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The DQQ is a Valid Tool to Collect Population-Level Food Group Consumption Data: A Study Among Women in Ethiopia, Vietnam, and Solomon Islands

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A B S T R A C T

Background: The Diet Quality Questionnaire (DQQ) is a rapid dietary assessment tool designed to enable feasible measuring and monitoring of diet quality at population level in the general public.

Objectives: To evaluate validity of the DQQ for collecting population-level food group consumption data required for calculating diet quality indicators by comparing them with a multipass 24-h dietary recall (24hR) as the reference.

Methods: Cross-sectional data were collected among female participants aged 15–49 y in Ethiopia ($n = 488$), 18–49 y in Vietnam ($n = 200$), and 19–69 y in Solomon Islands ($n = 65$) to compare DQQ and 24hR data in proportional differences in food group consumption prevalence, percentage of participants achieving Minimum Dietary Diversity for Women (MDD-W), percent agreement, percentage misreporting food group consumption, and diet quality scores of Food Group Diversity Score (FGDS), noncommunicable disease (NCD)-Protect, NCD-Risk, and the Global Dietary Recommendation (GDR) score using a nonparametric analysis.

Results: The mean (standard deviation) percentage point difference between DQQ and 24hR in population prevalence of food group consumption was 0.6 (0.7), 2.4 (2.0), and 2.5 (2.7) in Ethiopia, Vietnam, and Solomon Islands, respectively. Percent agreement of food group consumption data ranged from 88.6% (10.1) in Solomon Islands to 96.3% (4.9) in Ethiopia. There was no significant difference between DQQ and 24hR in population prevalence of achieving MDD-W except for Ethiopia (DQQ 6.1 percentage points higher, $P < 0.01$). Median (25th–75th percentiles) scores of FGDS, NCD-Protect, NCD-Risk, and GDR score were comparable between the tools.

Conclusions: The DQQ is a suitable tool for collecting population-level food group consumption data for estimating diet quality with food group-based indicators such as the MDD-W, FGDS, NCD-Protect, NCD-Risk, and GDR score.

Keywords: dietary assessment, diet quality, Food Group Diversity Score, Global Dietary Recommendations, Minimum Dietary Diversity for Women

Introduction

Although achieving healthy diets for all is critical to reach the United Nations Sustainable Development Goals, healthy diets are not assured for everyone and everywhere [1,2]. Globally, suboptimal diets are related to malnutrition in all its forms such as undernutrition, micronutrient deficiencies, and noncommunica ble diseases (NCDs) [1,3]. The prevalence of overweight, obesity, and NCDs are rising fastest in low- and middle-income countries (LMICs), where different forms of malnutrition coexist [4,5]. According to the World Health Organization, a healthy diet helps to protect against malnutrition in all its forms, that is, NCDs such as diabetes type 2, heart diseases, stroke, and cancer [6].

To assess whether populations consume healthy diets, first and foremost, diets need to be measured. There are various dietary assessment methods available such as food frequency

Abbreviations used: 24hR, 24-h dietary recall; DE, dietary energy; DQQ, Diet Quality Questionnaire; FGDS, Food Group Diversity Score; FN, false negative; FP, false positive; GDR, Global Dietary Recommendation; LMICs, low- and middle-income countries; MDD-W, Minimum Dietary Diversity for Women; NCD, noncommunicable disease; pp, percentage point.

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questionnaires, food records, and 24-h dietary recalls (24hR). Although the 24hR is prone to measurement error as a self-reported dietary assessment method, it is an accepted reference method for population-level dietary assessment [7]. Similar to most available dietary assessment methods, 24hR are relatively expensive and require high levels of training and skill, often rendering them infeasible to conduct in multitopic surveys or in resource-limited settings such as LMICs [8,9]. The absence of feasible, standardized, and valid tools to collect rapid and reliable dietary data has hindered the ability to measure and monitor diets globally [2,10,11].

The Diet Quality Questionnaire (DQQ) is a standardized low-burden tool for dietary assessment at the population level [12, 13]. This questionnaire is designed to collect food group consumption data required for calculating diet quality indicators among the general public across the world and has been implemented in 55 countries in the Gallup World Poll in 2021–2022 [13–16]. Indicators generated from the DQQ include the Minimum Dietary Diversity for Women (MDD-W), which indicates a higher likelihood of adequate micronutrient intake for women of reproductive age in LMICs [17,18], and new indicators to capture dietary risk factors for NCDs, such as the Global Dietary Recommendation (GDR) score [19]. The DQQ is a list-based method for asking about consumption of 29 food groups in the previous day and night [13]. The list-based method in general is valid to recall 24-h food group consumption data for the purpose of MDD-W calculation [20]. This study examines the validity of the DQQ as a list-based method for collecting population-level food group consumption data to calculate diet quality indicators, compared with a quantitative, interview-assisted multipass 24hR as the reference.

Methods

Study population

Cross-sectional dietary data were collected among 488 female participants aged 15–49 y in Ethiopia, 200 women aged 18–49 y in Vietnam, and 65 women aged 19–69 y in Solomon Islands. In Ethiopia, data were collected in November and December 2019 in 5 different regions: Amhara, Oromia, SNNPR, Tigray, and Addis Ababa, with 100 households in each region, randomly selected from 10 districts (2 in each region). In the regions Amhara, Oromia, SNNPR, and Tigray, together with the agriculture office, 2 districts were selected of which one was characterized as high agriculture productive and one as low agriculture productive. In Addis Ababa, together with the health office, 2 districts were selected of which one was characterized as urban slum and one as higher income area. After listing all eligible households (that is, those with female participants aged 15–49 y) from each district, 50 households per district were selected using systematic random sampling [21]. In Vietnam, data were collected in November and December 2019 in Nam Tu Liem district, a periurban area of Hanoi. Together with the local health authorities, all eligible households (women of reproductive age, nonpregnant and nonlactating) in the district were listed and 200 women were randomly selected. If households were unable or unwilling to participate, a new household was randomly selected. In Solomon Islands, data were collected in July and August 2018 in a rural coastal site of Baniata Village in the Western Province and in August and September 2019 in a rural inland site of Eastern Central Guadalcanal and an urban site of Jericho [22]. Households were randomly selected by first generating a list of all eligible households in the village and then using the randomization function in Excel. If households were unable or unwilling to participate, a new household was randomly selected [22].

