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Research

The quality of Indian diets: A comparison of two indices to predict risk of dietary inadequacies linked to non-communicable diseases

Srishti Mediratta, PhD[1], Pulkit Mathur, PhD[1a]

[1] Lady Irwin College, University of Delhi

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Nutritional inadequacies lead to various health problems among Indians. Improvements in diets can be addressed when different aspects of diet quality are known. The primary objective of the study was to assess diet quality of Indian adults belonging to the high-income group. The study also wanted to compare the suitability of two diet quality indices for use in the Indian scenario. A cross sectional study design with non-probability purposive sampling was used to collect data from 589 adults (20-40 years) in Delhi, India. Nutrient intake was assessed using the 24- hour dietary recall method. Two internationally recognized diet quality indices - Diet Quality Index- International Score (DQI-I) and the Global Diet Quality Score (GDQS) were selected to measure diet quality. 78% of the participants had poor diet quality using the DQI-I; the average score was 56.4 ± 5.6. The average DQI-I component scores for variety, adequacy, moderation and overall balance were 13.1±2.6, 27.5±2.2, 15.3±2.9, 0.43±0.9 respectively. Females were more likely (OR=2.07, 95% C.I.: 1.26 – 3.401) to have DQI-I scores in the lowest quartile (p=0.04). 88% had a moderate risk of nutritional inadequacy while 11% were at a high risk of nutritional inadequacy on the basis of their GDQS scores, the average of which was 16.9±2.1. There was a positive association between GDQS and DQI- I scores (ρ =0.316, p<0.001). The GDQS is better for assessing nutrient adequacy with healthy and unhealthy food consumption being compared. On the other hand, DQI-I gives a composite score combining the nutrient and food group intake and observes variety, adequacy, moderation and overall balance. Behaviour change communication strategies that encourage healthier food selection and promote dietary diversity may help improve nutritional quality of diets in Indian populations such as this one.

INTRODUCTION

There has been a rise in the prevalence of obesity and diet related non-communicable diseases in India (NFHS-5 2021). This has been partly attributed to an increased consumption of energy dense foods that are high in fat, sugar and salt (Keshari and Mishra 2016; Popkin 2017). WHO defines a healthy diet as one which includes at least five servings or 400 g of fruits and vegetables and a low content of fat, sugar and salt (WHO 2020). A good diet quality is one which is diverse and balanced such that it provides energy and nutrients for growth and healthy life (IAEA 2022). The quality of a diet depends on the frequency of consumption, combination of foods consumed, the content of potentially harmful ingredients, and the variety in the diet.

Researchers have developed many diet quality indices which are tools used to assess quality of the diet consumed (GDQS 2021; Kennedy 2013). These indices may comprise of food groups or nutrients or both to arrive at a score such as the Recommended Foods Score (RFS), Healthy Eating Index (HEI), Diet Quality Index- International Score (DQI-I) and Global Diet Quality Score (GDQS) where better scores lead to lower risk of developing non communicable diseases (McCullough et al. 2018; Shin and Kim 2021). Diet quality indices help to assess nutritional quality by categorizing the diet into healthy or unhealthy and linking it to health outcomes (Soowon Kim et al. 2018). Specific dietary components which need improvement can emerge from such analyses for planning nutrition and health policies (GDQS 2021; Soowon Kim et al. 2018). Internationally validated tools such as the DQI-I and the GDQS are useful for comparing diets consumed across nations. The DQI-I has been used in cross-sectional studies conducted in Iran and Sri Lanka, where it was found to be a good indicator of nutrient adequacy (Williams et al. 2019; Ebrahimi et al. 2020). The GDQS was developed from dietary cohort studies from sev-

a Corresponding author: pulkit.mathur@lic.du.ac.in

eral countries including India, for assessment of nutrient adequacy and intake of food groups (Bromage et al. 2021). However, they have not been widely tested for use in the Indian context.

Hence, the primary objective of this study was to assess the diet quality of Indian adults belonging to the high-income group aged 20-40 years. The study also wanted to compare the two internationally validated diet quality indices for their suitability in the Indian context.

