety, and/or combination of different foods, drinks, and nutrients in diets, and the frequency with which they were routinely consumed by hospitalized diabetic patients. The pattern was then used to determine the quality or adequacy (in terms of nutrient-dense) of diets given to diabetic patients in hospitals under this study. The results of the optimized dietary patterns served as a basis for deriving the recommended daily amounts for food groups. To send consistent and understandable messages to health care professionals, the results of the optimization calculations were converted from grams to practical quantities or serving sizes.

Dietary diversity

Dietary Diversity Score (DDS) was calculated by summing a given quantity of any food group that has been eaten at least once per day by diabetic patients during hospitalization. Food items recorded from catering units that were used to prepare menus for the patient in all hospitals were grouped according to FAO food group guidelines to calculate DDS. The DDS was calculated based on 13 food groups which are: green leafy vegetables, red and orange vegetables, starchy vegetables, beans, lentils and peas, other vegetables, whole grains, refined grains, fruits, dairy, oils, meat, poultry and eggs, fish and seafood, nuts, seeds and soy products.

Nutrient intake

Energy and nutrient intakes from each food item were computed from nutritional databases such as food composition tables, nutrient databases for each food item recorded from patients' food intakes were used to calculate median intake for each patient to determine daily nutrient intake per patient. The median calculations for each nutrient intake were compared with daily Recommended Nutrient Intakes (RDI) to identify nutrient adequacy and the quality of dietary patterns among diabetic patients.

Food market survey

A food market survey was conducted on markets and shops available near the hospital settings to validate the price of foods and identify other nutrient-dense local foods that were missing in the hospital food catering menu. The data was used in formulating optimal dietary patterns for hospitalized diabetic patients. The price was obtained from raw food ingredients.

Formulation of optimal dietary pattern

The linear goal programming model was formulation for the generation of the optimal diet for inpatients with diabetes. The

constraints in the model for this study were WHO, Diabetic Association, ESPEN manual and other authorized published reports. Cultural traditions and individual preferences were included by ensuring that foods to be included in the model were suited from common food patterns in the hospitals. The cost of food items y is the objective function that we aim to minimize.

The minimum and maximum value of essential nutrients were set based on the WHO, Diabetic Association, ESPEN manual and other authorized published reports when choosing food items to ensure a menu generated per meal avoids repetition of food items.

Constraints

Constraints were set for each food item and nutrient composition obtained from nutrient databases. Then, minimum and maximum constraints for all essential nutrients and calories were based on the DRI for patients with diabetes as recommended by WHO, the world health cancer research fund, ESPEN guidelines and the American diabetic association as well as other published studies (**Table 1**). The constraints were also set for food groups to meet daily adequate food intake from each food group as per recommendation. The obtained results were used in formulating food-based dietary guidelines for hospitalized diabetic patients.

The constraints were the RDI for all essential nutrients to ensure patients meet the recommended level of each nutrient.

$$Qi \leq \sum ainxn \leq Qiand\ x_n \geq 0 \quad (1)$$

Where Q is the RDI for a specific nutrient; Q*i* denoted the minimum or maximum acceptable quantity of nutrient *i*. a*in* denotes the amount of nutrient *i* in one portion of food item *n*; The weight of food item *n* is represented as *an*.

The minimum and maximum values for all essential nutrients were set based on WCRF/AICR 2018, WHO, ESPEN guidelines and IDF as shown in (**Table 2)**. We included more than food items 150 and their corresponding 34 nutrients.

Table 1. *Food constraints list for diabetic patients used in the optimization calculations for the formulation of food-based dietary guidelines for diabetes management.*

Food group	Minimum	Reason for minimum	Maximum	Reason for maximum
Vegetables (g/d)	250		400	Lower GI
Green leafy vegetables			400	Source officer, folate, carotenoids, iron calcium, and vitamin C
Red and orange vegetables			400	Vitamin A, C, B6, and Manganese, folate
Starchy vegetables g/d	70-180	Higher in carbs		
Fruit (g/d)	200	Lower GI		
Wholegrain cereals (g/d)	90	Lower GI		
Fish (g/week)	100		125	PUFA
Legumes (g/week)	65		135	Lower GI, high fiber
Meat and poultry (g/week)	300	Lower SAF		Health
Eggs (g/week)	150	Higher cholesterol		
Nuts and seeds (g/d)	15		25	PUFA and MUFA
Dairy products (g/d)	300	Higher in saturated fats	-	

**WHO and the World Cancer Research Fund Recommendations*

Table 2*. Food groups and their criteria to include or exclude specific foods in optimization of a healthy dietary pattern.*

Food group	Calorie	SFA	TFA	Sodium	(added/total sugars)	Fiber	Additional criteria
Vegetables	1	x	x	x	x	3	Minerals and vitamins
Fruit	1	x	x	x	x	3	Minerals and vitamins
Starchy vegetables	2	x	x	x	x	2	Include all less intake
Refined rains	3	3	3	3		x	
Whole grains	1	x	x	x	x	3	Fiber and some micronutrients
Beans, peas and lentils	1	x	x	x	x	1	Fiber, iron, folate
Nuts and seeds	1	x	x	x	x	3	MUFA and PUFA, iron, calcium, magnesium, folate
White meat		x	x	x	x	x	Iron, vitamin B_{12} or thiamin, protein for meat replacements
Red meat	x	3	x	x	x	x	
Dairy and milk substitutes	x	3	x	x	x	x	Calcium, vitamin B_{12}, protein for milk substitutes
Oils, fats and spreads	1	3	x	x	x	x	
Non-alcoholic beverages	3	x	x	3	3	x	Only water, tea, coffee without sugar

[1]Less content of a defined nutrient in a given food group

[3]High content of a defined nutrient in a given food group

[2]Medium content of a defined nutrient in a given food group

[x]Less or no content of a defined nutrient in a given food group

Citation: *Kisighii HA, Raymond J, Chacha M. Context-specific food-based dietary guidelines for managing diabetes among hospitalized patients in Tanzania. J Pub Health Nutri. 2022;5(4):117*

Decision variables

Food ingredients used to prepare meals for the patients during hospitalization were termed as decision variables. These were presented as follows:

$xn = weight$ (g) of a food item *n*.