Data collection

Both sociodemographic data, such as age and education level, and dietary data were collected by trained data collectors using questionnaires translated into the local language. All data were collected on paper except DQQ data in Vietnam, which were collected on tablets using the KoboToolbox software [22,23].

Dietary assessment tools

Two tools for dietary assessment were used: the DQQ and 24hR for collecting food group consumption data. Both tools were conducted across 2 nonconsecutive days among all respondents in Ethiopia and Solomon Islands and for only 1 d for all respondents in Vietnam. During the interview, the DQQ was administered first, followed by the 24hR. The order of administration was purposefully determined to ensure that the multipass 24hR process would not bias the DQQ results because the DQQ is designed for use as a rapid dietary assessment tool without probing.

Data were analyzed from 200 DQQs and 200 24hR from 200 women in Vietnam, 969 DQQs and 969 24hR from 488 women in Ethiopia, and 118 DQQs and 118 24hR from 65 women in Solomon Islands. A small number of respondents could not be reached for a second recall in Ethiopia ($n = 5$) and Solomon Islands ($n = 11$). All recalls collected were included in the analysis.

DQQ

The DQQ comprises yes/no questions about foods consumed in the previous day or night that correspond to 29 food groups. The food groups are as follows: *1*) foods made from grains; *2*) whole grains; *3*) white roots, tubers, and plantains; *4*) legumes; *5*) vitamin A–rich orange vegetables; *6*) dark green leafy vegetables; *7*) other vegetables; *8*) vitamin A–rich fruits; *9*) citrus; *10*) other fruits; *11*) baked/grain-based sweets; *12*) other sweets; *13*) eggs; *14*) cheese; *15*) yogurt; *16*) processed meats; *17*) unprocessed red meat (ruminant, for example, beef, lamb, and goat); *18*) unprocessed red meat (nonruminant, for example, pork); *19*) poultry; *20*) fish and seafood; *21*) nuts and seeds; *22*) packaged ultraprocessed salty snacks; *23*) instant noodles; *24*) deep fried foods; *25*) fluid milk; *26*) sugar-sweetened beverages (soft drinks); *27*) fruit juice and fruit-flavored drinks; *28*) sweet tea/coffee/cacao; and *29*) fast food. These food groups are used to construct the MDD-W and GDR scores. Before data collection, the DQQ was adapted for each country through in-depth key informant interviews to identify country-specific and culturally appropriate sentinel foods for all food groups [14]. The wording of the DQQ questions has been based on cognitive testing [13]. During data collection, data collectors administered the DQQ by reading aloud the list-based sentinel food questions to the respondents without any probing or additional dialog [24]. Example DQQ questions of food groups 5, 6, and 7, respectively, in Solomon Islands were as follows: "Yesterday, did you eat any of the following vegetables: carrots, pumpkin, or orange fleshed kumara?" (food group 5) "Slippery cabbage, kamau, kasume, taro leaves, kangkong, or pumpkin leaves?" (food group 6) "Cassava leaves, ofenga, sweet leaf, Chinese cabbage, or amaranth leaves?" (food group 6) "Tomatoes, cucumber, eggplant, green capsicum, sweet peas, snake beans, or long beans?" (food group 7) [25].

The DQQ food groups include those necessary for calculating MDD-W and additional food groups required for indicators associated with risk factors for NCDs [15]. The DQQ standardizes MDD-W data collection by using a standardized approach to question formulation and adaptation, aligned with the MDD-W measurement guide and based on expertise and input from a wide range of key informants in each country [13–15,26].

Multipass 24-h dietary recall

The multipass 24hR method was used, and data collectors asked respondents to name all food and drinks consumed during the preceding day and to describe ingredients and cooking methods of mixed dishes [27,28]. For food items available in households, amounts of all foods, drinks and ingredients of mixed dishes consumed were weighed to the nearest one decimal in grams using digital kitchen scales (Etekcity model EK6015) in Solomon Islands [22], Soehnle food weight scales in Ethiopia, and LP-B series in Vietnam. If a food item was not available for direct measurements, substitutes such as water were weighed and converted using conversion factors in Ethiopia [21] and Vietnam, and Solomon Islands, quantities were estimated using water, modeling clay, or strips of paper in the respondent's original dishware [22]. Standard portion sizes were used to determine the amount of food items when measuring the actual food was not possible in Ethiopia and Vietnam [21]. In Solomon Islands, displacement techniques were used to determine portion sizes if clay or paper were used to determine portion size. Food quantities were determined by converting quantities or densities of the clay or paper by using food density conversion factor estimates from the FAO International Network of Food Data Systems (INFOODS) Density Database. This database was used to determine grams and milliliters of foods, based on each food's specific density [22,29].

Diet quality indicators

For every respondent, list-based food group questions in the DQQ answered with "no" were categorized as 0 and with "yes" as 1. Food items consumed in amounts of 15 g or more in 24hR were categorized into the 29 DQQ food groups using a food group classification guide and MDD-W guiding principles [26, 30]. The initial categorization for the 3 countries was performed by 2 different persons, whereas the final categorization for all countries was checked by the same person. In a secondary analysis (Supplemental Material), foods consumed in <15 g were retained, to test whether the DQQ data were more comparable with the 24hR when items consumed in small amounts were excluded or included. Two sets of diet quality indicators were constructed based on the 29 food groups, originating either from DQQ or 24hR [15,26]. Diet quality indicators used in our study are the MDD-W and its nonbinary analog the Food Group Diversity Score (FGDS) and the GDR score and its subcomponents NCD-Protect and NCD-Risk.

MDD-W and FGDS

The MDD-W comprises 10 food groups: *1*) grains, white roots and tubers, and plantains; *2*) pulses (beans, peas, and lentils); *3*) nuts and seeds; 4) milk and milk products; *5*) meat, poultry, and fish; *6*) eggs; *7*) dark green leafy vegetables; *8*) other vitamin A–rich fruits and vegetables; *9*) other vegetables; and *10*) other fruits. Consumption of 5 or more out of these 10 food groups indicates a higher likelihood of adequate micronutrient intake for female participants of reproductive age (15–49 y) in LMICs. The MDD-W is a dichotomous indicator (0 or 1) expressed as the proportion of women meeting the MDD-W [18,26,31]. The FGDS is a semicontinuous score ranging from 0 to 10, by summing the scores for each food group (0: not consumed; 1: consumed) using the same food groups as the MDD-W. The FGDS is a proxy indicator of micronutrient adequacy for the general population expressed as the mean population score [31].

