

# Development of diet score for identifying the relationship between diet patterns and dietary guidelines in Singapore

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## Abstract

**Objectives:** Foods and dietary patterns substantially affect health outcomes. The overall dietary assessment score associated with dietary guidelines in Singapore has not been assessed previously. This study aimed to develop and evaluate diet score for identifying the relationship between dietary patterns and dietary guidelines in Singapore.

**Methods:** Using a localised diet score survey collaborated with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), we conducted a cross-sectional study of 600 Singapore persons in two-generational cohorts (40-64: 300 and > 65 years: 300). Proposed local diet score was calculated to reflect their overall compliance with the Dietary Guidelines in Singapore. ANOVA analysis was used to identify the significant difference among socio-demographic variables associated with diet score and comparison analysis was performed to compare the diet patterns and diet score.

**Results:** There are significant differences among age, education, housing, residency associated with diet score. Diet score of older cohort (M= 67.71, SD= 13.38) is significantly higher than young cohort (M= 60.73, SD= 14.71). The highest education level (University or tertiary) obtain the lowest diet score (M= 58.58, SD= 14.41). The participants who live in the landed property (M= 69.45, SD= 14.43) are higher than those who live in Condominium and Public House. And the participants who live alone (M= 67.26, SD= 14.66) have a higher average diet score.

**Conclusions:** Two-generational cohorts are not compliant with recommendations about dietary guideline well in Singapore. The present findings suggest that dietary patterns need improvement in aspects such as vegetables and extra food components.

## Introduction

Foods and dietary patterns are integral to the promotion of good health throughout one's lifetime. Dietary guidelines are statements that assist populations in choosing foods for preventing malnutrition in all its forms as well as a range of noncommunicable diseases (NCDs) and conditions [1-4]. The prevalence of obesity and diet-related NCDs is rising in Singapore [5]. The prevalence of obesity among adult Singaporeans aged 18 to 59 years was 8.9%, and that among older adults aged 60 to 74 years was 6.9% [6] 2013. To promote healthier diets in Singapore, Health Promotion Board (HPB) has introduced programmes such as the Healthier Choice Symbol (HCS) and Healthier Dining Programme (HDP) to increase the availability of healthier options, as well as campaigns such as the Eat, Drink, Shop Healthy Challenge to incentivise healthier purchases [7,8]. As the dietary components are consumed in combination and correlated with one another [9], there are increasing attention in dietary score research and guidance on dietary patterns [10,11].

Furthermore, diet score could examine the diet as a whole and measuring several aspects including quantity, quality, and variety of foods consumed against dietary guidelines and recommendations [12-15]. And the diet score will also allow investigation of the determinants and consequences [16]. Chen, *et al.* [17] concluded that adherence to diet index was significantly associated with lower T2D risk and Chia, *et al.* [17] pointed out that higher maternal diet quality during pregnancy was associated with the longer birth length and lower neonatal adiposity.

In the meantime, the population is ageing worldwide and in Singapore. By 2030, Singapore's older adults (aged 65 years and

above) will triple to about 900,000, or 18.7% of the total population [18]. The overall dietary assessment score associated with dietary guidelines in Singapore has not been assessed among the young and old adults previously. To promote a healthier diet, it is important to develop a diet score for a better understanding of foods and dietary patterns in Singapore.

## Methodology

### Study design

This was a cross-sectional study using convenience sampling. With an in-person survey, all the participants will be asked to complete a survey which assesses their demographic information, health and nutrition literacy, health behaviour, and psychological attributes. A total of 600 participants from Singapore was recruited across the two-generational cohorts (ages: 40-64 and 65 & above). The data collection was administered in two phases: i) a survey, and ii) a 3-day daily diary report. This paper reports the findings from the first phase.

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## Measurements

**Dietary Intake: CSIRO Healthy Diet Score.** The CSIRO Healthy Diet Score survey contains the 38 questions asking about the frequency and amounts of different foods consumed, food choices, and variety [14]. Generally, for the quantity components, individuals report their usual intake, in serves, per day, week or month. For the quality components, the frequency of wholegrains consumption, reduced-fat dairy consumption, frequency of trimming meat, fat type of spreads used, and water consumption (as a proportion of total fluids) are assessed. The variety of foods consumed within each core food group is also recorded.