MATERIALS AND METHODS

STUDY DESIGN

The present study had a cross-sectional design. The participants were selected using non-probability purposive sampling. The study was conducted in the city of Delhi, where 23 housing colonies from various districts and four geographical zones of the city, i.e North (6), South (6), East (5) and West Delhi (6) were selected. This ensured selection of a diverse sample. Colonies representing high-income group were selected based on the categorization given by city's municipal corporation (Muncipal Corporation of Delhi 2014). We decided to select the high-income group participants so that income was not a limiting factor in the selection of a good quality diet.

A total of 589 adults (20-40 years), who engaged in food purchasing for their families were selected. Key informants from resident welfare associations of the colonies were contacted who further helped in identifying households from where adults could form part of the sample. One participant was selected from each of the households and thereafter snowball sampling was used to identify other participants. The family income was taken into consideration while selecting participants and not solely their locality. The Modified Kuppuswamy's Socio-economic Scale (Singh, Sharma, and Nagesh 2017) was applied to cross check the income category of the participants.

The sample size was calculated based on the proportion of adults with a low fruit and vegetable consumption, as it was a major parameter to be measured. Low fruit and vegetable consumption is defined according to the WHO guidelines as less than five servings of fruits and/or vegetables daily (WHO 2020). The proportion of adults with low fruits and vegetable consumption was earlier measured to include 74.4 % males and 74 % females in India (Hall et al. 2009). The sample size for males and females was calculated separately with a design effect equal to 1, confidence interval of 95% and confidence limits set at 5%. In total 684 participants were enrolled between April 2019 and February 2020, however only 589 participants completed the study, giving a dropout rate of 14%. No further participants were recruited after February 2020 due to the Covid-19 outbreak.

DATA COLLECTION

The 24-hour recall method was used to assess the intake of food and nutrients on two non-consecutive days (working and non-working) and average values were calculated. These data were used to measure the diet quality. Diet quality indices were selected based on the criteria that the index should have been used universally and not be based on country specific dietary guidelines. Two indices - Diet Quality Index- International Score (DQI-I) and the Global Diet Quality Score (GDQS) were selected and pre tested before data collection.

The DQI-I has a maximum score of 100 points with a higher score indicating better diet quality. It has four main components, i.e variety (0-20 points), adequacy (0-40 points), moderation (0-30 points) and overall balance (0-10 points) (Sunmi Kim, Yang, and Park 2003). The 'per serving' portion sizes and Recommended Dietary Allowance (RDA) values were taken based on the Nutrient Requirements for Indians (ICMR-NIN 2020). The DQI-I was adapted to suit the Indian population; for example, 'pulses' was added as an alternative to the meat/poultry/fish/eggs in 'overall food group variety' since in the Indian diet pulses are considered to be an important source of protein.

The Global Diet Quality Score (GDQS) index contains two broad components, i.e., GDQS+ which has 16 categories of food groups and GDQS- which has 9 categories of food groups. The collective categories in the GDQS+ are termed as healthy while the categories of food groups in the GDQS- are called unhealthy. The index defines those who are at a high, medium and low risk of nutritional inadequacies using the following cut off points: below 15 is considered as high risk, between 15 and 23 is medium risk and above 23 is low risk of nutritional inadequacy.

STATISTICAL ANALYSIS

Dietary intakes were analysed using 'DietCal' software version 9.0 (Profound Tech Solutions, 2014, New Delhi, India). Statistical analysis was performed using SPSS software (SPSS version 22, a commercial software developed by IBM). The diet quality indices' scores were expressed in terms of mean and standard deviation for normally distributed data and as interquartile range for non-normally distributed data. The distribution of participants in each of the indices were reported as percentages and frequencies. The differences in the diet quality scores of DQI-I and GDQS across the demographic groups were assessed using the Mann- Whitney U test with a 95% confidence interval. Multinomial regression was applied to determine the predictors of diet quality among adults. Spearman's Rank test was used to assess the correlation between both the diet quality indices. Statistical significance was assumed at 5% level ($p<0.05$).

ETHICAL STANDARDS DISCLOSURE

This study was conducted after approval by the Institutional Ethics Committee of Lady Irwin College, New Delhi, India. Written informed consent was obtained from all subjects and participants were informed about the purpose of the study.