NCD-Protect

The NCD-Protect consists of 9 food groups: *1*) whole grains; *2*) pulses; *3*) nuts and seeds; *4*) vitamin A–rich orange vegetables; *5*) dark green leafy vegetables; *6*) other vegetables; *7*) vitamin A–rich fruits; *8*) citrus; and *9*) other fruits. The NCD-Protect score ranges from 0 to 9 and reflects adherence to GDRs on healthy components of the diet that protect against diet-related NCDs. A higher score indicates inclusion of more health-promoting foods in the diet and correlates positively with meeting the WHO GDRs to consume ≥400 g of fruits and vegetables per day, include whole grains, legumes, nuts and seeds in the diet, and consume ≥25 g of fiber per day [15,19]. Scoring of each food group is binary (0: not consumed; 1: consumed), and the NCD-Protect score is calculated by summing the scores of each food group [15,19].

NCD-risk

NCD-Risk consists of 8 food groups: *1*) soft drinks (sodas); *2*) baked/grain-based sweets; *3*) other sweets; *4*) processed meat (double weighted); *5*) unprocessed red meat; *6*) deep fried food; *7*) fast food and instant noodles; and *8*) packaged ultraprocessed salty snacks. The NCD-Risk score ranges from 0 to 9 and reflects adherence to GDRs on components of the diet to limit or avoid. A higher score indicates a lower likelihood of meeting the GDRs on dietary risk factors for NCDs, including avoiding free sugars in excess of 10% of dietary energy (DE), total fat >30% DE, saturated fat >10% DE, salt >5 g/d, red meat >350 g/wk, and avoiding processed meat [19]. In addition, the NCD-Risk score is a proxy for ultraprocessed food intake, with a higher NCD-Risk score related to higher ultraprocessed food consumption [15]. Scoring of each food group is 0 for not consumed and 1 for consumed, except "processed meat" scored with 2 when consumed, and the NCD-Risk is calculated by summing the scores of each food group [15,19].

GDR score

The GDR score (ranging from 0 to 18) reflects adherence to GDRs that relate to NCD risk factors (as described earlier). The higher the GDR score, the more GDRs on healthy diets are likely to be met. The GDR score is calculated by subtracting NCD-Risk from NCD-Protect and transforming to a positive range by adding 9 and is expressed as the mean population score [15,19].

Data analysis

Data analyses were performed using SPSS version 25.0 (IBM Corporation).

Population-level results from the DQQ and 24hR

Population prevalence (%) of food group consumption of the individual 29 DQQ and 10 MDD-W food groups and population prevalence of women achieving MDD-W were reported based on the DQQ and on the 24hR, respectively. Foods consumed in amounts <15 g in the 24hR were excluded from the main analysis, aligned with the MDD-W measurement guide [26]. Furthermore, a secondary analysis was performed including foods consumed in amounts <15 g in the 24hR to test whether the DQQ mitigated overreporting of foods consumed in small amounts. The DQQ does not include sentinel foods typically consumed in <15 g [14].

Differences in population prevalence were calculated by the value from the DQQ minus 24hR and compared using the McNemar test. A difference of >10 percentage points (pp) was considered practically important for matching actual population prevalence based on the reference method [19]. A Mean pp difference in population consumption prevalence of all food groups was calculated by summing the difference of each food group and dividing it by the total number of food groups.

Measurement agreement, false positives, and false negatives

Percent agreement coefficient was used to evaluate measurement agreement between DQQ and 24hR for consumption of food groups and for achieving MDD-W. The percent agreement coefficient (hereafter referred to as percent agreement) was calculated using the formula $(a + d)/n$, with "a" being the number of respondents reported not having consumed the particular food group based on both DQQ and 24hR, "d" referring to the number of respondents reported having consumed the particular food group based on both DQQ and 24hR, and "n" corresponding to the total number of respondents. The mean percent agreement between tools of all food groups was calculated by summing the difference of each food group and dividing it by the total number of food groups.

Misclassification [false positives (FPs) and false negatives (FNs)] of food group consumption and achieving MDD-W was examined using cross tabulations, based on the 24hR as the reference method. A difference of >10 pp was considered practically important (for matching actual population prevalence based on the reference method) for proportion of overreporting or underreporting and underclassifying or overclassifying achieving MDD-W on the population level. Sensitivity (that is, true positive rate) and specificity (that is, true negative rate) of the DQQ for correctly classifying women as (not) achieving the dichotomous MDD-W were calculated.

For semicontinuous indicators (FGDS, NCD-Protect, NCD-Risk, and GDR score), the nonparametric Wilcoxon signed-rank test was used to determine significant differences, which were considered practically important for matching actual population scores based on the reference method if they had a difference of >10 pp [19].

Results

The mean age of women was 33.3 ± 8.3 y. Most of the women recorded a normal weight status in Ethiopia (66.5%) and Vietnam (84.5%) and overweight or obese status in Solomon Islands (70.8%). In Ethiopia, 51.8% did not complete formal education; 66% completed high school or higher in Vietnam; and 52% completed primary school in Solomon Islands (52.3%) as the highest level of education attained (Table 1) [32–34].

Food group consumption

Food group consumption prevalence as measured by the DQQ and the 24hR is summarized in Table 2. In the 2 countries where data were collected in the same individuals over 2 d (Ethiopia and Solomon Islands), food group consumption prevalence was not significant and/or practically meaningful between the first day and second day of recalls using the DQQ (data not shown).