**Sociodemographics:** Sociodemographics including age, education, race, sex, and living status were used as covariates in the study. Age was coded in years. Responses for education included no education (reference group), primary school, some high school, completed high school, junior college/polytechnic, and university and above. Race (Chinese = 1, other = 0), sex (female = 1, male = 0), and living status (living alone = 1, not living alone = 0) were dummy-coded. Chronic conditions were assessed by asking participants whether they had any medical conditions that require dietary modification or physical activity, including diabetes, kidney disease, high cholesterol, gout, digestive conditions, and cancer. The total number of conditions reported ranged from 0 to 6 with a higher number indicating more conditions. Self-rated health was assessed by asking participants to rate their general health (1 = poor to 5 = excellent).

## Data Collection

The study was administered from April 2019 to August 2019. In total 300 participants from 156 Senior Activity Centres (SACs) / Voluntary Welfare Organizations (VWOs) were contacted, out of which 24 centres agreed to take part in the study. The exclusion criteria are as follows: (i) Age 39 and below; (ii) Those participants with poor/ critical physical and mental health conditions; (iii) Foreigners.

## Diet Score Calculation in Singapore

The recommended serving sizes in daily diet are 2 servings of fruits, 2 servings of vegetables, 3 servings of meat and dairy, 4-6 servings of bread and cereals, 8 servings of water (i.e. beverage), and less than 2 servings of alcohol for males and less than 1 serving of alcohol for females [19]. A maximum of 10 or 20 points is awarded for each food group if participants meet the recommended serving size guideline provided by HPB.

According to the My Healthy Plate [19], it is recommended that half of each meal should consist of fruits and vegetables, whilst meat and dairy and bread alternatives take up a quarter. Table 1 shows the breakdown of score allocation for the calculation of diet score in Singapore. As such, 20 points are allocated to the fruits and vegetables scoring due to its heavier weightage. For fats and oils, the 10-point score is divided into the type of fat consumed (maximum of 5 points) and the frequency of consuming it (maximum of 5 points). Butter and margarine are both given 2.5 points, alternatives such as peanut butter, jam, chocolate spread, kaya spread are given 0 points, and the no spread option is awarded 5 points. For frequency, always (all of the time) is awarded 5 points, usually (two-thirds of the time) is awarded 3.75 points, sometimes (half the time) is awarded 2.50 points and the rare and never options are awarded 0 points.

Individuals who eat more than the recommended serving do not score the maximum point [20]. Instead, their points are deducted based

on how much excess is eaten. This is calculated through the formula will be [maximum score attained - (serving size - recommended serving size)].

## Results and Analyses

Calculations were made using the SPSS IBM 25.0 software. Independent t-tests, analysis of variances were used on continuous data. K-means cluster was applied to categorise the diet score as three-level (low, medium and high). A one-way randomized ANOVA was used whether there are any statistically significant differences between the means of two or more independent. In all hypotheses, a significance level of  $\alpha=0.05$  was used, and a confidence interval of 95 % was accepted for statistical significance ( $p<0.05$ ) at a 2-tailed level.

## Demographics

We included 600 (40-64 cohort: 300; 65+ cohort: 300) participants who were eligible in the analysis (Table 2). For the young cohort, the average age was ( $M=55.31$ ,  $SD=6.57$ ) and 210 were males. 19.33% of the young cohort has University or tertiary qualification. 88% of these are living in a public house developed by the Housing & Development Board (HDB). There are 6.33% of participants who are living alone. For the older cohort, the average age was ( $M=74.65$ ,  $SD=6.80$ ) and 240 were males. Only 1.67% of them has a University or tertiary qualification. 95.33% of this cohort are living in a public house and 29.33% are living alone. Approximately 27.70% and 30.30% are poor self-rated health for the young and older cohort.

