Original Article

A community-based study on quality of diet impacting cardio-metabolic risk; hierarchical prediction and cluster analysis from a diet survey among adults

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Abstract

Background: Food is the basic human need and healthy diet is the foundation for good health. However unhealthy dietary practices are one of the leading risks for non-communicable diseases (NCD), a major health challenge worldwide. This study aimed to assess the diet quality (DQ) concerning the cardio-metabolic risk status among adult individuals in the community. **Methodology:** A community-based cross-sectional survey to assess the prevalence of NCD risk factors and diet quality was conducted over two months among individuals aged 30 years and above without a history of diabetes mellitus and/or hypertension. Data was collected using a semi-structured questionnaire and diet quality was assessed using a validated tool Short-Healthy-Eating-Index (sHEI). Statistical analysis such as descriptive statistics and odds ratio were computed at a 5% significance level. Cluster analysis was done by Scree plot and K-means clustering technique. **Results:** The study included 378 eligible survey respondents, of whom about 87% exhibited at least one cardio-metabolic risk manifestation. Good DQ significantly reduced the odds of being overweight ($P = 0.038$) and obesity ($P = <0.001$), whereas high intake of vegetables 10 times significantly reduced the odds of high central adiposity ($P = <0.001$). Good whole grains intake and limiting dietary sodium significantly reduced the odds of hypertension. The cluster analysis revealed that those clusters with low DQ scores displayed a higher risk of obesity, central adiposity and elevated blood pressure. **Conclusion:** The current study highlighted the strong impact of diet on cardiovascular and metabolic risk indicating the urgent need to promote healthy diet at the community level.

Keywords: Cardiovascular risk, cluster, diabetes, diet quality, healthy eating index, hypertension, metabolic risk

Introduction

Food, the basic human need, is essential for maintaining a healthy and active lifestyle. People have been striving for food security and stability throughout history, but despite progress, hunger and poverty still threaten some regions.[1] To address this issue, the United Nations has set a global target to end hunger by 2030 as part of the Sustainable Development Goals.[2] Many countries have implemented policies to combat food insecurity, and there have been significant agricultural advancements to increase food production for daily energy requirements.[3]

However, simply consuming enough calories is not enough to maintain good health and productivity. The human body requires

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a diverse range of nutrient-dense foods that are rich in protein, essential fats and micronutrients such as vitamins, minerals.[4] The ongoing paradigm shift from facing food insecurity (inadequate food quantity) towards nutritional insecurity (inadequate food quality) happened to be the reason for many lifestyle diseases.[5,6] The World Health Organization has emphasised that a healthy diet is the foundation for good health, whereas an unhealthy diet is one of the leading risks for non-communicable diseases (NCD) such as cardiovascular diseases, diabetes and cancer which are major health challenges worldwide.[7]

More than one-third of the world's population cannot afford a healthy diet, as nutritious food choices are often more expensive.[4] Moreover, unhealthy processed foods that are high in sugars, saturated fat and sodium (salt) are actively marketed.[8] This exacerbates the situation, as according to the Global Burden of Disease Study 2019, poor diet quality is the fifth leading risk factor (level 2; mediation category) for attributable disability-adjusted life years (DALYs) overall and the second and third-largest risk factor for attributable deaths among females and males, respectively.[9]

This report also stated a worldwide alarming rise in the rate of metabolic risks indicated by high body mass index (BMI), high fasting plasma glucose (FPG) and high systolic blood pressure (SBP) which are worrisome risk factors for cardiovascular diseases and outcomes. Globally the rise in BMI is mainly attributed to factors such as low physical activity, excess caloric intake and poor diet practices like eating less of protective foods (fruits, vegetables, legumes, whole grains, nuts and seeds) and consuming more harmful foods (processed foods, sugar-sweetened beverages, etc.) as these influence central adiposity.[9] A balanced good quality diet and a healthy lifestyle are required to prevent the onset and progression of metabolic syndrome.

The quality of food is also heavily influenced by socio-cultural contexts and there is an implicit need to understand the diet status of the community to design effective dietary interventions. This study aimed to assess the diet quality (DQ) concerning the cardio-metabolic risk status among adult individuals in the community.

Methodology

Study setting and participants

In this study, we analysed data from a community-based cross-sectional survey conducted as part of the Community Orientation Program for medical undergraduates. This survey was carried out in the rural field practice area of primary health centres affiliated with a private medical college in Tamil Nadu to assess the prevalence of NCD risk factors and diet patterns among individuals aged 30 years and above with informed consent. Individuals who were known to have diabetes mellitus and/or hypertension were excluded. An Indian study stated an 11% prevalence of Coronary Artery Disease among Indian nondiabetics.[10] This prevalence of 11% was taken as proportion (p), taking absolute precision (d) as five, design effect (de) as two and 20% non-response (nr) rate, the required sample size (N) was calculated to be 361 using the formula, $N = [pq\,(Z_{\alpha/2}/d)^2 \times de] + nr$. Health inspectors and medical interns supported the identification and recruitment of the eligible respondents voluntarily by convenience non-probability sampling method. The survey collected information such as age, sex, educational cum employment status, socio-demographic-economic details, addiction habits, dietary habits, anthropometry, blood pressure (BP). The study received approval from the Institutional Research Review Board and the Institutional Ethics Committee.