Table 1. Distribution of participants' (n=589) daily diets based on components of Diet Quality Index-International (DQI-I)

Component	Total Score	Scoring criteria	n (%)
Variety	0–20 points		
Overall food group variety (meat/poultry/fish/ eggs/ *pulse*; dairy; grain; fruit; vegetable)	15	≥1 serving from each food group	17(2.9)
	12	Any 1 food group missing	336(57)
	9	Any 2 food groups missing	227(38.5)
	6	Any 3 food groups missing	9(1.5)
	3	≥4 food groups missing	0(0)
	0	None from any food groups	0(0)
Within-group variety for protein source (meat, poultry, fish, dairy, pulses and legumes, eggs)	5	≥3 different sources	65(11)
	3	2 different sources	254(43.1)
	1	From 1 source	261(44.3)
	0	None	9(1.6)
Adequacy	**0–40 points**		
Vegetable group [a]	0-5 points	≥3–5 servings = 5, 0 servings = 0	
		≥ 100 %	183(31.1)
		< 100-50%	361(61.3)
		< 50%	45(7.6)
Fruit group [a]	0–5 points	≥2–4 servings = 5, 0 servings = 0	
		≥ 100 %	5(0.8)
		< 100-50%	11(1.9)
		< 50%	573(97.3)
Grain group [a]	0–5 points	≥6–11 servings = 5, 0 servings = 0	
		≥ 100 %	587(99.7)
		< 100-50%	2(0.3)
		< 50%	0(0)
Fiber [a]	0–5 points	≥20–30 g = 5, 0 servings = 0	
		≥ 100 %	357(60.6)
		< 100-50%	231(39.2)
		< 50%	1(0.2)
Protein	0–5 points	≥10% of energy = 5, 0% of energy	
		≥ 100 %	292(49.6)
		< 100-50%	297(50.4)
		< 50%	0(0)
Iron [b]	0–5 points	≥100% RDA = 5, 0% RDA = 0	
		≥ 100 %	25(4.2)
		< 100-50%	279(47.4)
		< 50%	285(48.4)
Calcium [b]	0–5 points	≥100% RDA= 5, 0% RDA= 0	
		≥ 100 %	3(0.5)
		< 100-50%	67(11.4)
		< 50%	519(88.1)
Vitamin C [b]	0–5 points	≥100% RDA = 5, 0% RDA = 0	
		≥ 100 %	460(78.1)
		< 100-50%	128(21.7)
		< 50%	1(0.2)

Component	Total Score	Scoring criteria	n (%)
Moderation	**0–30 points**		
Total fat	6	≤20% of total energy	0(0)
	3	>20–30% of total energy	104(17.7)
	0	>30% of total energy	485(82.3)
Saturated fat	6	≤7% of total energy	37(6.3)
	3	>7–10% of total energy	275(46.7)
	0	>10% of total energy	277(47)
Cholesterol	6	≤300 mg	586(99.5)
	3	>300–400 mg	0(0)
	0	>400 mg	3(0.5)
Sodium	6	≤2400 mg	137(23)
	3	>2400–3400 mg	370(63)
	0	>3400 mg	82(14)
Component	**Total Score**	**Scoring criteria**	**n (%)**
Empty calorie foods	6	≤3% of total energy	0(0)
	3	>3–10% of total energy	203(34.5)
	0	>10% of total energy	386(65.5)
Overall balance	**0–10 points**		
Macronutrient ratio (carbohydrate: protein: fat)	6	55~65:10~15:15~25	0(0)
	4	52~68:9~16:13~27	13(2.2)
	2	50~70:8~17:12~30	95(16.1)
	0	Otherwise	481(81.7)
Fatty acid ratio (PUFA: MUFA: SFA)	4	P/S = 1 ~ 1.5 and M/S = 1 ~ 1.5	0(0)
	2	Else if P/S = 0.8 ~ 1.7 and M/S = 0.8 ~ 1.7	5(0.8)
	0	Otherwise	584(99.2)

a. A diet that contains ≥2–4 servings of fruit, ≥3–5 servings of vegetable, ≥6–11 servings of grains, ≥20–30 g of fibre per day is given the highest score of 5 points depending on three energy intakes of 1700Kcal, 2200Kcal and 2700Kcal respectively.
b. Scoring based on recommended dietary allowance values of iron, calcium and vitamin C for Indians 2020 (ICMR 2020)
PUFA is polyunsaturated fats, MUFA is monounsaturated fats and SFA is saturated fats.