## Diet Score and Socio-Demographic

The socio-demographic information associated with diet score is shown in Table 3. The diet score was categorised by K-mean clustering into three-level (low:  $<40$ ; medium:  $40 - 79$  and high:  $> 79$ ). The diet score of the major participants ( $n=469$ ) is from 40 to 79. Hence, the local compliance with Dietary Guidelines by HPB in Singapore is not high enough. Age, education, housing, residency have significant differences due to the diet score. Diet score of older cohort ( $M=67.71$ ,  $SD=13.38$ ) is significantly higher than young cohort ( $M=60.73$ ,  $SD=14.71$ ). The highest education level (University or tertiary) obtain the lowest diet score ( $M=58.58$ ,  $SD=14.41$ ). The participants who live in the landed property ( $M=69.45$ ,  $SD=14.43$ ) are higher than those who live in Condominium ( $M=55.18$ ,  $SD=15.17$ ). And the participants who live alone ( $M=67.26$ ,  $SD=14.66$ ) have a higher average score compared to those with spouse and children ( $M=62.14$ ,  $SD=14.31$ ). Among the gender, ethnicity, income levels and medical condition count, there was no significant differences based on the diet score.

## Diet Score and Dietary patterns

Generally, there are eight food group components defined from HPB in Singapore [19]. They are 1) fruits (fruit and fruit juice), 2) vegetables, 3) Breads and cereals, 4) Meat and Dairy, 5) Beverages (Sports Drinks and Water), 6) Alcohol, 7) Extra Food (including Fast food, Fried food, Pastries, Chocolate and sweets and Icecream) and 8) Fats and oils (Table 1). We breakdown the average diet score as low, mid and high for each food group component. Seen from Figure 1, the high diet score across all participants largely consists of vegetables (19.06), followed by fruits (17.48) and beverages (10.20). The mid diet score results show the vegetables (13.78), fruits (12.40) and beverages (5.50). And the low diet score declines as the vegetables (2.68), fruits (7.94) and beverages (2.17). In the meantime, with the varying diet score, the major top food components have been changed: High diet score (vegetables, fruits and beverages); Mid diet score (vegetables, fruits and

**Table 1.** Score allocation for the proposed Singapore diet score (servings per day)

Food group components (by servings)		Score Points			
		0	5	10	20
Fruits	Whole fruit	[0, 1]	n.a.	[1, 2]	2
	Fruit juice	>1	n.a.	[0, 1]	0
Vegetables		[0, 1]	n.a.	[1, 2]	2
Breads and cereal		0-2	[2, 4]	[4, 6]	n.a.
Meat and Dairy		0-1.5	[1.5, 3]	3	n.a.
Beverages	Sports and soft drinks	>0	>0	0	n.a.
	Water and tea	0-4	[4, 8]	8	n.a.
Alcohol		If Males >2	[0, 2]	0	n.a.
		If Females >1	[0, 1]	0	n.a.
Extra food		>1	[0, 1]	0	n.a.
1. Fast food					
2. Fried food					
3. Pastries					
4. Chocolates and sweets					
5. Ice cream					
Fats and oils		Type of fat: - Butter (2.5) - margarine (vegetable oil-based spread) (2.5) - do not have spread (5.0) - others such as peanut butter, jam, chocolate spread, kaya spread (0)  Frequency: - always (all the time) (5.00) - usually (two-thirds of the time) (3.75) - sometimes (half the time) (2.50) - Rarely/never (0.00) - do not eat meat			

**Table 2.** The characteristics of participants from the two cohorts

	All (N = 600)	40-64 (n = 300)	≥ 65 (n = 300)	<i>p</i>
	<i>M (SD)</i> or %	<i>M (SD)</i> or %	<i>M (SD)</i> or %	
<b>Age (years)</b>	64.98 (11.76)	55.31 (6.57)	74.65 (6.80)	< 0.001
<b>Education</b>				< 0.001
No education	11.00%	1.00%	21.00%	
Primary school	27.30%	17.70%	37.00%	
Some high school	14.70%	15.30%	14.00%	
Completed high school	25.80%	28.70%	23.00%	
Junior college/polytechnic	10.70%	18.00%	3.30%	
University and above	10.50%	19.30%	1.70%	
<b>Chinese (yes)</b>	92.20%	90.70%	93.70%	0.171
<b>Female (yes)</b>	75.00%	70.00%	80.00%	0.005
<b>Live alone (yes)</b>	17.80%	6.30%	29.30%	< 0.001
<b>Chronic conditions (0-6)</b>	0.27 (.56)	0.21 (.52)	0.33 (.60)	0.009
<b>Fair to poor self-rate health (ref: good to excellent health)</b>	29.00%	27.70%	30.30%	0.472

Values are n (%), ± standard deviation.

alcohol) and Low diet score (fruits, alcohol and extra food). Hence, this proposed diet score can present the changes in dietary patterns on food group components.