Diet quality assessment

The respondents were asked about dietary habits using the Short Healthy Eating Index (sHEI).[11] It is a 22-item validated tool developed for diet quality assessment, estimating the average dietary intake of food groups on a typical day, excluding fasting and feasting days. It included 13 components: total fruits, whole fruits, total vegetables (green-leafy and less-starchy), green beans, whole grains, dairy, total protein from seafood, plant protein, fatty acids, refined grains, sodium, added sugars and saturated fats. Each component was given a set of scoring and/or reverse scoring rules, higher scores indicate healthy consumption of that specific food component and the total DQ score was computed by summing up the individual components scores. Additional scoring criteria were also given for calcium, vegetables, fibre intake, etc.

To measure food intake, the sHEI tool originally prompts to compare the food portion sizes with objects such as a computer mouse, a baseball, or a stack of cards. However, considering the comprehension level of the respondents, food portion sizes were roughly equated to the volume of an adult palm size during the survey. The question on saturated fat intake included the intake of deep-fried oily foods. Also few details were asked that would reflect the diet of the Indian context like adding extra salt, the consumption of pappad, pickles, etc., which were analysed separately. The respondents were also interrogated for a reality check, questioning their satisfaction with current diet practices and also recorded the type of change they want to make in their diet.

Cardio-metabolic risk assessment

The potential indicators of cardio-metabolic risk in adults such as body mass index, central adiposity, systolic and diastolic pressures were assessed during the survey. Anthropometric details such as height, weight, waist and hip circumference were measured using calibrated instruments and BMI was computed as per Asia-Pacific classification[12]; Waist-Height Ratio (WHtR) to determine central adiposity was classified as per NICE guidance[13]; blood pressure was recorded using digital apparatus, systolic BP $\geq$ 140 mmHg and/or diastolic BP $\geq$ 90 mmHg was taken as the criteria for systemic hypertension.

Statistical analysis

The data collected were entered into Google Forms, downloaded in Microsoft Excel format, checked for quality cum correctness and analysed using Jamovi software v. 2.3.21 from the R core team. The categorical data were summarised as proportions and continuous measures as means and median values; correlations for continuous measures were determined as per data distribution; the Odds ratio was computed to establish associations; confidence interval and *P* value were calculated for the summary and risk estimates at a 5% significance level. Hierarchical multinomial regression analyses were conducted for BMI and central adiposity as exclusive outcomes, having only the significant socio-demographic variables as the predictors in Block 1 whereas significant diet quality variables were also included as the predictors in Block 2 of the regression models. The K-means clustering analysis was done by bringing in the individual scores from 13 diet components and the number of clusters was decided as per the Scree plot guidance [Figure S1].[14] The socio-demographic profile, dietary habits, DQ scores (total and individual), anthropometric status, risky lifestyle habits, etc., that could potentially impact cardio-metabolic risk were analysed and compared between the clusters.

Results

The survey was conducted over two months and data from 378 eligible respondents were included in the study. The average and median ages of the respondents were 47.9 and 46, respectively, and the majority around 220 (58.2%) respondents were females. Educational details were available for 249 respondents and out of them only 16 (6.4%) were illiterate whereas 42 (16.9%) were graduates with 12 of them holding professional degrees. The majority of around two-thirds of the respondents were employed, and the mean per capita income was ₹3528 per month. The additional characteristics of the participants are given in Table 1.

The tool sHEI was found to have acceptable internal consistency, with a Cronbach's alpha score of 0.79. The mean and median values of diet quality scores determined by sHEI were 47.3 and 48.3, respectively [Table 2]. The diet scores were slightly higher among females and in the 40 to 69 age group but comparatively lower for those who were illiterate or unemployed [Table S1]. A whole 276 (87%) respondents exhibited at least one of the following cardio-metabolic risk manifestations which include overweight or obesity, increased or high central adiposity and systemic hypertension.

Diet quality impacting BMI

BMI, one of the metabolic risk predictors showed a negative correlation with total DQ scores [Figure S2]. The mean and median DQ scores were slightly higher for individuals with normal BMI category [Table S1]. The diet quality seemed to significantly impact both over and underweight as the hierarchical multinomial logistic regression analysis revealed that the increase of total DQ score significantly reduced the odds of becoming obese (OR = 0.95; CI = 0.92,0.97) as well as underweight (OR = 0.89; CI = 0.83,0.94) [Table 3]. Notably, intake of less-starchy green-leafy vegetables significantly reduced the odds of becoming obese by 1.6 times (95%CI = 1.13, 2.4; *P* = 0.009) in another predictive model. A univariate linear regression model also showed that individuals with good vegetable intake just by increasing one cup had a decrease in BMI by 3.34 units (OR = 3.34; CI = 0.32, 6.4; *P* = 0.03).