Objective function

The objective was to minimize the cost of the food items used for the preparation of diets for hospitalized patients. The diet is formulated to meet nutritional requirements for each individual per recommendation. This is shown by the equation below:

$$Minimize\ y = \sum c_n x_n \quad (2)$$

Where y is cost, c*n* was the cost of a quantity(weight) of food item *n*

Preparation of mathematical model calculations

Linear goal programming was used to model the food-based dietary guidelines for diabetic patients hospitalized in northern Tanzanian hospitals into everyday healthy food choices. Local foods commonly consumed were identified to be used in mathematical modeling. Local nutrient-dense foods including some neglected foods were included in developing a healthy dietary pattern for the management of diabetes. To come up with an affordable diet, the modeling considered the prices of foods that are most commonly consumed. The cost of each identified most commonly eaten food item to be taken from hospitals' requisition books and markets and shops nearby hospitals.

Excel solver installation

The Solver-add-inn was installed from the Microsoft Excel version 2016 to produce the linear programming (LP) for generating optimal solutions from the food lists and their identified nutrients and costs. Details filled in Microsoft Excel 2016 include food items and their nutrient content, and price per serving, and the constraints for all nutrients (macronutrients and micronutrients) to allow the LP to determine the optimal quantity of selected food ingredients to meet the nutritional requirement for diabetic patients as recommended by WHO, ESPEN guidelines and other published reports at a minimum cost. To identify healthy dietary patterns food groups and subgroups median in intakes grams were included in the models.

The dietary guidelines development process

A multidisciplinary technical working group was formed and assigned to formulate food-based dietary guidelines for the management of type 2 dietary among hospitalized patients in Tanzania. The technical working group was composed of nutritionists, food scientists, agriculture, health, education and research specialists. The key evidence-based dietary recommendations for addressing diabetes among patients hospitalized in different health facilities concerning developed guidelines were evaluated. Then, dietary patterns were then translated into guidelines formulated based on cultural appropriateness, acceptability, comprehensibility and practicality to consumers by considering key issues for developing food-based dietary guidelines according to FAO and WHO.

Statistical analysis

The data obtained from the nutritional assessment were entered in an Excel sheet to allow statistical analyses using Excel solver to be carried out. All data were checked to remove errors. Dietary intakes were initially analyzed using nutritional databases such as food composition and nutrient value tables including Tanzanian, Kenyan and USDA respectively and compared with reference dietary intake (RDI) according to different recommendations from WHO, ESPEN guidelines, and other authoritative recommendations. Demographic data were presented as mean and standard deviations and percentages. The, paired t-test was performed using Jamovi Software to compare cost variables between observed and optimized dietary patterns.

Results

Participants

A total of 100 hospitalized diabetic patients (males and females) from 5 hospitals (20 patients from each hospital) located in Northern Tanzania participated in the study. The majority of the respondents were males (75%) and 25% were females. The mean age was 57 ± 12 years among females and 60±5 years for males. More than 60% of the female patients were aged between 45 and 50 years and 50% of male patients ranged from 65 to 89 years.

Anthropometric measurements

The majority (70%) of the patients involved in the study had a Body Mass Index (BMI) of between 25.0 (45%) and 38.2 (25%), indicating that most of them were overweight and obese.

Food intake

Twenty-five (25) (**Table 3**) food items were obtained from daily hospitalized diabetic patients' menus. The identified foods include white bread, chapatti, rice, whole maize flour, raw banana, cabbage, carrots, green pepper, onions, tomatoes, ginger, garlic, potatoes, beef, margarine, beans, salt, vegetable oil, eggs, chicken, and amaranth, tea leaves, sugar, and milk. Grains were frequently consumed by hospitalized patients; mainly refined grains such as stiff maize porridge (Ugali), boiled rice and white bread which reached up to 74%. Overall vegetable consumption was 0.9cups (72g) per day, contributed by 0.3g dark green vegetables and 0.6g red and orange vegetables per day, legumes consumption was 0.45g per day mainly kidney beans, meat consumption was 28.3g per day while fruits, dairy products, nuts, seeds, poultry and seafood were absent in all hospital menus.

Dietary pattern

The diet optimization model results for amounts of each food group based on daily intake recommendations among diabetic patients were as follows: 2cups (220g) of vegetables,

Table 3. *Food items recorded in hospitals' catering units and their prices.*

No. of items	Food item	Unit kg	Cost (TSH)
1	Sugar	1	2300
2	Tea leaves	0.3	15000
3	Salt	1	16000
4	Cooking oil	1	4400
5	Rice	1	2500
6	Onions	1	1500
7	Tomatoes	1	1400
8	Carrots	1	1400
9	Meat	1	7000
10	Beans	1	2300
11	Chicken	1	6800
12	Cabbage	1	700
13	Amaranth	1	700
14	Wheat flour	1	1300
15	Whole maize flour	1	900
16	Eggs	1	400
17	Whole fresh milk	1	1200
18	White bread	1	1100
19	Pasta	1	1500
20	Irish potatoes	1	1400
21	Green pepper	1	2000
22	Margarine	1	4000
23	Unripe banana	1	2200
24	Ginger	1	500
25	Garlic	1	1000

1 cup (250g) of fruits achieved 51.2% and 71.3% for daily recommendation intake respectively, 48.04g whole grains with the exclusion of refined grains, 2 cups (473.17 ml) of dairy per day for only low-fat milk and milk products and 98.21g, 30.3g, 32.49g for meat, poultry, eggs; seafood and nuts seeds and soy products respectively which achieved 80% of protein food group intake of hospitalized patients (**Table 4**). Therefore, optimization excluded refined grains and increased whole grains to 85.04g followed by green-leafy and red and orange vegetables, beans, peas and lentils and other vegetables which were increased from 0.3-5 cups, 1.84 to 5.5cups, 0.45 to 1.5 cups, 0.02 to 5cups and 1.8 to 4cups respectively. Differences between the existing pattern and optimized pattern in other food groups were 1.5cups of fruits, 3cups of dairy products and 53.3g of protein foods. The dietary patterns developed had recommended amounts and limits of calories for adult diabetic patients' maximum of 1800kcal as shown in (**Table 5)**.