Of the 29 food groups, mean (SD) pp difference between DQQ and 24hR in population prevalence of food group consumption was 0.6 (0.7), 2.4 (2.0), and 2.5 (2.7) in Ethiopia, Vietnam, and Solomon Islands, respectively (Table 2). The difference between DQQ and 24hR in proportion prevalence was significant ($P < 0.01$) for 6 of the 29 food groups in Ethiopia, 5 in Vietnam, and 3 in Solomon Islands. All these differences were small in magnitude (<10 pp difference) except for the following: "vitamin A–rich orange vegetables" and "vitamin A–rich fruits" food groups in Vietnam (each 11.5% points different between the tools), and the food groups "white roots, tubers, and plantains" (15.2% points), "baked/grain-based sweets" (11.9% points), and

TABLE 1
Sociodemographic characteristics of women in Ethiopia, Vietnam, and Solomon Islands

Characteristic	Ethiopia (n = 488)	Vietnam (n = 200)	Solomon Islands (n = 65)
Age (y)	31.8 (7.8)	35.5 (7.2)	37.5 (11.7)
15–19	4.7	2.0	4.6
≥20 or older	95.3	98.0	95.4
BMI (kg/m^2)	21.1 (3.8)[2]	21.6 (2.6)	28.4 (5.3)
Underweight[1]	21.4	5.5	0.0
Normal weight[1]	66.5	84.5	29.2
Overweight or obese[1]	12.1	8.5	70.8
Education level[1]			
No (formal) education[3]	51.8	5.5	20.0
Primary education[4]	31.4	10.0	52.3
Secondary education[4]	13.9	18.5	21.5
Higher education[4]	2.9	66.0	6.2
Residential area			
Rural	81.1	—	49.2
Urban	18.9	100[5]	50.8

Values are given as mean (SD) or %.

[1] For respondents aged ≥20 y (adults), weight status was based on BMI (in kg/m^2) according to the World Health Organization (WHO) recommendations [32]: <18.5 for underweight, ≥18.5–24.9 for normal weight, ≥25.0–29.9 for overweight, and ≥30.0 for obese respondents. For respondents aged 15–19 y (adolescents), weight status was based on BMI-for-age z scores (BAZ) using the WHO reference 2007 child growth standards for 5- to 19-y-old children [33,34]: BAZ < −2 for underweight, BAZ ≥ −2 to ≤+1 for normal weight, BAZ >+1 to ≤+2 for overweight, and BAZ >+2 for obese.

[2] n = 481.

[3] No (formal) education includes no education, no formal education, and unfinished primary school.

[4] Primary, secondary, and higher education are primary school, secondary school, and high school or higher completed as highest level of education, respectively.

[5] All respondents in Vietnam had a periurban location of residence.

TABLE 2
Comparison between DQQ and 24hR for collecting DQQ food group consumption data among women in Ethiopia, Vietnam, and Solomon Islands

	DQQ food group	Ethiopia (969 24hR and 969 DQQs)						Vietnam (200 24hR and 200 DQQs)						Solomon Islands (118 24hR and 118 DQQs)					
		Population consumption prevalence (%)			Agreement			Population consumption prevalence (%)			Agreement			Population consumption prevalence (%)			Agreement		
						Misreporting (%)						Misreporting (%)						Misreporting (%)	
		24hR	DQQ	D	PA	FP	FN	24hR	DQQ	D	PA	FP	FN	24hR	DQQ	D	PA	FP	FN
1	Foods made from grains	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	99.0	98.0	−1.0	99.0	0	1.0	78.8	72.9	−5.9	83.9	5.1	11.0
2	Whole grains	96.8	93.9	−2.9[3]	92.8	2.2	5.1	5.0	7.0	2.0	94.0	4.0	2.0	2.5	1.7	−0.8	95.8	1.7	2.5
3	White roots, tubers, and plantains	23.9	28.4	4.5[3]	85.9	9.3	4.9	10.5	13.5	3.0	84.0	9.5	6.5	58.5	73.7	15.2[2,3]	69.5	22.9[2]	7.6
4	Legumes	57.8	61.1	3.3	79.2	12.1[2]	8.8	32.0	40.0	8.0	81.0	13.5[2]	5.5	0	0	0	100	0	0
5	Vitamin A–rich orange vegetables	8.3	11.7	3.4[3]	93.3	5.1	1.7	5.0	16.5	11.5[2,3]	86.5	12.5[2]	1.0	16.9	20.3	3.4	79.7	11.9[2]	8.5
6	Dark green leafy vegetables	32.0	32.5	0.5	90.8	4.9	4.3	67.0	71.5	4.5	83.5	10.5[2]	6.0	67.8	67.8	0.0	80.5	9.3	10.2
7	Other vegetables	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]	NA[5]	NA[5]	NA[5]	NA[5]	NA[5]	NA[5]	45.8	51.7	5.9	73.7	16.1[2]	10.2[2]
8	Vitamin A–rich fruits	0.1	0.6	0.5	99.3	0.6	0.1	7.5	13.0	5.5[3]	92.5	6.5	1.0	NA[6]	NA[6]	NA[6]	NA[6]	NA[6]	NA[6]
9	Citrus	0.5	1.0	0.5	99.3	0.6	0.1	47.0	58.5	11.5[2,3]	83.5	14.0[2]	2.5	4.2	8.5	4.3	94.1	5.1	0.8
10	Other fruits	3.3	6.2	2.9[3]	96.1	3.4	0.5	27.5	29.0	1.5	85.5	8.0	6.5	50.0	39.8	10.2	62.7	13.6[2]	23.7[2]
11	Baked/grain−based sweets	0.6	0.9	0.3	99.3	0.5	0.2	3.0	9.0	6.0[3]	93.0	6.5	0.5	28.8	40.7	11.9[2,3]	84.7	13.6[2]	1.7
12	Other sweets	0	0.3	0.3	99.7	0.3	0	0	1.5	1.5	98.5	1.5	0	1.7	11.9	10.2[2,3]	89.8	10.2[2]	0
13	Eggs	2.6	3.0	0.4	98.1	1.1	0.7	29.0	31.5	2.5	79.5	11.5[2]	9.0	1.7	9.3	7.6	90.7	8.5	0.8
14	Cheese[7]	2.5	5.1	2.6[3]	95.4	3.6	1.0	0	0	0	100	0	0	0	0	0	100	0	0
15	Yogurt[7]	2.5	5.1	2.6[3]	95.4	3.6	1.0	7.0	9.5	2.5	95.5	3.5	1.0	0	0	0	100	0	0
16	Processed meats	0	0.6	0.6	99.4	0.6	0	12.0	14.0	2.0	84.0	9.0	7.0	3.4	7.6	4.2	94.1	5.1	0.8
17	Unprocessed red meat (ruminant)	7.2	7.2	0	95.7	2.2	2.2	19.0	17.5	−1.5	91.5	3.5	5.0	2.5	0.8	−1.7	98.3	0	1.7
18	Unprocessed red meat (nonruminant)	0.1	0.3	0.2	99.8	0.2	0	74.0	78.0	4.0	81.0	11.5[2]	7.5	2.5	4.2	1.7	96.6	2.5	0.8
19	Poultry	0.6	0.5	−0.1	99.7	0.1	0.2	26.0	23.0	−3.0	85.0	6.0	9.0	8.5	10.2	1.7	96.6	2.5	0.8
20	Fish and seafood	0.5	0.6	0.1	99.5	0.3	0.2	36.5	29.5	−7.0	79.0	7.0	14.0[2]	55.1	56.8	1.7	77.1	11.9[2]	11.0[2]
21	Nuts and seeds	0.9	1.0	0.1	98.5	0.8	0.7	5.0	5.0	0	95.0	2.5	2.5	5.1	5.1	0	91.5	4.2	4.2
22	Packaged ultraprocessed salty snacks	0	0.5	0.5	99.5	0.5	0	0.5	1.0	0.5	99.5	0.5	0	0.5	1.0	0.5	96.6	3.4	0
23	Instant noodles	0	0.2	0.2	99.8	0.2	0	15.0	17.0	2.0	92.0	5.0	3.0	15.0	17.0	2.0	76.3	16.1[2]	7.6
24	Deep fried foods	0	1.1	1.1	98.9	1.1	0	1.5	3.0	1.5	96.5	2.5	1.0	1.5	3.0	1.5	87.3	5.9	6.8
25	Fluid milk	9.6	10.6	1.0	93.2	3.9	2.9	5.5	12.0	6.5[3]	89.5	8.5	2.0	3.4	5.1	1.7	95.8	2.5	1.7
26	Sugar-sweetened beverages (soft drinks)	6.4	7.4	1.0	97.5	1.8	0.7	0	2.0	2.5	98.0	2.0	0	0	2.0	2.5	93.2	5.1	1.7
27	Fruit juice and fruit-flavored drinks	0.2	1.1	0.9	98.9	1.0	0.1	0	3.0	3.0	97.0	3.0	0	0	3.0	3.0	89.8	7.6	2.5