Diet quality impacting central adiposity

Central adiposity, a better predictor of coronary risk correlated with overall DQ scores but this seemed to be influenced by age [Figure S2]. The hierarchical multinomial logistic regression model revealed that good consumption of vegetables, seafood protein and limiting dietary sodium significantly reduced the odds of increased central adiposity or becoming high [Table 3]. This analysis also highlighted that a high intake of vegetables can 10 times decrease the odds of high central adiposity.

Diet quality impacting blood pressure

Around one-fourth of the respondents were undiagnosed hypertensive, i.e. systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg. Systolic and diastolic BP were also found negatively correlated with the total DQ scores [Figure S2]. The mean and median DQ scores were slightly higher for individuals with normal BP [Table S1]. Binomial univariate linear regression analyses also showed that good whole grains scores significantly decreased the odds of systemic hypertension by 0.753 units (OR = 0.753; CI = 0.642, 0.884; *P* = <0.001) whereas limiting dietary sodium significantly decreased the odds of systemic hypertension by 0.866 units (OR = 0.866; CI = 0.765, 0.979; *P* = 0.022).

Diet satisfaction - reality check

The interrogation on reality check revealed over one-fifth of the respondents expressed dissatisfaction with their current diet

Table 1: Background characteristics of the participants

Characteristic total participants (*n*=378)	Statistical summary (Mean/Median/ Proportion)
Age, in years	
Mean±SD	47.9±11.8
Median, IQR	46, 17
Sex	
Male	158 (41.8%)
Female	220 (58.2%)
Educational status (*n*=249)*	
Graduates	42 (16.9%)
School/Diploma	191 (76.7%)
Illiterate	16 (6.4%)
Employment status (*n*=347)*	
Employed	248 (71.5%)
Unemployed	2 (0.5%)
Homemaker	97 (28%)
Per-capita monthly income (INR) Mean±SD	3528±5491

*Number of respondents excluding missing values practices where few felt that they should avoid unhealthy outside food, drink more water, increase their fruits, vegetables and nuts intake, etc., [Table 2].

Diet clusters - analysis

The k-means clustering analysis included 304 respondents and resulted in four significant clusters with distinct DQ scores ($P < 0.001$; Sum of Squares between clusters = 7313) [Table 4, Figures 1-3].

Cluster-IV had a maximum of 103 members, while Cluster-III had a minimum of 38 members. Cluster-III was the top-scoring cluster, with DQ scores lying between the 80th and 90th percentile. In contrast, Cluster-I was the least-scoring cluster, with a score falling below the 20th percentile. All the clusters except Cluster-IV comprised predominantly females. Cluster-I had the maximum per-capita income, but illiterate and unemployed individuals also belonged to this cluster. Cluster-IV had more individuals with a family history of any NCD (s) [Table 4].

Table 2: Desired diet change – Content analysis of responses

To increase greens, vegetables, fruits and fibre intake	10
To increase dairy and non-veg intake	4
To increase water intake	1
To increase nuts intake	2
To avoid outside, unhealthy food intake	1

The poorly scored Cluster-I had comparatively more individuals with a history of smoking and/or lacking regular physical activity. The low-scored Cluster-II had comparatively more habitual smokeless tobacco users. The moderately scored Cluster-IV had more members with habitual alcohol intake and those who preferred excess salty diet and/or outside-prepared food. These habitual risk factors were comparatively low in the top-scored Cluster-III. This Cluster-III also had proportionately lower individuals with overweight/obesity [Table 4].

The poorly scored Cluster-I had comparatively more individuals with high central adiposity. The number of individuals who have high normal BP and undiagnosed systemic hypertension is relatively high in Cluster-IV, which is a group that prefers a high-salt diet. On the other hand, the number of individuals under the age of 45 with high normal BP and undiagnosed systemic hypertension is relatively high in low-scored Cluster-II [Table 4]. However, more individuals from Cluster-I expressed some sort of dietary dissatisfaction and wished to modify their current diet practices [Table S2].

Discussion

It is evident from the findings of this community-based study that diet quality can significantly impact cardio-metabolic risk.

