BMJ Nutrition, Prevention & Health

Dietary patterns in the Mediators of Atherosclerosis in South Asians Living in America (MASALA) study: comparisons across methodologies

Jeannette M Beasley ,[1,2] Bridget Murphy Hussain,[3] Meghana D Gadgil,[4] Sameera A Talegawkar,[5] Niyati Parekh,[1] Shilpa N Bhupathiraju,[6,7] Nadia S Islam,[2] Alka M Kanaya[4]

To cite: Beasley JM, Hussain BM, Gadgil MD, *et al*. Dietary patterns in the Mediators of Atherosclerosis in South Asians Living in America (MASALA) study: comparisons across methodologies. *BMJ Nutrition, Prevention & Health* 2024;**0**:e000853. doi:10.1136/bmjnph-2023-000853

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/bmjnph-2023-000853).

For numbered affiliations see end of article.

Correspondence to
Dr Jeannette M Beasley; jbeasley@nyu.edu

Received 15 December 2023
Accepted 12 June 2024

DIETARY PATTERNS OVERVIEW

Dietary patterns are defined as the quantities, proportions, variety or combinations of different foods, drinks and nutrients in diets, and the frequency with which they are habitually consumed, allowing for the characterisation of the overall composition and quality of the eating behaviours of a population.[1] Dietary patterns can be derived based on data-driven (eg, principal component analysis), score-based (eg, Healthy Eating Index (HEI)) or preference-based (eg, plant-based) methods. This paper focuses on score-based dietary patterns in order to provide actionable guidance to inform intervention approaches to reduce cardiometabolic risk.

Diet quality is inversely associated with risk of cardiovascular disease morbidity and mortality.[2] Research has established the Dietary Approaches to Stop Hypertension (DASH) diet, Mediterranean-style diet, HEI and the Alternate Healthy Eating Index (AHEI) as the primary dietary patterns associated with reduced cardiovascular morbidity and mortality (table 1). More recently, the EAT-Lancet dietary pattern was designed in response to a call by the Lancet for dietary patterns that concurrently prioritise *both* planetary and human health.[3] While each of the aforementioned dietary indices focus on food group intakes, they differ based on ranges and cut-offs, and by what items are included in the scoring for use in population-based studies (table 1). Components of these diets are consistent with the American Heart Association's (AHA) dietary guidance[2] and the 2020–2025 Dietary Guidelines for Americans,[4] yet the diets should be evaluated for cultural appropriateness and accessibility among South Asians in the USA.

The purpose of this review is to summarise how score-based dietary patterns (online supplemental table 1) have been examined in relation to cardiometabolic outcomes within the Mediators of Atherosclerosis in South Asians Living in America (MASALA) cohort study. The rationale and methods for the MASALA cohort have been described elsewhere.[5] Briefly, MASALA is a prospective cohort study that enrolled community-dwelling individuals living in the USA from 2010 to 2013. Participants self-identified as having South Asian ancestry and were aged 40–84 years and without known cardiovascular disease. Those taking nitroglycerin, with active cancer, with impaired cognitive ability, with a life expectancy less than 5 years, who lived in a nursing home or who had plans to relocate were excluded. Dietary data were collected using the Study of Health Assessment and Risk in Ethnic groups food frequency questionnaire, a 163-item tool validated to assess dietary intake during the previous year among South Asian adults.[6] This enabled authors to analyse dietary intake and create score-based dietary patterns among MASALA respondents.

DASH diet

The DASH dietary pattern is characterised by a diet that promotes intake of fruits, vegetables, nuts and legumes, dairy and whole grains, while de-emphasising intake of red and processed meats, sugar-sweetened beverages and sodium.[7] The dietary index is broad in its definition of component food groups, facilitating the inclusion of culturally relevant food items that can more comprehensively capture the dietary patterns of South Asians living in the USA. As such, scoring is

Table 1 Definition, components, differentiating features and outcomes previously measured among dietary patterns recommended for cardiovascular disease prevention and treatment