RESULTS

The sample included an equal proportion of males (n=293) and females (n=296). About 80% belonged to high income group (n=471), and 20% to upper middle-income group (n=118). 74% (n=438) were 20-30 years of age and the rest 30-40 years old. 78% were unmarried.

DIET QUALITY INDEX- INTERNATIONAL (DQI-I)

Table 1 shows that 57% of the participants did not consume all the food groups per day and skipped one food group everyday thereby reducing the overall food group variety. 38.5% skipped two food groups every day. Protein variety within sources was also limited, with 44.3% consuming protein from only one source and another 43% consuming from two different sources per day. Looking at the adequacy component, 68.9% consumed less than the recommended servings of vegetables per day. However, only 7.6% consumed less than 50% of recommended servings of fruits per day. 99.7% consumed more than 100% of the recommended servings of grains per day. 39.4% consumed less than 100% of the recommended amount of fibre per day. 50.4% consumed less than 100% of recommended energy from protein per day. 95.8% consumed less than 100% of the RDA of iron, with 48.4% p consuming less than 50% of the RDA. 88.1%consumed less than 50% of RDA of calcium. 78.1%consumed more than 100% of the RDA of vitamin C.

82% of the participants had a total fat intake more than 30% of total energy per day with 20% consuming more than 35%. 47% had a saturated fat intake of more than 10% of total energy per day. 77% had a sodium intake of more than 2400 mg per day. 65.5% consumed more than 10% of their total energy per day from added sugar. 81.7% consumed macronutrient ratios in amounts other than the recommended ranges. 99.2% of diets had fatty acid ratios other than the recommended ranges.

The average DQI score was 56.4 ± 5.6 and the average variety, adequacy, moderation and overall balance scores were 13.1±2.6, 27.5±2.2, 15.3±2.9, 0.43±0.9 respectively.

The mean DQI-I was 56% of maximum possible scores, mean variety score was 65%, mean adequacy score was 67%, mean moderation score was 50% and mean overall balance was only 4% of maximum possible scores. DQI-I catego-

Table 2. DQI-I scores across various sociodemographic groups (N=589)

Variables	Median (IQR)	p-value
Total (n=589)	56(52-60)	
Gender		
Male (n=293)	56(53-61)	0.047*
Female (n=296)	55.5(52-59)	
Age		
20-30yrs (n=452)	56(52-60)	0.138
30-40yrs (n=137)	56(53-60)	
Income group		
Upper-middle income (n=118)	56(52.7-60)	0.388
High income (n=471)	56(52-59)	
Marital status		
Married (n=129)	56(52.7-61)	0.406
Unmarried (n=460)	56(52-59)	
Eating habit		
Vegetarians (n=382)	55(52-60)	0.166
Non-Vegetarians (n=207)	56(53-60)	

IQR: interquartile range P_{25}-$P_{75,}$ *Significant at p<0.05

rizes diets into good and poor quality based on the cut-off point of 60% of maximum possible scores. Using this criterion, 78% of the participants had poor diet quality. All participants had poor overall balance scores and 90% had poor moderation scores. Only minorities of the participants had poor variety scores (38%) and adequacy scores (9%). Table 2 shows that male participants had a higher DQI-I score than females (p=0.047). There were no significant differences between other sociodemographic variables.

Multinomial regression analysis was applied to identify predictors of DQI-I among adults. The likelihood ratio test utilized in Table 3 suggests that independent variables like gender (p=0.013) and marital status (p=0.025) contributed significantly to the final model. Women were more likely (OR=2.07, 95% C.I.: 1.26 – 3.401, p=0.04) to have DQI-I scores in the first quartile relative to the fourth quartile. Married participants had a lower chance of having DQI-I scores in the third quartile relative to the fourth quartile (OR=0.307, 95% C.I.: 0.118 – 0.803, p=0.01) when compared to those who were unmarried. In other words, male participants and those who were married had higher chances of having higher, healthier DQI-I scores.