Table 3: Hierarchical regression examining A. Body Mass Index and B. Central Adiposity concerning diet quality

A. BODY MASS INDEX (Normal BMI as reference category)						
Outcome	**BLOCK 1:- Model-fit *P*=0.328; R^2N=0.021**			**BLOCK 2:- Model-fit *P*=0.084; R^2N=0.04**		
	Predictor	**OR (95% CI)**	***P***	**Predictor**	**OR (95% CI)**	***P***
Underweight	Age	1.018 (0.999,1.04)	0.060	Age	1.03 (0.98,1.08)	0.339
	Income	1 (1,1)	0.211	Income	1 (0.999,1)	0.173
				DQ score	0.89 (0.833,0.94)	<0.001
Overweight	Age	0.99 (0.98,1.001)	0.077	Age	0.99 (0.95,1.03)	0.544
	Income	1 (1,1)	0.705	Income	1 (1,1)	0.829
				DQ score	0.96 (0.93,0.998)	0.038
Obese	Age	0.98 (0.97,0.99)	<0.001	Age	0.98 (0.96,1.1)	0.199
	Income	1 (1,1)	0.489	Income	1 (1,1)	0.643
				Diet score	0.95 (0.92,0.97)	<0.001
B. CENTRAL ADIPOSITY (Healthy as reference category)						
Outcome	**BLOCK 1:- Model-fit *P*=0.029; R^2N=0.03**			**BLOCK 2:- Model-fit *P*=0.03; R^2N=0.08**		
	Predictor	**OR (95% CI)**	***P***	**Predictor**	**OR (95% CI)**	***P***
Increased	Age	0.99 (0.98,1.01)	0.079	Age	0.99 (0.97,1.01)	0.452
	Income	1 (1,1)	0.189	Income	0.99 (0.99,1)	0.174
				Vegetables	0.12 (0.12,0.12)	<0.001
				Seafood protein	0.34 (0.35,0.45)	<0.001
				Low Sodium diet	0.83 (0.72,0.96)	0.011
High	Age	1.03 (1.02,1.04)	< .001	Age	1.0 (1.01,1.05)	0.015
	Income	1 (1,1)	0.319	Income	1 (1,1)	0.354
				Vegetables	0.094 (0.093, 0.0096)	<0.001
				Seafood protein	0.36 (0.32,0.4)	<0.001
				Low Sodium diet	0.84 (0.72,0.98)	0.028

Block 1: Significant socio-demographic variables; Block 2: Significant socio-demographic & diet quality variables. R^2N: Nagelkerke's R^2

Table 4: Diet clusters - Analysis (*n*=304)

Characteristic	Cluster I Poor-scores	Cluster II Low-scores	Cluster III Top-scores	Cluster IV Moderate-scores	*P*†
Background					
• Age, in years					
Mean±SD	48±12.1	48.3±12.8	49.8±12	47.7±11.1	0.859
Median, IQR	46.5, 19.8	46, 18	48, 17	48, 17.5	-
• Sex					
Male (*n*=137)	31 (22.7%)	34 (24.8%)	16 (11.7%)	56 (40.9%)	0.122
Female (*n*=167)	51 (30.5%)	47 (28%)	22 (13.2%)	47 (28%)	
• Educational Status (*n*=195)*					
Graduates	8 (4.1%)	11 (5.6%)	3 (1.5%)	13 (6.6%)	