(*continued on next page*)

TABLE 2 (*continued*)

	DQQ food group	Ethiopia (969 24hR and 969 DQQs)						Vietnam (200 24hR and 200 DQQs)						Solomon Islands (118 24hR and 118 DQQs)					
		Population consumption prevalence (%)			Agreement			Population consumption prevalence (%)			Agreement			Population consumption prevalence (%)			Agreement		
						Misreporting (%)						Misreporting (%)						Misreporting (%)	
		24hR	DQQ	D	PA	FP	FN	24hR	DQQ	D	PA	FP	FN	24hR	DQQ	D	PA	FP	FN
28	Sweet tea/coffee/ cocoa	NA[7]	NA[7]	NA[7]	NA[7]	NA[7]	NA[7]	5.0	6.5	1.5	91.5	5.0	3.5	5.0	6.5	1.5	82.2	5.1	12.7[2]
29	Fast food	0	0.3	0.3	99.7	0.3	0	0	0	0	100	0	0	0	0	0	100	0	0
Total (mean (SD))		NR	NR	0.6 (0.7)	96.3 (4.9)	2.3 (2.9)	1.4 (2.2)	NR	NR	2.4 (2.0)	90.6 (6.9)	6.0 (4.3)	3.5 (3.6)	NR	NR	2.5 (2.6)	88.6 (10.1)	6.8 (5.9)	4.6 (5.6)

24hR, 24-h dietary recall; D, percentage point difference in population prevalence of food group consumption between DQQ and 24hR (DQQ − 24hR); DQQ, Diet Quality Questionnaire; FN, false negative; FP, false positive; NA, not applicable; NR, mean of total not relevant; PA, percent agreement coefficient.

[1] Could not be compared because recording in the 24hR was by ingredient instead of food item.

[2] When both proportional difference $P < 0.01$ and percentage point difference was >10, or overreporting or underreporting was >10%.

[3] Difference (McNemar test $P < 0.01$) in food group population consumption percentage when assessed with DQQ versus 24hR.

[4] Could not be compared because DQQ contained an incorrect food item "green beans," which respondents understood as legumes that are green (T. Hailu Bekele, personal communication, January 15, 2021).

[5] Could not be compared because DQQ did not contain all commonly consumed vegetables.

[6] Could not be compared because DQQ contained a rare banana species, which was misunderstood as regular banana.

[7] In Ethiopia's DQQ, food items of the food groups "cheese" and "yogurt" were asked together in 1 question belonging to the food group "dairy foods," whereas in Vietnam and Solomon Islands, the food groups "cheese" and "yogurt" were asked separately. The latter is the design of the original DQQ [25]. Therefore, in this table, Ethiopia's "cheese" and "yogurt" results are the same.

TABLE 3
Comparison between DQQ and 24hR for collecting MDD-W food group consumption data among women in Ethiopia, Vietnam, and Solomon Islands