Dietary diversity

Minimum dietary diversity for diabetic hospitalized patients was calculated from 13 food groups recorded from hospitals' catering requisition books. Grains had the highest intakes of about 4% daily. Common foods consumed by patients include rice, white bread, chapatti and pasta and maize flour products. Less than 5% of vegetables were consumed in hospitals, while other food groups such as fruits, seeds, nuts and seafood were not included in hospitals' menus. Moreover, only 2% of meat, poultry, beans and dairy were consumed by patients. The mean Dietary Diversity Score (DDS) was 3.8 based on observed consumption of foods from different food groups among diabetic patients involved in this study. A higher proportion (74%) was from grains. Overall consumption vegetables and meat were consumed by less than 2% of the participants. While fruits, nuts, dairy, seeds and seafood were absent in hospitals' menus. Beans and meat consumed in the observed intake pattern to all patients was less than 5%.

Nutrient intake

Nutrient intake results were as follows; 1.5 ± 0.8mg iron, 30 ± 14.9µg folate, 0.56 ± 0.4 µg zinc, 2.3 ± 1.5µg selenium, 76 ± 3.1mg vitamin C, 38 ± 2mg vitamin E, 111 ± 20 µg vitamin A, and 1.9 ± 1.2 µg chromium (**Table 6**). In addition, dietary fiber and energy intake were 10.5g per day 2000 ± 10kcal respectively (**Table 7**).

Optimized dietary pattern

Optimized dietary pattern was able to generate sample healthy diet plans as shown in (**Table 8)** at four different cost levels. Each food plan specifies quantities of foods and beverages categories that can be purchased and prepared to make healthy meals and snacks during hospitalization among patients with diabetes.

Cost constraints

The daily average cost from the observed dietary pattern per patient intake was about 2782.7 Tanzanian shillings (1.20USD) and after optimization, it was 2867.99 Tanzanian shillings (1.24 USD).

Table 4. *Recommended daily amounts of food groups for management of diabetes in the food-based dietary guidelines.*

Food group	Subgroup Daily amount (g)	Optimization	Recommended intake
Vegetables		450.32	200-300
	Dark-green vegetables	50.1	36.428
	Red and orange vegetables	70.9	75
	Beans, peas and lentils	57.3	43.8
	Starchy vegetables	109.7	140
	Other vegetables	85	50.85
Fruits		427.2	200-300
Grains		120.08	170.08
	Whole grains	48.04	85.0486
	Refined grains	0.0	0.0
Dairy		628	720
Protein foods		85.03	85.048
	Meat, poultry, eggs	105.298	105.298
	Seafood	30.3	32.4
	Nuts, seeds, soy products	32.49	20.24
Oils		15.2	27
Total cost TSH (USD)		3256.8 (1.40)	

Table 5. *Daily amounts of nutrients delivered by the daily recommended amount for foods in optimized dietary guidelines.*

Nutrients	RDA Upper limit	Optimization 1	Optimization 2	Optimization 3
Energy (kcal)	1800	1860	1660	1790
Protein (g)	100	54	60	100
Carbohydrates (g)	300	130	210	136
Dietary fibers	28	31.3	25	36
Added Sugars	0	0	0	0
Saturated fats (g)	-	0	8.91	0.5
Trans-fats	0.5	0.3	0.2	0.5
Total fat (g)	68	53	65	50
Cholesterol (mg)	200	135.7	116	217
Linoleic acid (g)	12	22	19	9
Alpha-linolenic (g)	3.5	2.3	3.2	2.5
Saturated Fat (g)	22	16.5	10.5	19.9
Monounsaturated (g)	33	23	19.8	23.6
Polyunsaturated (g)	15	15	13.7	13.5
Potassium (mg)	10,000	4729	4696	4704
Phosphorus	4000	1380	1412	1560
Zinc (mg)	35	6.1	10.6	17.7
Magnesium (mg)	500	227	342	298
Copper (mg)	2	1.4	1.5	1.8
Selenium (µg)	400	50	34	42
Vitamin A (RE)	3000	1000	913	860
Beta-Carotene	17,000	12,830	7,516	9365
Vitamin E (mg)	1000	12	10.2	13.2
Vitamin K (µg)	1000	55	71.6	99.7
Vitamin C (mg)	1000	549	233	274
Vitamin B12 (µg)	23	11.5	7.3	6.6
Folate (µg)	1000	413	450	475
Calcium (mg)	2500	1000	1260	1300
Iron (mg)	45	29.5	36	28
Thiamine (mg)	500	10	20	18
Riboflavin (mg)	25	34.2	25.5	30
Niacin (mg)	35	32	29	28.5
Choline (mg)	500	300	105	200
Biotin	115	115	120	12
chlorine(µg)	3000	1300	2000	1234

Table 6. *Observed daily dietary intake among hospitalized diabetic patients.*

Food group	Subgroup (Intake amount in grams)	Observed dietary pattern	Initial Optimization	Recommended intake
Energy (kcal)		2180[b]	1600	1800[1]
Vegetables		72.84.41 [a]	315.4	200-300[1]
	Dark-green vegetables	0.3 [a]	1.18	36.428
	Red and orange vegetables	1.84 [a]	2.6 [a]	5.5
	Beans, peas and lentils	0.45	2.42	1.5
	Starchy vegetables	0.02 [a]	0.53	5
	Other vegetables	1.8 [a]	2.3 [a]	50.85[1]
Fruits		0[a]	0[a]	200-300[1]
Grains		1210.5 [b]	220.39 [b]	170.08
	Whole grains	216.8 [a]	912.4[a]	85.0486
	Refined grains	893.7 [b]	2.35	0.0
Dairy		0[a]	5.25 [a]	720
Protein foods		3 [a]	13.25 [a]	85.048
	Meat, poultry, eggs	28.3	20.49 [a]	105.298
	Seafood	0 [a]	0 [a]	32.399
	Nuts, seeds, soy products	0 [a]	0 [a]	20.249
Oils		17.4	12.56	27
Total cost TSH (USD)		2000(0.87)	2700.5(1.16)	

[a]*Inadequate intake of a defined food group;* [b]*Excess intake of a defined food group*

Table 7. *Results of the observed and optimization calculations for the hospital's food pattern among hospitalized diabetic patients.*