GLOBAL DIET QUALITY SCORE

The GDQS comprises of healthy and unhealthy food groups. Table 4 shows that in the GDQS+ component comprising of healthy foods, most of the participants consumed other vegetables (100%), legumes (97%), liquid oils (100%) and nuts and seeds (92%).

In the GDQS- component which comprised of unhealthy foods, a majority of the participants consumed foods from categories such as high-fat dairy (96%), white roots and tubers (89%), and refined grains and baked goods (74%). All of the participants who consumed sugar sweetened beverages, processed meat and juice had intakes at high levels.

The average GDQS score was 16.9±2.1, or "medium risk." The GDQS+ score (8.2±1.5) and the GDQS- score (8.7±1.2). Table 5 shows that there were no differences among socioeconomic groups except that the small difference between non-vegetarians and vegetarians was statistically significant (p<0.01).

As shown in Table 6, 88% of participants were at a moderate risk of nutritional inadequacy, 11% were at high risk and only 1% of the participants were at a low risk based on the GDQS scores. A higher percentage of participants (14%) who were vegetarians were at a high risk of nutritional inadequacy as compared to those who were non-vegetarians (8%; $\chi^{2=}$=6.836, p=0.03).

ASSOCIATION BETWEEN DQI-I AND GDQS SCORES

The min-max normalization was applied to both the indices since they have different scoring ranges. The Kolmogorov-Smirnov test was used to check normality and then Spearman's rank (p<0.001) correlation was assessed by Spearman's rho coefficient, since the variables were not normally distributed. According to Cohen's power for associations, less than 0.3 is considered a weak correlation, between 0.3 to 0.5 is a moderate correlation and more than 0.5 is a strong correlation (Cohen 1988; Khamis 2008). There was moderate association between GDQS score and DQI- I total score (ρ =0.316, p<0.001).

DISCUSSION

This study assessed the diet quality among adults using two internationally validated indices. Assessing diet quality us-

Table 3. Multinomial regression analysis to identify predictors of higher DQI-I among adults

Dependent variable (DQI-I quartiles)	Independent variables	B	S.E.	Wald	Exp (β) Coefficient (95% C.I.)	p value
Quartile 1 (n=151)	Intercept	0.327	0.473	0.478	-	0.48
	20-30 years	-0.397	0.481	0.681	0.67 (0.26 – 1.72)	0.40
	30-40 years #	0				
	Upper middle income	-0.326	0.298	1.199	0.72 (0.403–.29)	0.27
	High income #	0				
	Married	-0.692	0.477	2.101	0.50 (0.19- 1.27)	0.14
	Unmarried #	0				
	Females	0.731	0.252	8.419	2.07 (1.26–0.401)	0.004*
	Males #	0				
Quartile 2 (n=177)	Intercept	0.457	0.441	1.074	-	0.30
	20-30 years	-0.261	0.447	0.341	0.77 (0.32- 1.84)	0.55
	30-40 years #	0				
	Upper middle income	-0.282	0.284	0.985	0.75 (0.43–0.31)	0.32
	High income #	0				
	Married	-0.004	0.436	0.00	0.99 (0.42–2.33)	0.99
	Unmarried #	0				
	Females	0.280	0.242	1.33	1.32 (0.82–2.15)	0.24
	Males #	0				
Quartile 3 (n=133)	Intercept	0.821	0.463	3.146	-	0.07
	20-30 years	-1.004	0.477	4.43	0.36 (0.144–0.93)	0.035*
	30-40 years #	0				
	Upper middle income	-0.356	0.309	1.325	0.71 (0.38–1.28)	0.25
	High income #	0				
	Married	-1.18	0.490	5.79	0.31 (0.11–0.80)	0.01
	Unmarried #	0				
	Females	0.641	0.260	6.087	1.89 (1.14 3.15)	0.01*
	Males #	0				