	MDD-W food group	Ethiopia (969 24hR and 969 DQQs)						Vietnam (200 24hR and 200 DQQs)						Solomon Islands (118 24hR and 118 DQQs)					
		Population consumption prevalence (%)			Agreement			Population consumption prevalence (%)			Agreement			Population consumption prevalence (%)			Agreement		
						Misreporting (%)						Misreporting (%)						Misreporting (%)	
		24hR	DQQ	D	PA	FP	FN	24hR	DQQ	D	PA	FP	FN	24hR	DQQ	D	PA	FP	FN
1	Grains, white roots and tubers, and plantains	99.8	98.3	−1.5[1]	98.1	0.2	1.7	99.0	98.0	1.0	99.0	0	1.0	97.5	94.9	−2.6	94.1	1.7	4.2
2	Pulses (beans, peas, and lentils)	57.8	61.1	3.3	79.2	12.1[2]	8.8	32.0	40.0	8.0	81.0	13.5[2]	5.5	0	0	0	100	0	0
3	Nuts and seeds	0.9	1.0	0.1	98.5	0.8	0.7	5.0	5.0	0	95.0	2.5	2.5	5.1	5.1	0	91.5	4.2	4.2
4	Dairy	11.2	13.3	2.1	93.6	4.2	2.2	11.5	18.0	6.5	87.5	9.5	3.0	3.4	5.1	1.7	95.8	2.5	1.7
5	Meat, poultry, and fish	8.3	8.8	0.5	95.1	2.7	2.2	94.5	95.0	0.5	95.5	2.5	2.0	61.0	64.4	3.4	83.1	10.2[2]	6.8
6	Eggs	2.6	3.0	0.4	98.1	1.1	0.7	29.0	31.5	2.5	79.5	11.5[2]	9.0	1.7	9.3	7.6	90.7	8.5	0.8
7	Dark green leafy vegetables	32.0	32.5	0.5	90.8	4.9	4.3	67.0	71.5	4.5	83.5	10.5[2]	6.0	67.8	67.8	0.0	80.5	9.3	10.2[2]
8	Other vitamin A–rich fruits and vegetables	8.3	12.1	3.8[1]	92.9	5.5	1.7	11.0	24.0	13.0[1,2]	84.0	14.5[2]	1.5	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]
9	Other vegetables	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]	NA[5]	NA[5]	NA[5]	NA[5]	NA[5]	NA[5]	45.8	51.7	5.9	73.7	16.1[2]	10.2[2]
10	Other fruits	3.7	6.9	3.2[1]	95.6	3.8	0.6	62.0	70.5	8.5[1]	83.5	12.5[2]	4.0	51.7	41.5	−10.2	66.1	11.9[2]	22.0[2]
Total, mean (SD)		NR	NR	1.2 (1.3)	93.5 (6.0)	3.9 (3.6)	2.5 (2.6)	NR	NR	3.3 (3.1)	87.6 (7.1)	8.6 (5.4)	3.8 (2.6)	NR	NR	3.5 (3.7)	86.2 (11.2)	7.2 (5.4)	6.7 (6.9)

24hR, 24-h dietary recall; D, percentage point difference in population prevalence of food group consumption between DQQ and 24hR (DQQ − 24hR); DQQ, Diet Quality Questionnaire; FN, false negative; FP, false positive; MDD-W, Minimum Dietary Diversity for Women; NR, mean of total not relevant; PA, percent agreement coefficient.

[1] Difference (McNemar test $P < 0.01$) in food group population consumption percentage when assessed with DQQ versus 24hR.

[2] When both proportional difference $P < 0.01$ and percentage point difference was >10, or overreporting or underreporting was >10%.

[3] Could not be compared because DQQ contained a rare banana species, which was misunderstood as regular banana.

[4] Could not be compared because DQQ contained an incorrect food item "green beans," which respondents understood as legumes that are green (T. Hailu Bekele, personal communication, January 15, 2021).

[5] Could not be compared because DQQ did not contain all commonly consumed vegetables.

TABLE 4
Comparison between DQQ and 24hR for achieving MDD-W among female participants aged 15–49 y in Ethiopia, Vietnam, and Solomon Islands

Indicator	Ethiopia (969 24hR and 969 DQQs)						Vietnam (200 24hR and 200 DQQs)						Solomon Islands (95 24hR and 95 DQQs)					
	Population prevalence (%)			Agreement			Population prevalence (%)			Agreement			Population prevalence (%)			Agreement		
					Misclassifying (%)						Misclassifying (%)						Misclassifying (%)	
	24hR	DQQ	D	PA	FP	FN	24hR	DQQ	D	PA	FP	FN	24hR	DQQ	D	PA	FP	FN
MDD-W	1.3	7.4	6.1[1]	92.9	6.6	0.5	58.5	64.0	5.5	77.5	14.0	8.5	24.2	32.6	8.4	76.8	15.8	7.4

24hR, 24-h dietary recall; D, percentage point difference in population prevalence of female participants aged 15–49 y for achieving MDD-W between DQQ and 24hR (DQQ − 24hR); DQQ, Diet Quality Questionnaire; FN, false negative; FP, false positive; MDD-W, Minimum Dietary Diversity for Women; PA, percent agreement coefficient.
[1] Difference (McNemar test $P < 0.01$) in women aged 15–49 y achieving MDD-W when assessed with DQQ vs. 24hR.

"other sweets" (10.2% points) in Solomon Islands. In addition, in Solomon Islands, the "other fruits" group was 10.2% points higher in the DQQ (not significant).

Of the 10 MDD-W food groups, the mean (SD) pp difference of population prevalence in food group consumption between DQQ and 24hR was 1.2 (1.3), 3.3 (3.1), and 3.5 (3.7), in Ethiopia, Vietnam, and Solomon Islands, respectively (Table 3). In Ethiopia, the difference in proportion prevalence was significant but small (<10 pp) for 3 of 10 MDD-W food groups ($P < 0.01$). In Vietnam, 2 of the 10 MDD-W food groups showed significant differences in proportion prevalence between DQQ and 24hR, of which only 1 food group "other vitamin A–rich fruits and vegetables" exceeded a difference of 10 pp.

The mean (SD) percent agreement for collecting food group consumption data between DQQ and 24hR was 96.3% (4.9) in Ethiopia, 90.6% (6.9) in Vietnam, and 88.6% (10.1) in Solomon Islands (Table 2). When combining the DQQ food groups into the 10 MDD-W food groups, the mean (SD) percent agreement between DQQ and 24hR for collecting MDD-W food group consumption data was 93.5% (6.0), 87.6% (7.1), and 86.2% (11.2) in Ethiopia, Vietnam, and Solomon Islands respectively (Table 3).

In Ethiopia, the FP rate exceeded 10% only for legumes. In Vietnam, overreporting exceeded 10% for 6 of 29 food groups: legumes, vitamin A–rich orange vegetables, dark green leafy vegetables, citrus, eggs, and unprocessed red meat (nonruminant). When aggregated into MDD-W food groups, the FP rate was the same for legumes, eggs, and dark green leafy vegetables (which are not further aggregated) and exceeded 10% for other fruits and other vitamin A–rich fruits and vegetables. In Solomon Islands, the FP rate exceeded 10% for 8 of 29 food groups: white roots, tubers, and plantains; vitamin A–rich orange vegetables; other vegetables; other fruits; baked/grain-based sweets; other sweets; fish and seafood; and instant noodles. When aggregated into MDD-W food groups, the FP rate exceeded 10% for 3 of 10 groups: meat, poultry, and fish; other vegetables; and other fruits.