Nutrients	Recommendation	Observed intake	Initial optimization
Calorie (Kcal)	1500	2000±10[a]	1650
Protein(g)	39	42	45
Saturated fats (g)	< 15	17.38[a]	1.5
Total fat (g)	31.7	60.9	52.2
ω -3(g)	100	89.2	102
ω-6(g)	12	140	15
PUFA	25	1.4[b]	2.86[b]
Fiber(g)	28	10±7.5	30
CHO(g)	45	334±12	60
Ca (mg)	1320	970±23.2	2000
Fe (mg)	10	1.5±0.8[b]	113
Mg(mg)	240	98	364
P(mg)	1250	2023	1800
K(mg)	4.5	2.628	7.4
Na(mg)	<1500	2239	1300
Zn(µg)	8	0.56±0.4[b]	12.4
Se(µg)	40	2.3±1.5[b]	60.1
Cu(µg)	700	160	904
Flu(µg)	2	67	20
Mn(µg)	1.6	134	1.69
Cr(µg)	21	1.9±1.2	21
Vit.A(IU)	1700	111±20[b]	2000
Thiamin(mg)	200	164	198.4
Rib(mg)	150	137	1500
Niacin(mg)	35	1612	350
Vit. B6(mg)	60	135	605
Folate(µg)	400	30±14.9[b]	600
Vit B12(µg)	10.54	140	100
Path(µg)	3	0.4	4
Vit C(mg)	500	76±3.1[b]	500
Vit D(IUs)	2,000	51[b]	100
Vit E(IU)	600	38±2[b]	603
Vit K(µg)	9	145	90
Choline(mg)	550	20±1.54[b]	20[b]
Biotin(mcg)	30	9	63

[a]*Excess intake of defined nutrients;* [b]*Inadequate intake of a defined nutrient*

Citation: *Kisighii HA, Raymond J, Chacha M. Context-specific food-based dietary guidelines for managing diabetes among hospitalized patients in Tanzania. J Pub Health Nutri. 2022;5(4):117*

***Table 8**. Sample diet plans generated from an optimized dietary pattern for the management of diabetes.*

Diet plan 1	Diet plan 2	Diet plan 3
Breakfast	**Breakfast**	**Breakfast**
1ounce Grains	1ounce Grains	1 cup Fruit
½ cup Fruit	1 cup Dairy	1 cup Dairy
½ cup Dairy	1 ½ ounce Protein Foods	
Morning Snack	**Morning Snack**	**Morning Snack**
1ounce Grains	1 cup Fruit	1ounce Grains
1 cup Fruit	½ cup Dairy	½ cup Dairy
		1 ½ ounces Protein Foods
Lunch	**Lunch**	**Lunch**
2 ounces Grains	2 ounces Grains	2 ounces Grains
1 cup Vegetables	1 cup Vegetables	1 cup Vegetables
½ cup Fruit	½ cup Dairy	1 cup Dairy
1 cup Dairy	2 ounces Protein Foods	
2 ½ ounces Protein Foods		
Afternoon Snack	**Afternoon Snack**	**Afternoon Snack**
½ cup Vegetables/vegetable salad	1ounce Grains	1ounce Grains
½ cup Dairy	¼ cup nuts/ seeds	½ cup Vegetables
		½ cup Dairy
		2 ounces Protein Foods
Dinner	**Dinner**	**Dinner**
2 ounces Grains	2 ounces Grains	2 ounces Grains
1 cup Vegetable	1 cup Vegetables	1 cup Vegetables
1 cup Dairy	1 cup Fruit	1 cup Fruit
3 ounces Protein Foods	1 cup Dairy	2 ounces Protein Foods
	2 ounces Protein Foods	

***Table 9**. Foods and food groups used to develop optimal dietary patterns for diabetic patients.*

Food group (FAO)	Sub-food group (examples)
Vegetables	**Dark green vegetables** (amaranth leaves, beet greens, broccoli, chard, collards, cress, dandelion greens, kale, mustard greens, romaine lettuce, spinach, watercress, nightshade, pumpkin leaves, cowpea leaves, spinach etc.)
	Red and orange vegetables (kabocha, carrots, chili peppers, red or orange bell peppers, sweet potatoes, pumpkin, tomatoes and butternut.)
	Beas, peas and lentils (black beans, black-eyed peas, chickpeas, cowpeas, edamame, kidney beans, lentils, lima beans, mung beans, navy beans, pigeon peas, pink beans, pinto beans, split peas, soybeans, and white beans.
	Starchy vegetables (cassava, lima beans, immature or raw (not dried) peas (e.g., cowpeas, black-eyed peas, green peas, pigeon peas), plantains, white potatoes, yam)
	Other vegetables (asparagus, bean sprouts, beets, Brussels sprouts, cabbage (all kinds) cauliflower, celeriac, celery, chayote, cucumber, eggplant, garlic, ginger root, green beans, lettuce, mushrooms, okra, onions, peppers (chili and bell types that are not red or orange) radicchio, sprouted beans (e.g. sprouted mung beans)
Grains	**Whole grains** (example, amaranth seed, barley (not pearled), brown rice, buckwheat, millet, oats, popcorn, whole-grain cornmeal, whole-wheat bread, whole-wheat chapati, whole-grain cereals and crackers, and wild rice)
	Refined grains (white bread, refined-grain cereals and crackers, corn grits, cream of rice, cream of wheat, barley (pearled), pasta, and white rice)
fruits	Apples, bananas, grapefruit, lemons, limes, mandarin oranges, dates, mangoes, watermelon, papaya, passion fruit, figs, grapes, jackfruit peaches, pears, pineapple, plums, pomegranates, guava, starfruit, tamarind, blackberries and strawberries.
Protein foods	**Meats** (Meats include beef, goat, lamb, pork, rabbit and turkey, Organ meats include brain, chitterlings, giblets, gizzard, heart, kidney, liver, stomach, sweetbreads, tongue, and tripe.
	Poultry (Poultry includes chicken, dove, duck, game birds (e.g., ostrich, pheasant, and quail))
	Seafood and fish (crab, salmon, sardine, tilapia, mackerel, tuna, and whiting), flounder, haddock, hake, herring, lobster, mullet, oyster,
	Eggs (Eggs include chicken eggs and other birds' eggs)
Nuts and seeds	1. **Seeds**: Sesame Seeds, Pumpkin Seeds, Sunflower Seeds, etc. 2. **Nuts**: almond, cashew nut, peanut, walnut, etc.
Dairy	Yogurt, sour milk, fresh whole milk
Oils	Olive oil, sunflower oil, flaxseed oil, corn oil

Discussion

Amongst the hospitalized diabetic patients included in the study, the majority of the respondent were males (75%) and 25% were females. The mean age showed that most of the female patients were aged between 45 and 65years while males 50% of patients were aged 65 to 89. Their Body Mass Index (BMI) was between 25 and 38 indicating that most of them were overweight and obese. Overweight and obesity have been reported to be among the risk factors for diabetes and its associated complications. The prevalence of overweight and obesity was also reported among Northern Tanzanian diabetic patients who attend the clinic in the year 2017. The prevalence reported being about 45% and 44% overweight and obesity respectively [9].