School/Diploma	34 (17.4%)	41 (21%)	20 (0.3%)	53 (27.2%)	0.029
Illiterate	8 (4.1%)	0	0	4 (2%)	
• Employment Status (*n*=288)*					
Employed	46 (16%)	61 (21.2%)	21 (7.3%)	77 (26.7%)	
Unemployed	1 (0.35%)	1 (0.35%)	0	0	0.12
Homemaker	26 (9%)	18 (6.25%)	15 (5.2%)	22 (7.6%)	
• Per-capita monthly income ₹ (Mean±SD)	4472±11412	3746±2957	2579±2331	3311±2374	0.052
• Family H/o NCD‡ (*n*=69)	12 (17.4%)	22 (31.9%)	9 (13%)	26 (37.7%)	0.01
Diet					
• Total Diet Quality score: sHEI Range 17 to 79 (Mean±SD)	38.5±4.5	45.6±5.6	56.1±4.34	52.3±4.96	<0.001
• Vegetable intake in *cup-eqv* (Mean±SD)	1.24	1.3	1.27	1.24	<0.001
• Fibre intake in g (Mean±SD)	14.8	15.1	15.0	15.4	0.09
• Calcium intake in mg (Mean±SD)	956	1058	970	1016	0.006
• Preferring excess salty-food§ (*n*=163)	21 (12.8%)	48 (29.4%)	15 (9.2%)	79 (48.5%)	<0.0001
• Consuming outside food daily (*n*=104)	5 (4.8%)	34 (32.7%)	5 (4.8%)	60 (57.7%)	<0.0001
Habitual Risk					
• Current or Past Smokers (*n*=32)	10 (31.2%)	7 (21.9%)	3 (9.3%)	12 (37.5%)	0.124
• Smokeless tobacco use (*n*=7)	1 (14.3%)	3 (42.9%)	1 (14.3%)	2 (28.6%)	0.67
• Alcoholism (*n*=22)	5 (22.7%)	5 (22.7%)	2 (9%)	10 (45.5%)	0.11
• No regular physical activity (*n*=50)	19 (38%)	11 (22%)	6 (12%)	14 (28%)	0.07
Cardio-Metabolic Risk					
• Body Mass Index: Asia-Pacific classification (*n*=293)*					
Underweight	4 (1.4%)	2 (0.68%)	2 (0.68%)	3 (1%)	
Normal	10 (3.4%)	18 (6.14%)	10 (3.4%)	23 (7.8%)	0.498
Overweight	5 (1.7%)	5 (1.7%)	2 (0.68%)	13 (4.4%)	
Obese	34 (11.6%)	43 (14.7%)	14 (4.8%)	44 (15%)	
• Waist-Height Ratio: Degree of central adiposity – NICE guidance (*n*=236)*					
Healthy	14 (5.9%)	6 (2.5%)	3 (1.27%)	21 (8.9%)	
Increased	10 (4.23%)	29 (12.3%)	14 (5.9%)	23 (9.7%)	0.007
High	17 (7.2%)	21 (8.9%)	10 (4.23%)	16 (6.8%)	
• High normal Blood Pressure: SBP 130mmHg and/or DBP ≥85 mmHg					
All ages (*n*=98)	23 (23.4%)	29 (29.6%)	11 (11.2%)	35 (35.7%)	0.005
<45 years (*n*=40)	10 (25%)	15 (37.5%)	3 (7.5%)	12 (30%)	0.05
• Systemic Hypertension: SBP ≥140 mmHg and/or DBP 90 mmHg					
All ages (*n*=66)	14 (21.2%)	21 (31.8%)	7 (10.6%)	24 (36.3%)	0.015
<45 years (*n*=23)	6 (26%)	9 (39%)	2 (8.7%)	6 (26%)	0.23