Note: Quartile 4 (n=128) Last category is reference;
This parameter is set to zero because it is redundant;
* Significant at ≤0.05 level

ing DQI-I showed that most participants did not consume all the food groups in a day, which reduced the food group variety. Protein variety was also limited as most participants had protein intake from only one or two sources in a day. Most participants had vegetable, fruit, protein and iron intakes below recommended criteria in spite of belonging to high income groups. Studies have shown that the protein intake as a percent of energy and the intake of iron among Indians is lower than the recommendations. This is because intake of foods rich in fat, sugar and salt occupies a larger portion in their diet than pulses/legumes, meat, poultry, eggs, fruits and vegetables. This leads to poor diet quality even for those belonging to the highest income quartiles (Ganpule-Rao et al. 2021; P. Gupta and Sachdev 2022; Pawlak, Berger, and Hines 2018; Sharma et al. 2020).

Under the moderation component of the DQI-I, most participants exceeded the thresholds for total fat, saturated fat, sodium and calories from added sugar. In a study conducted among adults in Iran, a poor DQI-I score was associated with a higher risk of developing metabolic syndrome where participants in the highest DQI-I quartile had a 70% lower risk of developing metabolic syndrome and hypertriglyceridemia (Abdurahman et al. 2021). Maintaining dietary intake within the recommendations for total fat, saturated fat, cholesterol, sodium, empty calories/free sugars will help to reduce the risk of developing diet related non communicable diseases (Lunghar and Banu 2022).

In this study, a majority of the participants had a poor overall dietary balance. The DQI-I provides the macronutrient ratio for carbohydrate, protein and fat. Kelly, Gilman, and Ilich (2019) found that assessing macronutrient intake ratio is a better way of measuring diet quality than the percentage energy contributed by each of the macronutrients to the total energy intake. Also, in the present study most of the participants had poor fatty acid ratio balance of PUFA, MUFA and SFA, with higher intakes from saturated

Table 4. Distribution of participants according to low, medium and high categories of consumption of each of the GDQS food groups (n=589)

	Consumers of any of that food n (%)	Participants who consumed each food, divided into GDQS categories n (%)		
		Low	Medium	High
GDQS and GDQS+ (Healthy)				
Citrus fruits	70(12)	0(0)	70(100)	0(0)
Deep orange fruits	8(1)	0(0)	8(100)	0(0)
Other fruits	290(49)	77(27)	195(67)	18(6)
Dark green leafy vegetables	81(14)	26(32)	24(30)	31(38)
Cruciferous vegetables	291(49)	0(0)	14(5)	277(95)
Deep orange vegetables	41(7)	0(0)	14(34)	27(66)
Other vegetables	589(100)	0(0)	92(16)	497(84)
Legumes	574(97)	0(0)	507(88)	67(12)
Deep orange tubers	9(2)	0(0)	7(77)	2(23)
Nuts and seeds	541(92)	509(94)	32(6)	0(0)
Whole grains	536 (91)	0(0)	0(0)	536 (91)
Liquid oils	589(100)	0(0)	0(0)	589(100)
Fish and shellfish	32(5)	0(0)	31(97)	1(3)
Poultry and game meat	102(17)	39(38)	63(62)	0(0)
Low-fat dairy	37(6)	0(0)	30(81)	7(19)
Eggs	101(17)	27(27)	74(73)	0(0)
GDQS and GDQS– (Unhealthy)				
High-fat dairy	565(96)	0(0)	205(36)	346(61)
Red meat	16(3)	0(0)	2(13)	14(87)
Processed meat	31(5)	0(0)	0(0)	31(100)
Refined grains and baked goods	436(74)	62(14)	149(34)	225(52)
Sweets and ice cream	178(30)	9(5)	71(40)	98(55)
Sugar-sweetened beverages	92(16)	0(0)	0(0)	92(100)
Juice	22(4)	0(0)	0(0)	22(100)
White roots and tubers	522(89)	0(0)	79(15)	443(85)
Purchased deep fried foods	238(40)	10(4)	46 (20)	182(76)

fats than unsaturated fats. WHO suggests consuming unsaturated fats found in fish, avocado, sunflower, soybean, canola and nuts as a replacement to saturated fats to ensure healthier diet quality (WHO 2020). The Nutrient Requirements for Indians recommends to increase the MUFA rich oils and PUFA rich oils within total fat calories by using a combination/blend of two or more oils and limit the intake of SFAs by reducing intake of ghee/butter (ICMR 2020).