Food intake is a major contributor to health and well-being among individuals particularly hospitalized patients. Hospital food is one of the ways to help patients meet their nutritional requirements during hospitalization for health improvement [10]. Although a wide variety of nutritious foods are available near the hospital settings in Tanzania, many hospital foods patterns do not provide all desired nutrients and calorie needs within recommendation [11]. Observed hospital food intake patterns had lower intakes of vegetables, whole grains, legumes while fruits, dairy, seafood, nut and seeds were absent as a result do not meet adequate dietary diversity. Similar studies have shown most dietary intake patterns are inadequate as they consist of fewer vegetables, fruits and whole grains which lead to poor dietary diversity [12,13]. The obtained dietary diversity score of hospitalized diabetic patients was small less than 4 indicating that hospital food intake patterns had inadequate dietary diversity intake. This has been associated with inadequate dietary intakes of essential nutrients including dietary fiber, iron, vitamin D, folate, zinc, vitamin C, selenium, calcium and vitamin A as a result of increased burden in public health concerns for diabetic patients. Some studies including [6,11] have reported similar findings among hospitalized patients that, they have inadequate intake due to some factors including poor diet. In most developing countries including Tanzanian hospitals, low quality, and monotonous diets is the norm. Grains mainly refined, tubers and fewer vegetables, lack of fruits, nuts, seeds, seafood and less increase the vulnerability of micronutrients deficiencies among patients [12,14,15]. However, there is little information on dietary adequacy intake among hospitalized patients including diabetic patients particularly from other countries, unfortunately, the available limited data show that there is poor dietary adequacy among patients. Likewise, comparable information about dietary intakes, dietary patterns, and diet quality for patients across hospitals is also rare. This may be because of the associated costs and difficulty of quantitative dietary intake data collection, there are no nationally representative surveys providing information on dietary intakes for diabetic patients.

Vegetables and fruits are major contributors of several nutrients that are under-consumed in many Tanzanian hospitals including folate, magnesium, potassium, dietary fiber, and vitamins A, C, and K. Most of these are of public health concern for the general public [16,17]. Consumption of 2.5 cups per day from a variety of vegetables and fruits is associated with the prevention and management of diabetes and other chronic diseases [16,18]. In addition, due to their less calorie, they help to maintain a healthy weight [16]. Hospital daily intake patterns fall below amounts recommended for both fruits and vegetables (Table 5).

In most markets near the hospitals, consumers have a variety of whole grain-based foods, vegetables, fruits, legumes, seafood and proteins foods options that can help them meet dietary diversity and nutrient needs. This has been reported that local foods can provide adequate diets based on individual needs [19,7,13]. However, most hospital food intake patterns included highly refined grain foods rather than whole-grain foods, in which some refined grain foods such as white bread are higher in sodium, added sugars and solid fats such as saturated and trans-fats [20]. Refined grains are highly consumed compared to other food groups, in which in most settings such as institutions and some organizations are the main source of energy [21,13]. Whole grains help meet dietary fiber and other essential nutrient needs including B vitamins, iron, magnesium, selenium [22,23]. At least half of recommended total grain intake should be whole grains. Hospital food patterns do not provide even the minimum recommended intake of whole grains which is equivalent to 3ounces per day in which the average intake of whole grains is less than 1ounce-equivalent per day of whole grains. Optimized dietary intake patterns for hospitalized diabetic patients replaced refined grains with whole grains foods. Replacing refined grains from a given dietary pattern does not affect dietary adequacy [21].

Milk and milk products contribute many nutrients, such as calcium and vitamin D (for products fortified with vitamin D like yogurt) to the diet. According to World Cancer Foundation (2018), the intake of milk and milk products is associated with a reduced risk of type 2 diabetes and other cardiovascular diseases. Intake of milk and milk products is absent in hospitals' intake patterns. The optimized dietary pattern has generated 3 cups of dairy to be included in daily patients' menus to meet daily recommended intake.

Protein food groups consist of meat, seafood, poultry, eggs, beans, peas, soy products, nuts and seeds. In addition to protein, these foods contribute nutrients such as niacin, thiamin, riboflavin, B6, vitamin E, iron, zinc, and magnesium to the diet. Optimized dietary intake patterns for diabetic patients emphasize on intake of lean meat to limit intake of saturated fats. Patients would be required to be provided at least either of each protein food per week to ensure dietary variety. Consumption of a balanced variety of protein foods can improve the intake of essential nutrients among inpatients with diabetes [16,18]. Each protein food should provide 5ounces (141.75) per day. Meat is the most commonly consumed protein food, while poultry, eggs, seafood, beans and peas, soy products, nuts, and seeds are absent in hospital food intake patterns. However, meat, poultry can be replaced by nuts and seeds, especially for diabetic patients. Seafood has increased to 3 1/2 ounces (85g) per week to omega-3 fatty acids, eicosapentaenoic acid (EPA) and Docosahexaenoic Acid (DHA) and diabetes. Seafood higher in EPA and ADH but lower in mercury include sardines, salmon, herring, oysters and anchovies are emphasized in a healthy optimized dietary pattern for management of diabetes.

Hospital food intake pattern has less variety and amounts of foods that provide essential nutrients at calorie limit. Thus, increasing their intake of vegetables, fruits, whole grains, fat-free or low-fat milk and milk products, seafood, and healthy oils promote adequate nutrient intake within recommended calories while limiting other nutrients such as sodium, saturated fats, and trans-fats. Similarly, some studies have formulated dietary guidelines for the general population in which the key principles are as set by WHO to be considered in developing dietary guidelines that provide healthy dietary patterns [7].