*Number of respondents excluding missing values; †*P* value computed for observations across the clusters by the One-Way ANOVA Kruskal–Wallis method for continuous measures and the Chi-square method for categorical data; ‡Any non-communicable diseases like Diabetes Mellitus, Systemic Hypertension, Heart disease or Stroke; §Salty foods are pickles, pappad, dried fish, etc., and/or the habit of adding extra salt to the diet.

Also, the diet quality scores led to the formation of four distinct diet clusters with differing cardio-metabolic risk statuses.

The socio-demographic details revealed maximum female participation which was reflected in the first three of four clusters. Females also had slightly higher overall DQ scores as the top-scored Cluster-III had more homemakers who exhibit constant involvement in household food decisions.[15] The DQ profile for Indians 2021 reported a gender disparity in dietary diversity, where men consumed more food groups than women but also had unhealthy intakes of soft drinks, deep-fried foods and processed meats.[16] Our study also had similar findings, where men scored comparatively higher in fruit and vegetable intake but lost in added sugars and saturated fat consumption.

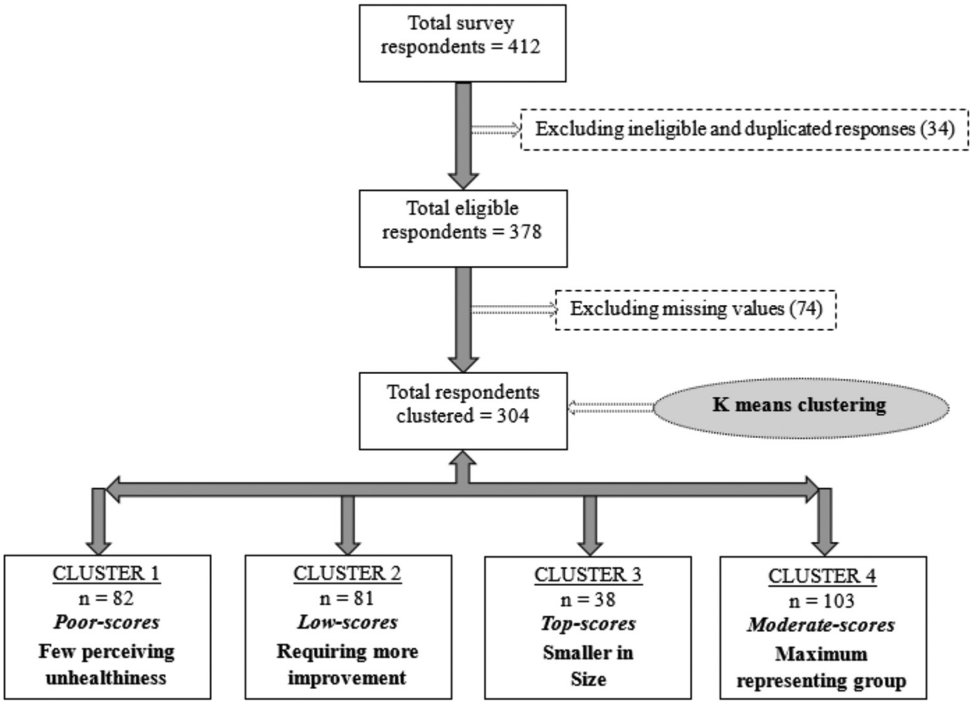

Figure 1: Flow chart depicting respondents' recruitment and clustering

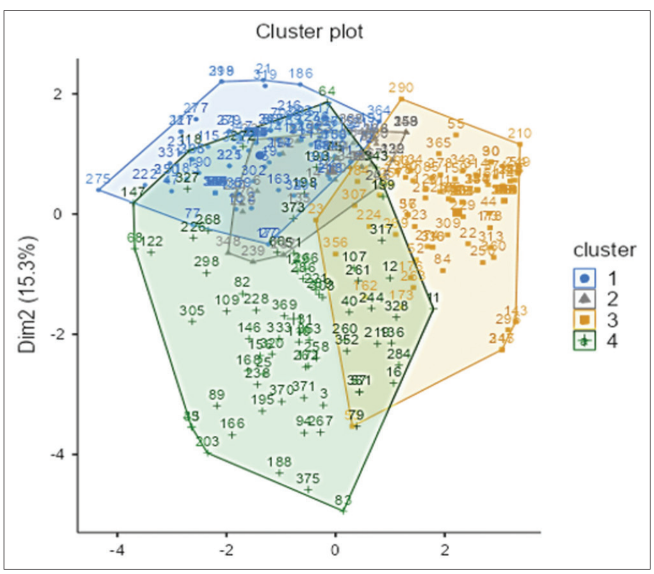

Figure 2: Diet quality clusters

Age is the leveraging factor for diet but food-variety choices need not decline with age as presumed and healthy older adults can have more diverse diets.[17] In this study, the DQ scores were slightly higher among 40 to 69-year-olds than those who were younger and older than them. Social and peer pressure often influences young individuals to experiment with new products or foods without fully considering the consequences. On the other hand, some extremely old people face oral or general health issues that prevent them from consuming different food groups.[18]

The current study also has shown that individuals who were illiterate and unemployed have comparatively low DQ scores and belong to the poorly scored Cluster-I. Per-capita income has an impact on the choice of consumption like fruits and seafood and an inverse trend was observed between per-capita income and sodium cum added sugars consumption. The Cluster-III which had the lowest mean per-capita income had shallow fruit-related scores. This is consistent with the fact that in rural India nutritious food intake is positively influenced by per-capita expenditure on food items, household size and literacy rate whereas negatively by poverty rate.[19,20] Also, processed foods and SSBs have become more affordable even in poorer households of low-middle-income countries warranting urgent action.[8]

The quality of diet plays a vital role in maintaining health and body weight and the well-established link between obesity and cardiovascular risk emphasises the importance of healthy diet.[21] The current findings highlighted that adequate DQ significantly reduced the chance of becoming obese or underweight. Additionally, BMI was also inversely correlated with less-starchy green-leafy vegetable intake as plant-origin diets are beneficial to lower atherosclerotic risk.[22] Consistent with that, Cluster-I had poor vegetable-related scores and had only a few members with normal BMI.

Waist-Height Ratio determines central adiposity regardless of gender and ethnicity, has high specificity and is a good predictor of metabolic syndrome.[23] To lose central fat, a low-carbohydrate high-fat (LCHF) diet is suggested which is composed of carbohydrates restricted to less than 45% of energy intake, limiting starch and sugar, intake of healthy (mono- and polyunsaturated) fats and moderate protein.[24] But all these