In the present study, the total DQI score was 56.4 ± 5.6 among the participants and 78% participants had poor diet quality scores, i.e., below 60 % of the total DQI-I score. Male participants had a higher DQI-I score (p=0.047) than females. Studies conducted in Indonesia and Tunisia have shown that males had a higher DQI-I score and, as in the present study, this was because women participants had a lower intake of meat, poultry and eggs Studies have shown that women often choose vegetarian foods because of their consciousness towards body image and feeling of aversion towards meat products (Costa et al. 2019; Siegrist and Hartmann 2019).

As per the GDQS categorization, 88% in the present study were at moderate risk of nutritional inadequacy and 11% were at a high risk of nutritional inadequacy. This may have been due to consumption of large amounts of unhealthy foods by most participants. A study among women in Andhra Pradesh, India showed that majority of the respondents consumed refined grains and baked goods (100%), sweets and ice cream (51%) and high fat dairy foods (71%) in the high intake ranges (Matsuzaki et al. 2021). Another study that assessed the diet quality using GDQS in Africa showed poor scores were due to access to refined and ultra-processed food that is high in fat, sugar and salt (Yarega and Baye 2022).

We found no significant predictors for GDQS scores using regression models, except that the risk of nutritional inadequacy was higher among vegetarians. Some other studies have also found that vegetarians have a higher risk

Table 5. GDQS scores across sociodemographic groups (N=589)

Variables	Median (IQR)	p-value
Total (n=589)	17(15.5, 18.2)	
Gender		
Male (n=293)	17(15.5, 18.2)	0.763
Female (n=296)	17(15.5, 18.5)	
Age		
20-30yrs (n=452)	17(15.5, 18.0)	0.090
30-40yrs (n=137)	17(15.8, 18.5)	
Income group		
Upper-middle income (n=118)	17(15.9, 18.5)	0.234
High income (n=471)	17(15.5, 18.2)	
Marital status		
Married (n=129)	17(15.6, 18.5)	0.413
Unmarried (n=460)	17(15.5, 18.0)	
Eating habit		
Vegetarians (n=382)	16(15, 18)	<0.001**
Non-Vegetarians (n=207)	17(16.2, 18.5)	

IQR: interquartile range P_{25}-P_{75}; ** Significant at ≤0.05 level

Table 6. Distribution of participants (N=589) based on the risk of nutritional inadequacy according to the GDQS scores

	GDQS total scores			Chi square test
	≥23	≥15 to <23	<15	
	Low risk of nutritional inadequacy	Moderate risk of nutritional inadequacy	High risk of nutritional inadequacy	
Total (n=589)	4(1)	517(88)	68(11)	
Gender				
Male (n=293)	1(1)	261(89)	31(10)	χ^{2}=1.563, p=0.45
Female (n=296)	3(1)	256(86)	37(13)	
Age				
20-30yrs (n=452)	3(1)	388(86)	61(13)	χ^{2}=7.24, p=0.02
30-40yrs (n=137)	1(1)	129(94)	7(5)	
Income Group				
Upper-middle income (n=118)	1(1)	109(92)	8(7)	χ^{2}=3.319, p=0.19
High income (n=471)	3(1)	408(87)	60(12)	
Marital status				
Married (n=129)	1(1)	116(90)	12(9)	χ^{2}=0.829, p=0.66
Unmarried (n=460)	3(1)	401(87)	56(12)	
Eating habit				
Vegetarian (n=382)	4(1)	326(85)	52(14)	χ^{2}=6.836, p=0.03
Non-vegetarian (n=207)	0(0)	190(92)	17(8)	

of nutritional inadequacy and micronutrient deficiencies (Pawlak, Berger, and Hines 2018; Obeid et al. 2019). However, increasing the amounts of pulses, dairy products, legumes and nuts will ensure higher protein diets for lactovegetarians, such as most are in India (as well as eggs for those who consume eggs). The EAT Lancet Commission suggests to double the consumption of fruits, vegetables, nuts and legumes along with reduced intake of red meat for healthier diets. Although many regions depend on meat/poultry for their protein intake, the Commission suggests that higher consumption of plant-based sources of protein in the diets along with fish and egg will allow a reduced intake of animal meat (EAT Lancet Commission 2019).