This study describes the process and results of the formulation of food-based dietary guidelines for hospitalized diabetic patients. A consumption pattern formulated in line with these guidelines enhances the management of diabetes, supplies adequate nutrients and energy compared to the mean intakes of the observed pattern [7,8]. The process for formulating food-based dietary guidelines for diabetic patients described in this study combined mathematical models (linear goal programming) and data-based elements (such as nutrients per food item) with expert knowledge and common sense. Similarly, different studies have used linear programming (mathematical models) in formulating healthy dietary patterns as well as food-based dietary guidelines e.g Romanian food-based dietary guidelines (WHO, 2016), Netherland food-based dietary guidelines [24] and optimal dietary patterns for maternal nutrition by [13]. The formulated food-based dietary guidelines consist of quantitative dietary patterns as per recommendations for hospitalized diabetic patients. The dietary guidelines cover the cultural traditions, budget, personal preferences, food availability based on seasonal variations.

The optimized dietary patterns reduced the number of refined grain foods and allow the increase of vegetables particularly green leafy, orange and red vegetables, legumes and fewer starchy vegetables such as plantains, roots and tubers. Optimized dietary patterns were as close as the existing intake pattern to ensure cultural traditions, personal preferences and cost constraints [7]. Fruits were included in the model since hospitals' intake patterns did not include them in the patients' menus. Another major dietary shift involved an increase in dairy products, mostly low-fat fluid milk such as yogurt. The present dietary guidelines have met the recommended intakes based on WHO and other published manuals [7]. Given that hospital, food intake patterns had inadequate dietary diversity hence patients fail to meet the recommended intake.

The shift from the current hospital dietary intake pattern to an optimized dietary intake pattern will result in higher consumption of vegetables, fruits, whole grains, legumes, nuts, seeds and seafood which comprise the characteristics of a healthy dietary pattern. A healthy dietary pattern provides all nutrients in a recommended amount while limiting calories, sodium, sugars and saturated fats. It focuses on locally available foods and beverages that are nutrient-dense to meet the nutritional needs of hospitalized diabetic patients. Local foods which are nutrient-dense including indigenous food ingredients which are acceptable to consumers such as baobab fruits, tamarind and other vegetables are available in optimized dietary pattern formulated.

As a consequence, observed hospitals' food intake patterns results were inconsistent based on the recommended intake among diabetic patients. Intake of dietary fiber was below the recommended intake of 30g per day. Similarly, foods that contribute to high fiber vegetables, whole grains and fruits were below the recommended intake of 400g per day. The findings show that diets with high consumption of plant-based food products rich in fiber and low in calories are reported to lower the risk of non-communicable diseases including diabetes mellitus, and its associated complications. [25,18,5].

The possibility of the multi-nutrient deficit is largely overlooked in diabetic care, even though clinical studies indicate that good nutrient status may slow the progress of the disease [26]. The observed dietary patterns consumed by diabetic patients do not align with the dietary recommendations. Patients had poor diet quality as a result they had inadequate intake of essential nutrients. This may have been related to increased risk of complications associated with diabetes mellitus such as hypertension and kidney diseases which result in prolonged hospital stay, increased hospital readmission, mortality, and increased burden of inadequate micronutrients of a public health concern among inpatients [27,28]. Nutrients such as calcium, iron, vitamin C, chromium, selenium vitamin D and dietary fiber were below recommendation to diabetic patients (Table 6), this was also reported by similar studies [29,30].

Inadequate vitamin C decreases the absorption of chromium and iron [31]. Poor iron intake leads to anemia among patients with diabetes mellitus resulting in reduced quality of life among diabetic patients as a result of the elevation of proinflammatory cytokines that plays a key role in insulin resistance and induces the appearance of cardiovascular complications, diabetic micro-and macrovascular, kidney disease and anemia [32] disease progression, and other comorbidities that contribute to increased risk of cardiovascular diseases such as hypertension [33]. Zinc is a multi-functional nutrient involved in glucose and lipid metabolism, hormone function and wound healing [34], it binds to insulin to ensure adequate storage in the pancreas for its release when glucose enters the bloodstream as well as prevents inflammation to cells. Inadequate zinc intake is associated with increase blood cholesterol [34,35] inflammations of cells as a result of poor processing, storage, secretion, and transportation of insulin by the Langerhans cells in the body [34,36]. Zinc, vitamin C, E, and selenium are antioxidants [34]. Insufficient intake of antioxidants increases the production of oxidative stress that damage cells responsible for secretion and response to insulin hormone [34]. Low dietary folate increases homocysteine and lowered the biosynthesis of methionine which affect the DNA and RNA synthesis, and methylation patterns in neural tube tissue as a result of the development of retinopathy (blindness) to the patients with diabetes mellitus [37,38].

Similarly, poor intake of chromium, magnesium, and selenium as shown by the hospitals' intake patterns of lowers insulin sensitivity, carbohydrate, protein and lipid metabolism and increased LDL [39,40]. The low intakes of calcium may increase the prevalence of low bone mass and osteoporosis among diabetic patients. Similarly, previous studies have reported inadequate nutrient intake among hospitalized patients [6]. Likewise, Alaini, Rajikan, and Elias reported an inadequate distribution of these nutrients. The burden has been increasing among hospitalized patients with these disease conditions as a result leading to the poor healing process, increased hospital readmission, mortality rate and unplanned costs [11].

The formulated dietary pattern ensures that its recommendations for diabetes management can meet people's preferences, cultural perspectives and ensure their affordability. For

example, Table 5, presents a sample of amount for foods for each food group to be eaten daily. In making choices for foods in each food group locally available nutrient-dense foods were included to meet nutrient recommendations Dietary pattern has included all forms and types of foods that are nutrient-dense based on a defined food group such as fresh, dried and indigenous food items to ensure dietary diversity (**Table 9**). Studies have shown the relationship between dietary diversity and adequate nutrient intake [41]. Diets rich in vegetables and fruits are widely known as beneficial for health because of the vitamins, minerals and antioxidants that these foods contain and they are low in calories [42]. Particularly for diabetic patients, this means there is a significant increase compared with their current observed average vegetable consumption of 72.84 g. Therefore, quantities of each food item within each food group were translated to understandable portion size to help patients served appropriate amounts of daily foods to meet daily recommended essential nutrients based on limits of intakes for their health as shown in (Table 5).