	DASH diet	Mediterranean-style diet	Healthy Eating Index	AHEI	Healthy plant-based index	Planetary Health Diet Index
Definition	Dietary pattern derived from a randomised controlled trial comparing DASH to a fruit and vegetable pattern and control diet to evaluate the effects of diet on blood pressure.[35]	A traditional eating pattern found among populations living in the Mediterranean during the 1950s–1960s.[36]	An index of overall diet quality created by the US Department of Agriculture to monitor changes in dietary intake.[16]	Quantitative scoring for qualitative dietary guidance from the US Dietary Guidelines for Americans.[23]	Plant-based diets have been associated with improved health outcomes.[37]	Planetary boundaries and environmental sustainability guide scientifically established targets for intakes of food groups that ensure human health.[6]
Components	Rich in fruits, vegetables, legumes, whole grains, low-fat dairy; low in sodium, sugar-sweetened beverages, red and processed meat.[9]	Fruits, vegetables, legumes, nuts, whole grains, meat/meat products, fish, alcohol, monounsaturated to saturated fat ratio.[8]	'Adequacy': total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids.	Fruits, vegetables, nuts and soy protein, ratio of white to red meat, cereal fibre, trans fat, polyunsaturated to saturated fat ratio, multivitamin use, alcohol intake.[4]	Graded dietary pattern that positively weighs plant foods and negatively weighs animal foods.	Whole grains, tubers or starchy vegetables, vegetables, fruits, dairy foods, protein sources, added fats, added sugars.[6]
Differentiating features	Inclusion of low-fat dairy; inclusion of legumes (eg, lentils); consideration of sodium and sugar-sweetened beverages.	Alcohol intake between 5 and 15 g/day receives better score than no intake or higher intake; promotion of olive oil.	Differentiation of total fruit and whole fruit; combination of 'greens and beans' as one component; inclusion of seafood with plant protein sources; inclusion of fat type based on unsaturated fat to saturated fat ratio; inclusion of added sugars.[3]	Alcohol intake of 1.5–2.5 servings/day in men and 0.5–1.5 servings/day in women receive better score than no intake or higher intake; inclusion of trans fat; multivitamin use.	Healthy plant food groups included whole grains, fruits, vegetables, nuts, legumes, vegetable oils and tea/coffee, whereas less healthy plant food groups included fruit juices, sugar-sweetened beverages, refined grains, potatoes and sweets/desserts. Animal food groups included animal fats, dairy, eggs, fish/seafood, meat (poultry and red meat) and miscellaneous animal-based foods.	Distinguishing tubers and starchy vegetables; groups for dark green vegetables, red and orange vegetables, and other vegetables; inclusion of whole milk or derivatives of whole milk; stating goal of macronutrient and micronutrient intake, caloric intake and emphasis on sustainability.[6]
	No components measuring alcohol intake, unsaturated to saturated fat ratio or multivitamin use.[9]	No dairy, sodium or sugar-sweetened beverage intake factored into score.[8]		No dairy, sodium or sugar-sweetened beverage intake factored into score; no legumes (eg, lentils).[4]		
Application to US South Asians	May be most appropriately applied to US South Asians due to emphasis on fruits, vegetables, legumes, whole grains and low-fat dairy.	May not be appropriate for US South Asians due to heavy emphasis on fish, olive oil and alcohol intake; designed to apply to populations from the Mediterranean.	Can be applied to US South Asians, but may result in lower scoring due to no differentiating component for nuts and legumes, no red/processed meat score.	Can be applied to US South Asians, but may result in artificially lower score due to emphasis on alcohol intake and no inclusion of dairy intake or legume intake.	Can be applied to US South Asians and adds depth compared with vegetarian classification systems by focusing on the quality of plant-based foods.	Can be applied to US South Asians, but emphasis on environmental sustainability may limit access for some groups, depending on both physical and socioeconomic access.[10]
Scoring system	Dietary Approaches to Stop Hypertension.	South Asian Mediterranean.	Healthy Eating Index.	Alternate Healthy Eating Index.	Plant-based diet index, healthy plant-based diet index, unhealthy plant-based diet index.	Planetary Health Diet Index.