In Ethiopia, no food group had an FN rate exceeding 10%. In Vietnam, the fish and seafood group had a FN rate of >10%; when this group was aggregated with other flesh food in the MDD-W food group meat, poultry, and fish, the FN rate dropped to 2%. In Solomon Islands, 6 of 29 food groups had a FN rate higher than 10%: foods made from grains, dark green leafy vegetables, other vegetables, other fruits, fish and seafood, and sweet tea/coffee/cacao. When aggregated into the MDD-W food groups, the FN rate for grains, white roots and tubers, or plantains and meat, poultry, and fish dropped to <10%, and that for other fruits was >10%.

Diet quality indicators

The difference in population prevalence of female participants aged 15–49 y achieving MDD-W when comparing the DQQ and 24hR was significant only in Ethiopia (DQQ was 6.1 pp higher, $P < 0.01$); differences of 5.5 pp in Vietnam and 8.4 pp in Solomon Islands were nonsignificant (Table 4). For classifying women as (or not) achieving MDD-W, percent agreement between the DQQ and 24hR was 92.9% in Ethiopia, 77.5% in Vietnam, and 76.8% in Solomon Islands (Table 4), with a sensitivity of 61.5%, 85.5%, and 66.7% and specificity of 93.3%, 66.3%, and 78.7% in Ethiopia, Vietnam, and Solomon Islands,

TABLE 5
Comparison between DQQ and 24hR of diet quality indicator scores of the FGDS, NCD-Protect, NCD-Risk, and GDR score of women in Ethiopia, Vietnam, and Solomon Islands

Indicator	Ethiopia (969 24hR and 969 DQQs)			Vietnam (200 24hR and 200 DQQs)			Solomon Islands (118 24hR and 118 DQQs)		
	24hR	DQQ	*P*	24hR	DQQ	*P*	24hR	DQQ	*P*
FGDS (0–10)	2 (2–3)	3 (2–3)	<0.001	5 (4–6)	5 (4–6)	0.37	3 (3–4)	4 (3–5)	0.10
NCD-Protect (0–9)	2 (2–3)	2 (2–3)	<0.001	3 (2–3)	3 (2–4)	0.005	2 (1–3)	2 (1–3)	<0.001
NCD-Risk (0–9)	0 (0–0)	0 (0–0)	<0.001	1 (1–2)	1 (1–2)	0.002	1 (0–1)	1 (0–2)	0.03
GDR score (0–18)	11 (11–12)	11 (11–12)	<0.001	10 (9–11)	10 (10–12)	0.002	10 (9–11)	10 (9–11)	0.07

24hR, 24-h dietary recall; DQQ, Diet Quality Questionnaire; FGDS, Food Group Diversity Score; GDR, Global Dietary Recommendations. Values are in median (25th–75th percentiles). *P* value of Wilcoxon signed-rank test.

respectively (data not shown). None of the diet quality indicators showed both significant differences and >10 pp difference in scores between tools. In Ethiopia and Vietnam, NCD-Protect, NCD-Risk, and GDR score showed significant differences in median (25th–75th percentiles) scores($P < 0.001$ in Ethiopia, $P < 0.005$ and $P < 0.002$ in Vietnam) being below 10 pp (Table 5). FGDS median (25th–75th percentiles) scores calculated from DQQ and 24hR were 3 [2–3] and 2 [2–3], respectively, in Ethiopia ($P < 0.001$); differences in median (25th–75th percentiles) were nonsignificant and not >10 pp for Vietnam and Solomon Islands (Table 5).

Analysis when including amounts consumed <15 g

In most cases, there was no significant difference in the proportion of respondents reporting having consumed each food group when foods consumed in amounts <15 g were included (Supplemental Material). In Ethiopia, there was a significant and large difference (>10%) in the proportion of respondents who reported consuming legumes (12.2% points higher when amounts <15 g were included). The prevalence of respondents who reported consuming legumes in the DQQ agreed more closely with the prevalence in the 24hR when amounts <15 g were excluded. There were significant but small differences in 5 other food groups in Ethiopia (dark green leafy vegetables; nuts and seeds; meat, poultry, and fish; other vitamin A–rich fruits and vegetables; and other vegetables) and only in other vitamin A–rich fruits and vegetables in Vietnam. For dark green leafy vegetables; nuts and seeds; and meat, poultry, and fish, the DQQ agreed more closely with the 24hR when amounts <15 g were excluded. For vitamin A–rich orange vegetables in both Ethiopia and Vietnam, the DQQ data agreed more closely with the 24hR when <15 g were included.

Discussion

In this study, we aimed to evaluate the validity of the DQQ against 24hR as the reference among subpopulations of women in 3 different geographically and culturally distinct LMICs. By administering the 2 dietary methods sequentially in the field, we reduced potential correlated measurement error, which could have inflated earlier found associations of results between tools to collect diet quality data [35]. Results show that there are minimal differences in population level prevalence of food group consumption whether based on data collected through the DQQ or the 24hR. In the countries where data were collected from the same individuals on 2 different days, the population prevalence of food group consumption was not significant and/or practically meaningful between days, which show test-retest reliability. These results suggest that the DQQ is a valid tool for collecting population-level food group consumption data required for calculating diet quality indicators in LMICs. The use of a suite of evaluative indicators allowed us to look at different aspects of performance of the DQQ compared with that by the 24hR reference. Instead, of considering only at significance of pp differences, we also considered whether differences were practically meaningful for the interpretation of public health significance [36] using a cutoff point exceeding 10 pp differences between tools for matching with actual population prevalence or indicator scores [19].

Although differences were small and/or nonsignificant, MDD-W derived from the DQQ tended to be consistently higher than that from the 24hR in all 3 countries, and more food groups were overreported than underreported based on DQQ. In Ethiopia, the large sample size could be responsible for the significant difference using the Wilcoxon signed-rank test for median scores of diet quality indicators (FGDS, NCD-Protect, NCD-Risk, and GDR score) between the 2 tools. Nevertheless, differences in percentage of women consuming each food group between DQQ and 24hR did not have a practically meaningful effect on the total diet quality scores (MDD-W, FGDS, NCD-Protect, NCD-Risk, and GDR score), leading to comparable scores and interpretation of public health significance in any country irrespective of tool used.

It is important to note that our study was not conducted on a national level, meaning that the diet quality indicator scores based on either DQQ or 24hR found in our study are not generalizable to a country level. However, the sample sizes in our study are sufficient for its purpose, which was to evaluate the validity of collecting population-level food group consumption data between 2 tools [37].