Price and affordability are key barriers to accessing sufficient, safe, nutritious food to meet dietary needs and food preferences for an active and healthy life. More nutritious foods and diets cost more than basic staples and energy-sufficient diets [8]. Therefore, effective drivers of food choice including price and income constraints were addressed through linear programming to allow hospitals to adapt healthy dietary patterns for their patients. The optimized cost of healthy diet measures allows for substitution within each food group to meet the recommended quantities for a healthy dietary pattern. Additional requirements such as personal or culturally typical food preferences would impose additional costs. To enable all people to shift behavior toward healthy diets, the prices of those diets, particularly of the most nutrient-rich food groups, need to decrease [8].

There was no significant difference in costs between optimized and observed dietary intake patterns. Costs from optimized dietary patterns per patient were approximately at 3760.86 Tanzanian shillings (2.37 USD) compared to the observed dietary pattern costs ranging from 2782.7 Tanzanian shillings (1.20USD) to 2867.99 Tanzanian shillings (1.24 USD) cost per patient intake per day (Table 5). However, the optimized healthy dietary pattern can be obtained from different costs to enhance patients' opt for the diet plan with affordable cost to them.

Certain foods and food components that are consumed in excessive amounts include sodium, saturated and trans-fatty acids, added sugars, and refined grains have been reported to increase the risk of certain chronic diseases such as diabetes, cardiovascular and kidney diseases [43]. Excessive intake replaces nutrient-dense forms of foods in the diet, making it difficult for patients to achieve recommended nutrient intake and control calorie intake. The recommendations in this optimized healthy dietary pattern are based on evidence that eating less of these foods and food components can help diabetic patients meet their nutritional needs within appropriate calorie levels, as well as help reduce associated complications from diabetes. Hospital eating patterns exceed the limit of added sugars and sodium from consumption of foods and beverages high in sugars across food groups from high intake of pre-prepared foods such as and white bread. Sugars added foods have been reported to contribute to increased calories but low nutrient content which leads to the rise of blood glucose levels in diabetic patients [44,45]. Foods with high saturated and trans fats such as red meat, full-fat dairy products such as and whole milk, cakes, cookies, biscuits and rolls, fried foods (doughnuts, crisps, chips) fried chicken and stick margarine and palm oil are limited in the optimal dietary pattern for management of diabetes mellitus. As an alternative, high saturated fats with MUFA and PUFA rich food ingredients such as olive oil, nuts, almonds, cashews, pecans and macadamias, canola oil, avocado, nut butter, olives and peanut oil and walnuts, sunflower seeds, flax seeds or flax oil, fish, such as salmon, mackerel, herring, albacore tuna, and trout, corn oil, soybean oil and safflower oil respectively are included in a healthy optimal dietary pattern. High intake of saturated and trans-fats has been reported to interfere with insulin resistance [46]. The findings from optimized health patterns can meet nutritional requirements for health enhancement among diabetic patients after limiting sugar and salt added foods, refined grains and high saturated foods.

Conclusion

Food-based dietary guidelines provide recommendations for adequate, balanced and varied food intakes that enhance diabetes management through complementing medical treatments to produce good health outcomes and decrease further complications from the disease. Dietary guidelines can be used for designing advice on healthy eating patterns from a quality diet to meet the nutritional requirements of individuals and ensure overall health.

Acknowledgements

The authors wish to thank Joshua Mwasunda for sharing his expertise and perspectives on the applicationof linear programming in Clinical Nutrition and Dietetics. Furthermore, we thank Alfred Said Sife and Fanuel Letting Kiptoo for providing advice on early versions of this manuscript.

Funding

This work was supported by the Nelson Mandela African Institution of Science and Technology (NM-AIST).

Disclosure Statement

The authors report there are no competing interest to declare

Data Availability Statement

Dataset analysed and generated during this study are available from the corresponding author on request.

References

1. Duggan, E, Carlson K, Umpierresz G. Metabolic Consequences of Surgical Stress. Anesthesiology, March, 2017;1-14.
2. Gupta L, Lal P, Khandelwal D. Optimizing Macronutrients in People with Diabetes. J Soc Health Diab. 2018;6(02):065-71.

3. Forouhi NG, Misra A, Mohan V, et al. Dietary and nutritional approaches for prevention and management of type 2 diabetes. BMJ. 2018;361:k2234.

4. Kong JP, Baharom B, Jamhuri N, et al. Adequacy of energy and protein intake among hospitalized patients on therapeutic diet in government hospitals: A preliminary study. Nutr Food Sci. 2019:50(5):903-20.

5. Guo Y, Huang Z, Sang D, et al. The Role of Nutrition in the Prevention and Intervention of Type 2 Diabetes. Front Bioeng Biotechnol. 2020;8:1-15.

6. Larby A, Roberts S, Desbrow B. Accuracy and adequacy of food supplied in therapeutic diets to hospitalised patients: An observational study. Nutr Diet. 2016;73(4):342-47.

7. Dwyer JTB. The Importance of Dietary Guidelines. Reference Module in Food Sciences. 2019;1-16.

8. Herforth. Studies, Economics Technical. In Agricultural Development Economics Technical FAO.

9. Damian DJ, Kimaro K, Mselle G, et al. Prevalence of overweight and obesity among type 2 diabetic patients attending diabetes clinics in northern Tanzania. BMC Res Notes. 2017;10(1):515.

10. Roberts S, Hopper Z, Chaboyer W, et al. Engaging hospitalised patients in their nutrition care using technology: development of the NUTRI-TEC intervention. BMC Health Services Research. 2020;20(1):1-11.

11. Lori C, Valaitis R, Laur C. Low Food Intake in Hospital:patient, instittional, and clinical factors. Appl Physiol Nutr Metab. 2018;43(12):1239-46.

12. Arimond M, Wiesmann D, Becquey E et al. (2010). Dietary diversity as a measure of the micronutrient adequacy of women's diets in resource-poor areas: Summary of results from five sites. J Nutr. 2010;140(11):2059S-69S.

13. Raymond J, Kassim N, Rose JW, et al. Optimal dietary patterns designed from local foods to achieve maternal nutritional goals. BMC Public Health. 2018;18(1):1-12.