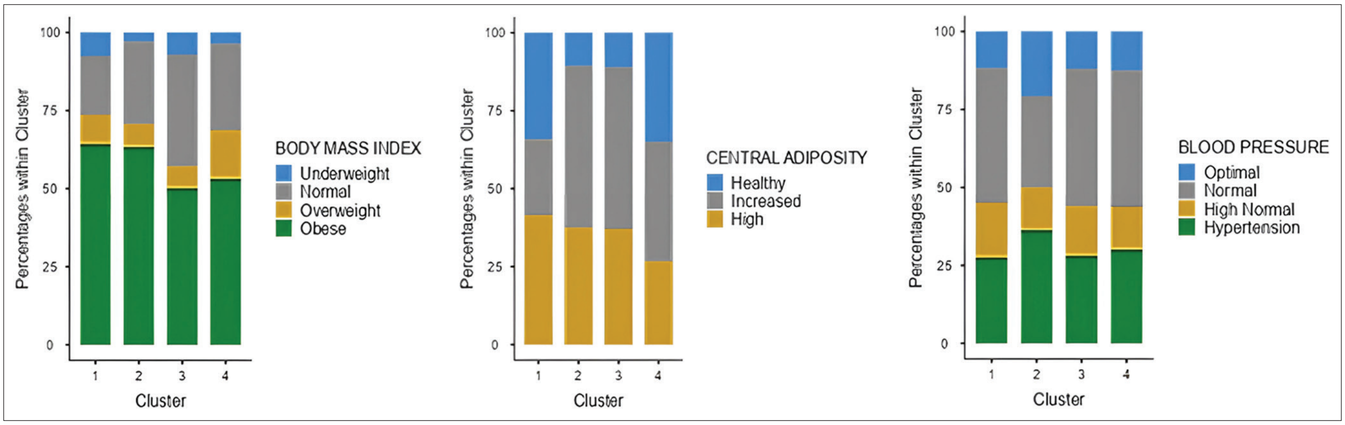

Figure 3: Cardio-metabolic risk status across the clusters

consumption scores were poor in Cluster-I which had maximum members with high central adiposity.

More than one-fourth of the respondents had undiagnosed hypertension in line with the National Family Health Survey (NFHS) 2019-21 which stated that over two-thirds of hypertensive individuals in India are undiagnosed.[25] Cluster-II had more people with high normal blood pressure and unhealthy sodium, refined grains and fatty acids scores. This cluster also had a concerning number of individuals under 45 years with high normal BP which would prepone their risk of heart and brain abnormalities and related events.

The current study highlighted that the clusters with low DQ scores displayed higher metabolic risk characterised by obesity, central adiposity and elevated BP. These clusters had notably more smokers or smokeless tobacco users as a healthy diet and lifestyle go hand-in-hand. Conversely, the clusters with higher DQ scores showed a lower risk of these conditions. Over time, Indian diets have moved away from traditional cereals towards processed foods gradually developing chronic ailments with poor nutrition choices.[26] Only very few respondents realised this, expressed some need for change and gave insightful responses. The newer National Programme for Prevention and Control of Non-Communicable Diseases (NPNCD) in India has identified unhealthy diet as a behavioural risk factor that needs screening and awareness.[27]

The PRECEDE-PROCEED health promotion model proved effective in preventive behaviours and found useful in modifying eating habits, achieving metabolic control and operationalising various health promotion programs.[28–30] This operates by assessing baseline risk and targeted behavioural change. Scaling it up, community-level dietary risk assessment triggers context-specific interventions like promoting protective foods, popularising simple-low-cost-nutritious food, easily preparable healthy recipes and discouraging harmful foods through tax-imposing on SSBs, processed foods and enforcing front-of-package nutritional labelling system, etc., that would eventually bring down cardiovascular and metabolic risk in the community also protecting people's fundamental right of food choice.

The current study is one of very few Indian studies that assessed community-level diet quality concerning cardio-metabolic risk. This study used a validated tool sHEI which estimates overall diet quality with a low researcher burden. The study tool was originally developed in the American context and needed some modifications to fit into the Indian context. The survey respondents were not ruled out for certain physiological and pathological conditions like pregnancy, lactation, food allergy, etc., that would influence dietary habits which is one of the major limitations of the study. Additionally, the study tool does not include information on red meat consumption, which could potentially affect cardiac events. Certain discrepancies found in some scoring criteria were lacking explanations. The outcome assessment hasn't included any laboratory markers like serum cholesterol, plasma glucose level, etc., Moreover, respondents' knowledge of foods and serving sizes, their recalling difficulties, collection of data by multiple individuals, a significant amount of missing information and certain inherent limitations of analytical techniques could have biased the findings in any direction.

However, the current study highlighted the strong impact of diet quality and dietary practices on cardiovascular and metabolic risk. More studies on dietary interventions in real life can establish meaningful causal relationships in guiding healthy diet promotion policies.

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Conflicts of interest

There are no conflicts of interest.

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Table S1: Mean and Median diet quality scores of the respondents

Characteristic	Mean±SD	*P*†	Median, IQR
Age, in years			
30 to 39	46.8±8.49		48.6, 13.8
40 to 49	47.2±8.02	0.942	48.2, 12.8
50 to 59	47.7±8.09		49.2, 12.8
60 to 69	47.9±7.61		47.3, 12.4
≥70	46.5±7.13		46.2, 11.3
Sex			
Male	46.7±7.3	0.353	48.3, 13.7
Female	47.7±8.55		48.3, 11.2
Educational status (*n*=249)*			
Graduates	48.1±8.06		48.9, 13.0
School/Diploma	47.7±7.73	0.001	48.7, 12.1
Illiterate	39.1±6.88		36.5, 13.5
Employment status (*n*=347)*			
Employed	47.3±7.54		48.4, 11.3
Unemployed	44.1±2.93	0.554	44.1, 2.07
Homemaker	47.9±9.01		48.4, 15.7
Body Mass Index: Asia-Pacific classification (*n*=293)			
Underweight	44.9±7.31		46.9, 9
Normal	49.8±7.81	0.096	50, 9.01
Overweight	48.3±7.00		48.9, 7.96
Obese	47.2±7.45		48.4, 11.7
Waist-Height Ratio: Degree of central adiposity – NICE guidance (*n*=236)			
Healthy	45.9±8.08		47, 12
Increased	48.4±6.47	0.164	48.9, 8.01
High	46.8±7.22		48.3, 10.2
Blood Pressure (*n*=268)			
Normal	48.4±6.95		49.3, 11.9
High normal	47.4±8.35	0.38	48.4, 11.7