### Discussion

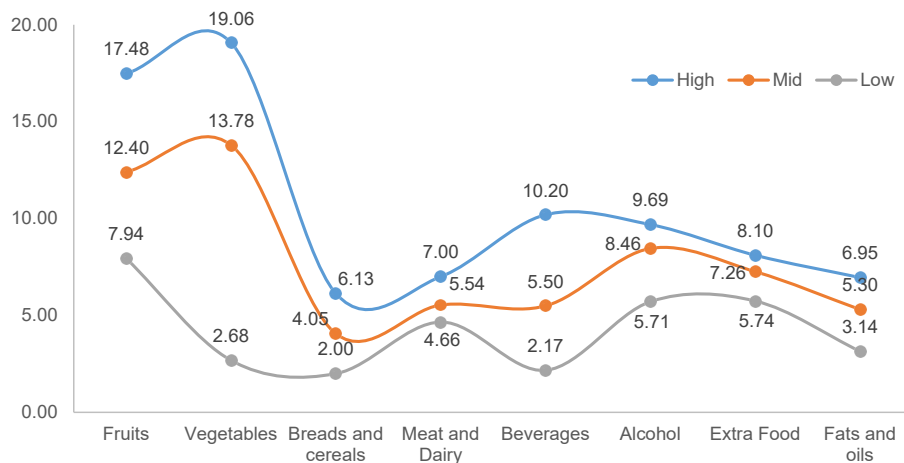
Dietary assessment measures are useful to gather dietary patterns and develop strategies to improve diets for chronic disease prevention [4]. Base on the literature review [13,17,20,22], this is the first study to develop and examine the food component-based diet scores with dietary patterns in Singapore. In this study, the localised diet score derived from 38 diet-related questions [10] was positively and significantly correlated with the dietary patterns suggested by HPB [19]. Similar

individual subcomponents in the two diet scores (e.g., vegetables, fruit, and beverages) were also significantly impacted. Furthermore, the localised diet score demonstrated a significant association with established sociodemographic (age, education, housing, residency).

Consistent with our findings, other observational studies have highlighted the importance of diet score in predicting diet-related health outcomes [1,10,17,23]. And the local compliance with Dietary Guidelines by HPB in Singapore is not good enough. Our findings also show the low diet score on extra food (Fast food, Fried food, Pastries, Chocolate and sweets and Icecream), which is in line with high sugar consuming (average 60g of sugar daily) among Singaporean highlighted by both Ministry of Health and Health Promotion Board [5]. Overall,