AHEI, Alternate Healthy Eating Index; DASH, Dietary Approaches to Stop Hypertension.

able to incorporate both traditional food items, such as daal (lentils) and raita (yoghurt with vegetables), while including American food influences, including down scoring for processed food intake high in sodium and sugar-sweetened beverages.[7] While the dietary pattern is not overtly designed to quantify South Asian food intake, it allows for flexible inclusion of a large breadth of food items that may be consumed by a largely immigrant population group that is at various stages of acculturating to practices and behaviours in the USA.[8]

Hussain *et al* characterised concordance with the DASH dietary pattern as quantified using the Fung *et al*'s population-based DASH diet score among MASALA participants[9] (online supplemental table 1). Participants with more behavioural risk factors for cardiovascular disease had lower overall DASH diet score and were less likely to be in the highest DASH diet score category (Hussain *et al*, in preparation). Higher adherence to the DASH diet was associated with lower risk of developing hypertension after 5 years of follow-up (adjusted relative risk 0.33, 95% CI 0.13 to 0.85, p=0.02).[9] Results from this work support the use of DASH among South Asians in the USA, and future studies could consider specific interventions that emphasise a DASH-style diet inclusive of culturally relevant foods to promote adoption South Asian adults in the USA.

Mediterranean-style diet

The Mediterranean-style diet pattern is largely defined by high olive oil and fish intake characteristic of food locally available to residents of the Mediterranean, potentially limiting external exchangeability depending on local availability of ingredients and culturally appropriate practices.[10] The diet emphasises moderate intake of alcohol, mainly polyphenol-rich alcohol such as red wine. The relationship between alcohol intake and cardiovascular disease has been largely debated with conflicting findings, particularly among racially and ethnically diverse population groups.[11 12] Moreover, the Mediterranean-style diet does not measure dairy intake, which research indicates may have a positive effect on cardiometabolic outcomes,[13] particularly among South

Table 2 2021 American Heart Association (AHA) recommendations and dietary intake for select foods and nutrients among MASALA participants

Recommendation	Dietary intake measure	Women, n=409, mean (SD)	Men, n=476, mean (SD)
Adjust energy intake and expenditure to achieve and maintain a healthy body weight.	Average total calories consumed, kcal/day*	1571.1 (437.4)	1739.1 (523.6)
Eat plenty of fruits and vegetables, choose a wide variety.	Total fruits, servings/day	2.1 (1.3)	1.9 (1.3)
	Total vegetables, servings/day	4.3 (2.3)	3.8 (2.3)
Choose foods made mostly with whole grains rather than refined grains.	Whole grains, servings/day	1.8 (0.9)	2.0 (1.1)
Choose healthy sources of protein.			
a. Mostly protein from plants (legumes and nuts).	Legumes, servings/week	14.4 (6.9)	13.7 (8.0)
b. Fish and seafood.	Fish and shellfish, servings/week	0.77 (1.61); median 0 (IQR 0, 1.0)	1.02 (1.61); median 0.35 (IQR 0, 1.46)
c. Low-fat or fat-free dairy products instead of full-fat dairy products.	Dairy, servings/week	9.0 (8.0)	7.7 (7.3)
d. If meat or poultry are desired, choose lean cuts and avoid processed forms.	Red and processed meat, servings/week	0.8 (1.9)	1.4 (2.4)
Choose minimally processed foods instead of ultraprocessed foods.*			
Minimise intake of beverages and foods with added sugars.	Sugar-sweetened beverages, servings/week	2.3 (3.8)	3.4 (4.2)
Choose and prepare foods with little or no salt.	Sodium, g/day	2.6 (0.97)	2.7 (0.97)
If you do not drink alcohol, do not start; if you choose to drink alcohol, limit intake.	<1 serving/week, n (%)	340 (81.3)	261 (54.8)
Adhere to this guidance regardless of where food is prepared or consumed.*			

*Servings are defined as follows: whole grains, 1 oz equivalents; fruits and vegetables, 1/2 cup equivalents; legumes, 1/2 cup; fish/ shellfish, 3.5 oz or 100 g; nuts and seeds, 1 oz; processed meat, 3.5 oz or 100 g; sugar-sweetened beverages (SSBs), 8 fl oz; sweets and bakery desserts, 50 g. The food frequency questionnaire did not provide a measure of processed food intake or location of meal preparation/consumption.
MASALA, Mediators of Atherosclerosis in South Asians Living in America.