14. Bandoh DA, Kenu E. Dietary diversity and nutritional adequacy of under-fives in a fishing community in the central region of Ghana. BMC Nutrition. 2017;3(1):1-7.

15. Oldewage-Theron W, Kruger R. Dietary diversity and adequacy of women caregivers in a peri-urban informal settlement in South Africa. Nutrition. 2011;27(4):420-27.

16. Rush E, Savila F, Jalili-Moghaddam S, et al. Vegetables: New zealand children are not eating enough. Front Nutr. 2019;5:134.

17. Wallace TC, Bailey RL, Blumberg JB, et al. Fruits, vegetables, and health: A comprehensive narrative, umbrella review of the science and recommendations for enhanced public policy to improve intake. Crit Rev Food Sci Nutr. 2020;60(13):2174-211.

18. World Cancer Research Fund. Recommendations and public health and policy implications. Continous Update Project. 2018;1-92.

19. Arimondary M, Bineti SV, Yves M, et al. Local foods can meet micronutrient needs for women in urban Burkina Faso, but only if rarely consumed micronutrient-dense foods are included in daily diets : A linear programming exercise. Matern Child Nutr. 2018;14(1):e12461.

20. Papanikolaou Y, Slavin JL, Clemens R, et al. Do refined grains have a place in a healthy dietary pattern: Perspectives from an expert panel consensus meeting. Curr Dev Nutr. 2020;4(10): nzaa125.

21. Masset G, Monsivais P, Maillot M, et al. Diet optimization methods can help translate dietary guidelines into a cancer prevention food plan. J Nutr. 2009;139(8):1541-48.

22. Carcea M. Nutritional value of grain-based foods. Foods. 2020;9(4):504.

23. Kellogg's. Fibre and Whole grains. Heart and Stroke Foundation of Canada, 2020; 1-6.

24. Brink E, Van Rossum C, Postma-Smeets A, et al. Development of healthy and sustainable food-based dietary guidelines for the Netherlands. Public Health Nutr. 2019;22(13):2419-35.

25. Alaini R, Rajikan R, Elias SM. Diet optimization using linear programming to develop low cost cancer prevention food plan for selected adults in Kuala Lumpur, Malaysia. BMC Public Health, 2019;19(4):1-8.

26. Walker AF. Potential micronutrient deficiency lacks recognition in diabetes. Br J Gen Pract. 2007;57(534): 3-4.

27. Berger MM, Pantet O, Schneider A, et al. Micronutrient Deficiencies in Medical and Surgical Inpatients. J Clin Med. 2019;8(7):931.

28. Gurmu AB, Nykänen EPA, Alemayehu FR, et al. Cost-minimized nutritionally adequate food baskets as basis for culturally adapted dietary guidelines for ethiopians. Nutrients. 2019;11(9):2159.

29. Dubey P, Thakur V, Chattopadhyay M. Role of minerals and trace elements in diabetes and insulin resistance. Nutrients. 2020;12(6):1864.

30. Kaur B, Henry J. Micronutrient status in type 2 diabetes: A review. Adv Food Nutr Res. 2014;71:55-100.

31. Beck KL, Conlon CA, Kruger R, et al. Dietary determinants of and possible solutions to iron deficiency for young women living in industrialized countries: A review. Nutrients. 2014;6(9):3747-76.

32. Soliman AT, De Sanctis V, Yassin M, et al. Iron deficiency anemia and glucose metabolism. Acta Biomed. 2017;88(1):112-18.

33. Balouch GH, Shaikh S, Shah SZ, et al. Silent ischaemia in patients with type 2 diabetes mellitus. World Applied Sciences Journal, 13(2), 213-216.

34. Toma A, Makonnen E, Yimer G. Role of zinc in diabetes mellitus, oxidative stress and other human healthy: a review article. Am J Res Commun. 2013;1(11):411-26.

Citation: *Kisighii HA, Raymond J, Chacha M. Context-specific food-based dietary guidelines for managing diabetes among hospitalized patients in Tanzania. J Pub Health Nutri. 2022;5(4):117*

35. Farooq M. Zinc deficiency is associated with poor glycemic control. J Coll Physicians Surg Pak. 2019;29(3):253-57.

36. Khanam S. Role of zinc supplementation on diabetes. Endocrine Disorders, 2018;2(1):10-11.

37. Lei XW, Li Q, Zhang JZ, et al. The protective roles of folic acid in preventing diabetic retinopathy are potentially associated with suppressions on angiogenesis, inflammation, and oxidative stress. Ophthalmic Res. 2019;62(2):80-92.

38. Malaguarnera G, Gagliano C, Salomone S, et al. Folate status in type 2 diabetic patients with and without retinopathy. Clin Ophthalmol. 2015;9:1437-42.

39. Cefalu WT, Hu FB. Role of chromium in human health and in diabetes. Diabetes Care. 2004;27(11):2741-51.

40. Chowdhury S, Pandit K, Roychowdury P, et al. Role of chromium in human metabolism, with special reference to type 2 diabetes. J Assoc Physicians India. 2003;51:701-05.

41. Tavakoli S, Dorosty-motlagh AR, Hoshiar-Rad A, et al. Is dietary diversity a proxy measurement of nutrient adequacy in Iranian elderly women? Appetite. 2016;105:468-76.

42. Montaña C, Mar R, Gonz E, et al. Food-Based Dietary Guidelines around the World : A Comparative Analysis to Update AESAN Scientific Committee Dietary Recommendations. Nutrients. 2021;13(9):3131.

43. Blair M. Diabetes Mellitus Review. Urol Nurs. 36(1), 27-36.

44. Erickson J, Slavin J. Total, added, and free sugars: Are restrictive guidelines science - Based or achievable? Nutrients. 2015;7(4):2866-78.

45. Shin HR, Kim WJ. Healthy eating habits 2 for patients with diabetes. In World Helath Organization. 2017.

46. Angelieri CT, Barros CR, Siqueira-Catania A, et al. Trans fatty acid intake is associated with insulin sensitivity but independently of inflammation. Braz J Med Biol Res. 2012;45(7):625-31.

Citation: *Kisighii HA, Raymond J, Chacha M. Context-specific food-based dietary guidelines for managing diabetes among hospitalized patients in Tanzania. J Pub Health Nutri. 2022;5(4):117*