**Table 3.** The socio-demographic information associated with diet score

	Diet score (total) (n=600)	#Diet Score (low: <40) (n=35)	#Diet Score (mid: 40-79) (n=469)	#Diet Score (high: >79) (n= 96)	P Value*
<b>Age group (years)<sup>†</sup></b>					0.034
45-64	60.73 (14.71)	33.41 (4.62)	60.78 (10.62)	83.42 (3.85)	
Above 65	67.71 (13.38)	36.23 (3.26)	63.90 (9.67)	85.22 (4.62)	
<b>Gender</b>					0.84
Male	59.36 (14.18)	32.39 (5.62)	59.19 (10.78)	82.02 (2.07)	
Female	65.84 (14.22)	34.82 (3.71)	63.42 (9.87)	85.06 (4.59)	
<b>Ethnicity</b>					0.88
Chinese	64.10 (14.48)	34.30 (4.29)	62.30 (10.19)	84.70 (4.62)	
Malay	66.18 (16.20)	25.82 (-)	62.58 (12.26)	84.29 (1.70)	
Indian	63.86 (11.90)	-	62.25 (11.21)	79.97 (-)	
Others	65.94 (13.60)	-	61.35 (10.84)	84.28 (0.47)	
<b>Education</b>					0.022
Never attended school	64.73 (13.71)	36.82 (0.60)	62.67 (9.94)	86.40 (4.84)	
Primary school	64.17 (13.72)	32.62 (3.45)	62.44 (9.67)	84.18 (4.04)	
Some of high school	64.94 (14.37)	35.58 (3.89)	63.36 (9.85)	85.17 (4.92)	
Completed high school	66.25 (14.78)	35.69 (3.44)	62.86 (10.88)	84.09 (3.95)	
Junior college/Polytechnic/ ITE	63.46 (15.62)	30.00 (3.71)	61.40 (10.52)	84.82 (5.60)	
University or tertiary	58.58 (14.41)	33.58 (7.10)	59.86 (11.07)	85.56 (7.04)	
<b>Income</b>					0.063
No income	65.59 (14.39)	33.37 (4.42)	62.46 (10.29)	85.74 (4.59)	
\$1-199/week	66.05 (13.16)	36.50 (2.29)	62.74 (9.48)	84.46 (4.49)	
\$200-299/week	63.88 (15.65)	36.30 (2.92)	62.30 (11.16)	83.20 (3.10)	
\$300-399/week	65.02 (13.74)	-	60.94 (11.69)	83.02 (3.66)	
\$400-599/week	63.97 (13.59)	37.64 (0.44)	63.79 (10.46)	80.80 (1.48)	
\$600-799/week	61.60 (16.12)	32.70 (4.26)	61.62 (9.90)	84.61 (1.92)	
\$800-999/week	56.01 (11.93)	-	56.01 (11.93)	-	
\$1000-1249/week	60.22 (12.00)	36.00 (-)	61.74 (10.59)	-	
\$1250-1499/week	59.68 (10.79)	-	59.68 (10.79)	-	
\$1500-1999/week	49.88 (17.91)	27.67 (9.02)	57.29 (13.01)	-	
\$2000 or more/week	66.26 (14.45)	36.50 (-)	66.62 (6.80)	80.22 (0.41)	
Not specified	62.74 (15.14)	33.19 (4.78)	62.73 (10.19)	84.97 (5.80)	
<b>Housing</b>					0.002
Condominium	55.18 (15.17)	31.50 (8.03)	57.61 (11.93)	84.20 (-)	
HDB	64.61 (14.29)	34.36 (3.96)	62.50 (10.10)	84.80 (4.50)	
Landed	69.45 (14.43)	35.07 (-)	66.61 (10.76)	81.44 (2.10)	
Residential care and others	65.63 (13.61)	-	65.63 (13.61)	-	
<b>Residency</b>					0.013
Alone	67.26 (14.66)	35.03 (2.68)	62.90 (10.04)	86.02 (4.78)	
With spouse and children	62.14 (14.31)	33.30 (5.44)	61.16 (10.70)	84.06 (4.49)	
With spouse only	65.17 (14.77)	34.83 (3.43)	62.74 (10.15)	84.85 (4.34)	
With children only	66.56 (13.41)	34.94 (4.51)	65.23 (8.72)	83.36 (3.89)	
With friends and relatives	62.44 (12.49)	36.50 (-)	61.21 (10.35)	81.78 (1.92)	
<b>Medical condition count</b>					0.18
0	64.21 (14.37)	34.17 (4.57)	62.34 (10.15)	84.84 (4.33)	
1	64.09 (15.06)	34.08 (4.79)	62.24 (10.83)	84.39 (4.84)	
2	65.66 (13.75)	35.17 (1.99)	63.06 (9.76)	84.78 (3.93)	
3	65.63 (10.82)	-	62.25 (7.78)	83.66 (4.51)	
4	-	-	-	-	
5	51.52 (9.90)	-	51.52 (9.90)	-	
6	60.00 (-)	-	60.00 (-)	-	
7	41.75 (-)	28.50 (4.46)	55.00 (-)	-	



**Figure 1.** High, mid and low diet score among food group components

these findings provide further evidence that this localised diet score collaborating with the CSIRO Healthy Diet Score survey can reflect diet patterns within a study population. This diet score can allow for broader implementation and thus may be useful for understanding diet-disease relationships in populations from diverse sociodemographic backgrounds.

## Conclusion

As a summary, this study has developed a local diet score, which is calculated by adding the summed points of every food group components. With reflecting varying food group components, the localised diet score seems to be a useful method to assess dietary patterns in young and older adults in Singapore. Further research is needed to validate the score with biochemical and clinical indicators of nutritional status. Also, the utility of the score needs to be examined in other populations such as children. In the future, this dietary score can be administered online for individuals and implemented in supermarket chains (including NTUC FairPrice, Cold Storage, etc.) and hospital settings to give individuals a rating on how healthy dietary patterns are.

## Conflict of Interest (COI) statement

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## IRB protocol/human subjects approval numbers

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