Asians.[14] The Mediterranean-style diet is also inaccessible to many people in the USA due to cost and availability. The Mediterranean-style diet may not be the most appropriate dietary pattern when studying cardiovascular outcomes among population groups that are not related to the Mediterranean region, particularly when working to establish recommendations that are culturally appropriate to diverse population groups.

Rai *et al* combined ethnic-specific foods for South Asians as well as foods commonly associated with the Mediterranean diet to develop a South Asian Mediterranean (SAM) diet score (online supplemental table 1).[15] At baseline, higher adherence to the SAM diet was associated with lower glycated haemoglobin (−0.4%±0.2% per 1-unit increase in SAM score, p=0.004) and lower pericardial fat volume (1.2±0.6 cm^3, p=0.03) after controlling for confounders (online supplemental table 1). In prospective analyses including 5 years of follow-up, each 1-unit increase in SAM score was associated with a 25% lower odds of incident type 2 diabetes (OR 0.75, 95% CI 0.59 to 0.95) after controlling for confounders (online supplemental table 1) .

Healthy Eating Index

The HEI is a measure of overall diet quality, independent of quantity, that can be used to assess alignment with the Dietary Guidelines for Americans.[16] It was first released in 1995,[17] and was last updated to reflect the 2020–2025 guidelines.[18] The HEI has since been updated to reflect changes in the Dietary Guidelines for Americans,[19] and large epidemiological studies in the USA, such as the Atherosclerotic Risk in Communities, have demonstrated that adherence to the HEI-2015 was associated with reduced cardiovascular morbidity and mortality.[20 21] The HEI has not been studied among South Asian adults. Future analyses may be conducted, but data on added sugar may be limited. Additionally, the scoring may not adequately emphasise or reflect the robust legume intake among the MASALA participants, and the HEI-2015 score includes red and processed meat in the protein scoring, which may bias the scoring results among a cohort that consumes little to no meat.[19 20]

Alternative HEI

In 2002, the AHEI revised the HEI and was found to better predict cardiovascular disease morbidity and mortality risk within the Nurses' Health Study.[22] Similar to the Mediterranean-style diet, the AHEI provides improved scoring for alcohol intake, assigning the lowest (poor) score to individuals reporting no alcohol intake.[23] The score does not account for dairy or legume intake, which are rich sources of various vitamins, minerals and fibre and common in culturally diverse dietary patterns. The AHEI has previously been studied in the MASALA cohort.[24]

Rodriguez *et al* [24] compared the AHEI in South Asian participants in the MASALA cohort to Chinese American, white, Hispanic and African American participants in the Multi-Ethnic Study of Atherosclerosis (MESA) cohort. South Asians consumed greater amounts of vegetables, fruits, whole grains, nuts and legumes but fewer amounts of sugary beverages, red meat and trans fatty acids compared with MESA participants. South Asians living in the USA also had lower omega-3 fatty acids and polyunsaturated fatty acid consumption levels. Interestingly, immigrants consistently had 3–7 points higher mean AHEI-2010 compared with US-born individuals.

Plant-based indices

Researchers within the Nurses' Health Study created three indices to characterise the role of plant-based foods in dietary patterns.[25] To derive the overall plant-based diet index (PDI), plant foods received positive scores, while animal foods (eg, animal fats, dairy, eggs, fish/seafood) received reverse scores. For the healthful plant-based diet index (hPDI), whole grains, legumes, fruits, vegetables and other healthy plant-based foods received positive scores, while less healthy plant foods (eg, refined grains, sweets/desserts) and animal foods received reverse scores. Lastly, the authors created an unhealthful plant-based diet index (uPDI) by assigning positive scores to less healthy plant foods and reverse scores to healthy plant foods and animal foods.

Bhupathiraju *et al* derived the three plant-based diet indices within the MASALA cohort and investigated baseline and longitudinal associations with cardiometabolic risk.[26] At baseline, the authors observed inverse associations between PDI and hPDI scores and homeostasis model assessment of insulin resistance, low-density lipoprotein cholesterol, weight and body mass index after accounting for confounders (online supplemental table 1) (all p<0.05). Higher scores on the hPDI, but not PDI, were associated with lower glycated haemoglobin, higher adiponectin, a smaller visceral fat area and a smaller pericardial fat volume. Each 5-unit higher hPDI score was associated with lower likelihood of fatty liver (OR 0.76, 95% CI 0.64, 0.90) and obesity after accounting for confounders (online supplemental table 1) (OR 0.88, 95% CI 0.80, 0.97). There were no associations between uPDI scores and cardiometabolic risks.