There were fewer differences between DQQ and 24hR in Ethiopia than in Vietnam and Solomon Islands. This may be related to differences in diversity of diets wherein diets reported in Vietnam and Solomon Island are more diverse than those of Ethiopia. Respondents with a less diverse diet may have found it easier to recall their food consumption. Furthermore, in contrast with respondents in Ethiopia and Vietnam, most (about 71%) of the respondents in Solomon Islands were overweight or obese, which has been shown to be associated with underreporting of dietary intake, and, therefore, could be an additional explanation why underreporting of food group consumption was more often seen in Solomon Islands [38].

The DQQ is designed to mitigate the recalling of food items consumed in amounts <15 g by excluding such food items if they are typically consumed in small amounts [14]. The 15-g cutoff is important to avoid falsely inflating food group diversity [26]. The results of this study provide evidence that, in general, these exclusions indeed mitigated overreporting of foods consumed in small amounts (Supplemental Material) but not always. For foods generally consumed in large amounts, the DQQ is able to filter out foods consumed in small amounts. In Ethiopia, for example, the 24hR showed that most legume consumers ate >15 g (only 17.4% consumed <15 g). Hence, the proportion of the population consuming legumes in the DQQ was more consistent with the results in 24hR when amounts <15 g were excluded. However, the DQQ did not eliminate the reporting of food items consumed in amounts <15 g if those items are not generally consumed in large amounts. In particular, "carrots" is an item included in the DQQ, which appeared in the 24hR to be often consumed in amounts <15 g in Ethiopia and Vietnam by about half of all respondents consuming "vitamin A–rich orange vegetables." Accordingly, for the food group vitamin A–rich orange vegetables, the DQQ results differed more greatly from the 24hR results when foods consumed in small amounts <15 g were excluded. Regardless, it is not feasible to exclude carrots from the DQQ question wording because carrots are often one of the few food items in the food group "vitamin A–rich orange vegetables" that are commonly consumed; moreover, they are often consumed in amounts >15 g. Therefore, the DQQ, does seem to mitigate reporting of food items generally used as condiments and in small amounts for flavor but does not exclude the reporting of food items idiosyncratically used in small amounts by respondents. With a rapid screening tool that does not collect quantitative amounts, the exclusion of all foods consumed in amounts <15g is likely unsolvable. Regardless, none of the diet quality scores with vitamin A–rich orange vegetables as a component meaningfully overestimated diet quality outcomes in our study.

Although a key goal of validation research is to use an accurate reference measure that captures true dietary intake, there is no gold standard (that is, no exact measure) for food group consumption assessment. Owing to this reality, this study can be considered as a relative instead of absolute validation [39]. Although the 24hR is prone to measurement error, as are all self-reported dietary assessment methods, it is an accepted reference method for a population-level dietary assessment [7] and the method most commonly used, which makes it a useful reference method—because it would be the most likely alternative used by researchers.

Considering this limitation, the DQQ resulted in more FPs and FNs than the 24hR, but it is uncertain if these were truly false results from the DQQ or if they may have been false results from the 24hR. Studies in low-income countries that examined misreporting of foods in 24hR, using same-day weighed intakes as the reference method, found that errors of underreporting are more frequent than overreporting, particularly with fruit, snacks, and beverages being underreported more frequently than foods habitually consumed in main meals [40–42]. In this study, the DQQ resulted in overreporting in other fruits, baked/grain-based sweets, and other sweets, among other food groups, compared with 24hR. Social desirability could have played a role in overreporting food groups that are considered good to respondents, such as other fruits [40]. Although the type of food groups with overreporting was different per country, most food groups with overreporting were those that may not be usually consumed on a daily basis. It is possible that respondents correctly reported consumption of these episodically consumed foods when explicitly asked by the DQQ question wording, compared with the 24hR when they were not reminded of each food and might have forgotten. However, because of the absence of a gold standard, it cannot be concluded which tool is more accurate for capturing consumption of episodically consumed foods. Therefore, we recommend further research for validating the DQQ against a nonmemory-based dietary assessment method such as weighed food records.

In this study, the DQQ that were implemented had errors in 3 questions, which were, therefore, dropped from the analysis: in Ethiopia, the "other vegetables" DQQ question included the item "green beans," which was intended to mean "French beans" but was translated as "fresh-harvested legumes," which inflated reporting of this food group. In Vietnam, the DQQ that was implemented omitted 2 sentinel food items, which would have resulted in undercounting of the food group. In Solomon Islands, the "vitamin A–rich fruits" food group in the DQQ included a rare orange banana species that was misunderstood as regular banana, one of the most common fruits, thus overinflating the category. The latter result underscores the importance of careful adaptation of list-based questions so that rare varieties are not included, and rather only common and universally understood sentinel food items are included to avoid confusion. Based on these findings, the DQQ adaptation team has refined their methods to avoid similar errors in further country adaptations. For example, specifically asking key informants what certain food items mean in the respective country (for example, a question that the DQQ adaptation team member may ask a key informant during an interview would be "What does 'green beans' mean?") and asking key informants if included food items in the DQQ are indeed the most commonly consumed ones and/or if food items need to be excluded or added [14].

The study population consisted of female participants, most of whom were aged 15–49 y. This is an appropriate sample for testing the validity of the tool to measure MDD-W, but because the DQQ is designed for the general public, we recommend further validation studies of the DQQ among other subgroups of the general population including men and other groups such as school-aged children and adolescents.

In conclusion, the DQQ and the 24hR showed comparable results in the 3 diverse LMIC populations in this study, indicating that the DQQ is a valid tool for collecting food group consumption data at population level. The differences found did not meaningfully influence diet quality indicators of MDD-W, FGDS, NCD-Protect, NCD-Risk, and GDR score. This low-burden tool opens the way for measuring and monitoring of diet quality at the population level, particularly in LMICs, especially for multitopic surveys such as demographic and health surveys and other national or regional surveys.

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The authors' responsibilities were as follows: BTMU, EFT, AWH, LET, and IDB: designed research; CV, GP, THB, and LTH: conducted research; CV, GP, THB, and LET: provided essential materials; BTMU and LET: analyzed the data and performed statistical analysis; BTMU, EFT, AWH, and IDB: wrote the paper; BTMU, EFT, AWH, and IDB: had primary responsibility for final content; and all authors: read and approved the final version of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tjnut.2022.12.014.

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