*Number of respondents excluding missing values. †*P* value computed by One-Way ANOVA Kruskal-Wallis method

Table S2: Mean diet scores and perceived diet dissatisfaction across the clusters

Characteristic	Cluster I Poor-scores *n*=82	Cluster II Low-scores *n*=81	Cluster III Top-scores *n*=38	Cluster IV Moderate-scores *n*=103
Total DIET quality score sHEI (Range: 17 to 79)	38.5±4.5	45.6±5.6	56.1±4.34	52.3±4.96
• Total fruits (Range: 0 to 5)	0.68	2.43	1.26	2.6
• Whole fruits (Range: 0 to 5)	0.67	2.01	0.99	1.9
• Total vegetables More greens, less starchy (Range: 1.6 to 3.56)	1.6	2.66	2.85	2.72
• Greens and beans (Range: 0 to 5)	0.30	4.75	5	5
• Whole grains (Range: 0.51 to 6.94)	1.0	2.77	2.19	3.01
• Dairy (Range: 3.22 to 6.51)	3.67	4.22	3.81	3.88
• Total protein from seafood (Range: 4.11 to 4.97)	4.70	4.82	4.79	4.85
• Plant protein (Range: 0.49 to 4.20)	1.16	1.54	1.24	1.10
• Fatty acids (Dairy, Saturated fat) Range: 2.56 to 5.93	5.44	4.87	5.43	4.82
• Refined grains Range: 2.13 to 9.25	2.13	3.05	9.25	9.21
• Sodium (Range: 0.7 to 6.07)	5.74	2.71	6.07	6.06
• Added Sugars (Range: 0 to 10)	8.11	5.49	10	4.13
• Saturated Fats from refined grains, SSB (Range: 1.82 to 6.56)	3.31	4.18	3.2	3.0
Dissatisfied with current diet (*n*=52)	19 (36.5%)	13 (25%)	5 (9.6%)	15 (28.8%)

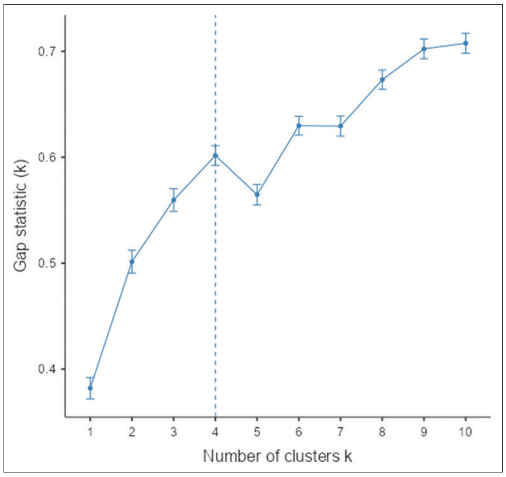

Figure S1: Scree plot sowing optimal number of clusters

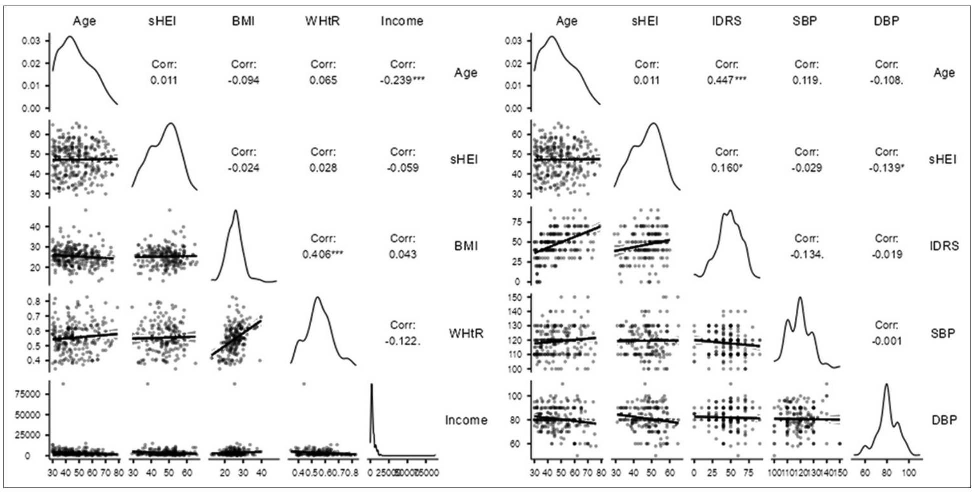

Figure S2: sHEI (Diet quality) correlations