Planetary Health Diet Index

The EAT-Lancet Commission on healthy diets from sustainable food systems was assembled to create global targets that align with environmentally sustainable and human health goals set forth from the United Nation's Sustainable Development Goals and the Paris Agreement.[3] These food recommendations were designed to closely consider the planetary health and environmental impact of foods and food systems alongside supporting nutrient density and intake. The EAT-Lancet dietary pattern was designed in response to a call for dietary patterns that concurrently prioritise *both* planetary and human health.[3]

The diet draws a distinction away from calories and energy density, towards nutrient density that is able to address both micronutrient deficiencies and risk for chronic disease associated with inadequate nutrient intake, despite excessive energy consumption.[3] The Planetary Health Diet Index developed a quantitative scoring methodology that measures individual intake and its level of consistency with the EAT-Lancet goals.[27] The score has 16 components with a theoretical score ranging from 0 to 150 points.[27] The Planetary Health Diet Index was derived as a quantitative measure of the EAT-Lancet guidance.[26] Ongoing research within the MASALA cohort is using the Planetary Health Diet Index to apply the EAT-Lancet diet to US South Asians.

DIETARY INTAKE FOR SELECT FOODS AND NUTRIENTS HIGHLIGHTED IN THE 2021 AHA RECOMMENDATIONS

Table 2 summarises sex-specific average intake of dietary parameters that were highlighted as part of the 2021 AHA recommendations.[2] On average, MASALA participants consume 2 (SD=1) servings of fruits, 4 (SD=2) servings of vegetables and 2 servings of whole grains daily. Intake of red/processed meat per week is low (0.8, SD=1.9 for women and 1.4, SD=2.4 for men). Fewer than half (45%) of men, and just 19% of women, consume at least one serving of alcohol weekly.

In summary, 14 manuscripts have been published that focus on dietary intake or behaviours within the MASALA cohort, either descriptive or assessing associations with cardiometabolic risk and other outcomes. Half of these papers (n=7) were not included in this review because they did not involve score-based dietary patterns.[14 28–34] Given the concordance of findings with diet patterns examined in other racial/ethnic groups, the role of evaluation in South Asians is to determine which culturally appropriate/traditional foods are important to assess and consume within this population. Future research should focus on developing culturally appropriate dietary recommendations and increasing accessibility to foods that align with these recommendations to improve the prevention, treatment and management of cardiovascular disease among South Asians in the USA.

Author affiliations
[1]New York University, New York, NY, USA
[2]NYU Grossman School of Medicine, New York, NY, USA
[3]Fairfield University, Fairfield, CT, USA
[4]University of California San Francisco, San Francisco, CA, USA
[5]Milken Institute School of Public Health, George Washington University, Washington, DC, USA
[6]Harvard Medical School and Brigham and Women's Hospital, Boston, MA, USA
[7]Harvard University T H Chan School of Public Health, Boston, MA, USA

Acknowledgements Neel Godbole helped with editing the proofs of this manuscript.

Contributors Project conceptualisation and design: JMB, AMK. Data summary: JMB, BMH. Drafting of the initial manuscript: JMB, BMH. Editing and review of the manuscript: JMB, BMH, MDG, SAT, NP, SNB, NSI, AMK.

Funding The MASALA project was supported by R01HL093009 and the National Center for Research Resources and the National Center for Advancing Translational Sciences, through the UCSF-CTSI Grant Number UI1 RR02413. Investigator effort was also supported by R01MD016071 and R01DK127916. The content is solely the responsibility of the authors and does not represent the offical views of the National Institutes of Health.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The MASALA study protocol has been approved by the Institutional Review Boards of NYU Langone Medical Center, Northwestern University and the University of California, San Francisco (s21-01018). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The MASALA study has data sharing protocols in place, as fully described here: https://www.masalastudy.org/for-researchers.

ORCID iD
Jeannette M Beasley http://orcid.org/0000-0002-9343-6895

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