Participants in this study belonged to upper middle- and high-income groups, and thus were not constrained by the price of food products. Our study thus highlights that belonging to a higher socioeconomic group does not always ensure a good diet quality. Another study showed that even in the highest income quintiles, increased intakes of ultra-processed foods which tend to be high in fat, sugar and salt with low intakes of fruits and vegetables than recommended amounts, reduces the overall diet quality (Young et al. 2020). Rise in socioeconomic income increases affordability and better access to food items but selecting healthier food choices is a complex process that requires nutritional knowledge and understanding of better diet quality (Chae et al. 2018). Creating awareness about balanced diets and increasing intake of the healthier food groups through nutrition education and behaviour change communication is a cost-effective way of improving diet quality (S. Gupta, Sunder, and Pingali 2020; Nair and Augustine 2018). A study conducted in Bangladesh showed that generating awareness in the community brought such behaviour changes as increased purchase of eggs and flesh foods ($p<0.01$) and a reduction in use of packaged juices and carbonated beverages ($p<0.01$) (Warren et al. 2020).

In the present study, there were moderate associations between GDQS and DQI- I total scores. Both the indices differ in structure as well as methods of scoring and assessing diet quality. The DQI-I index includes both nutrients and food groups, whereas the GDQS index is based on only food groups. The DQI-I looks at four main components of diet quality - variety, adequacy, moderation and overall balance, whereas the GDQS index contains only the two broad components of healthy and unhealthy foods. The DQI-I categorizes diets into poor quality if the composite score is less than 60%, whereas GDQS defines risk of nutritional inadequacies into high, medium and low using cut off points 15 and 23. The choice between using the two diet quality tools depends on the outcome one intends to measure. The DQI-I can be used when one wants to examine the different components of diet quality, while the GDQS is more useful in determining the nutrient inadequacies of the population.

The GDQS index is designed to be suitable for low- and middle-income countries and has been validated in the Indian population (Matsuzaki et al. 2021). It is a more useful index to provide distribution of healthy and unhealthy foods consumed by population. (Trijsburg et al. 2019). For the purpose of monitoring or evaluating any public health intervention, a food-based index is more meaningful rather than a nutrient specific index (Echouffo and Ahima 2019). A food group-based index such as the GDQS is easier to calculate and better for assessing the consumption of healthy vs. unhealthy food groups by the population. Both GDQS and DQI-I can be used in future studies to assess the relationship between diet quality and diet-related non-communicable diseases.

One of the limitations of the present study was that the responses were self-reported and not based on actual observation. Another was the method of selecting the sample, which was not probability-based.

CONCLUSION

In spite of being economically well off, according to the DQI-I, 78% of the participants had poor diet quality. According to the GDQS 88% were at moderate risk and 11% were at a high risk of nutritional inadequacy. Behaviour change communication strategies need to be planned to generate awareness about better food choices to increase diversity and consumption of healthier food groups. They should also focus on aspects like moderation and overall balance in the diet. This will also assist in reducing risk of nutritional inadequacies in diets. Equally or more importantly, policies such as taxation, reformulation, restricting the sale of food products which are high in fat, sugar, salt are effective approaches for improving diet quality at population level (P. Gupta and Sachdev 2022; Massri et al. 2019; Sánchez-Romero et al. 2020).

The GDQS is useful for studies aiming to assess nutrient adequacy and comparing healthy versus unhealthy food consumption. On the other hand, DQI-I can be used when a composite score is required and when the variety, adequacy, moderation and overall balance are to be examined separately. Both the indices should be explored to understand the association of diet quality with diet related non communicable diseases as well as for monitoring interventions for improving diet quality.

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CONFLICT OF INTEREST

None; the authors report no conflict of interest towards production of the article.

AUTHORSHIP

The first author was involved in conceptualization, methodology, conducting literature review, data collection, data curation, formal analysis, interpretation of the data, visualization and writing- original draft. The second author was involved in conceptualization, providing critical suggestions for design of the study, interpretation of data, supervision, visualization, review of the draft. All authors have approved the final article.

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