What is a Dietary Pattern?

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Conflict of Interest disclosures

- None

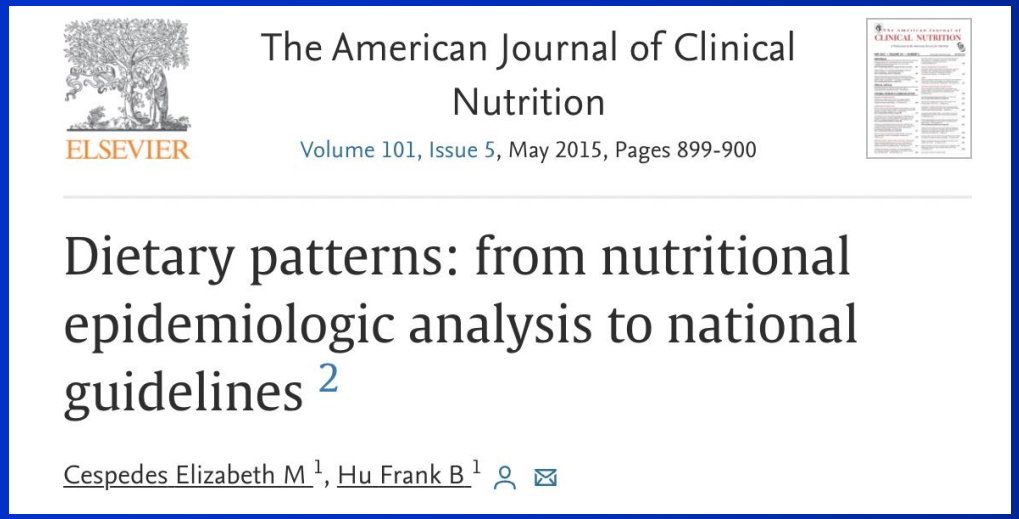
Dietary Pattern Analysis: A New Direction in Nutritional Epidemiology

Frank B. Hu

Current Opinion in Lipidology 2002; 13:3-9

- **Difficult to attribute effects to single dietary components**
- **Dietary patterns account for complicated interactions and cumulative effects**
- **Dietary patterns are more realistic representations of dietary intake in real life and can be better translated into guidelines**

What is a dietary pattern?



The American Journal of Clinical Nutrition

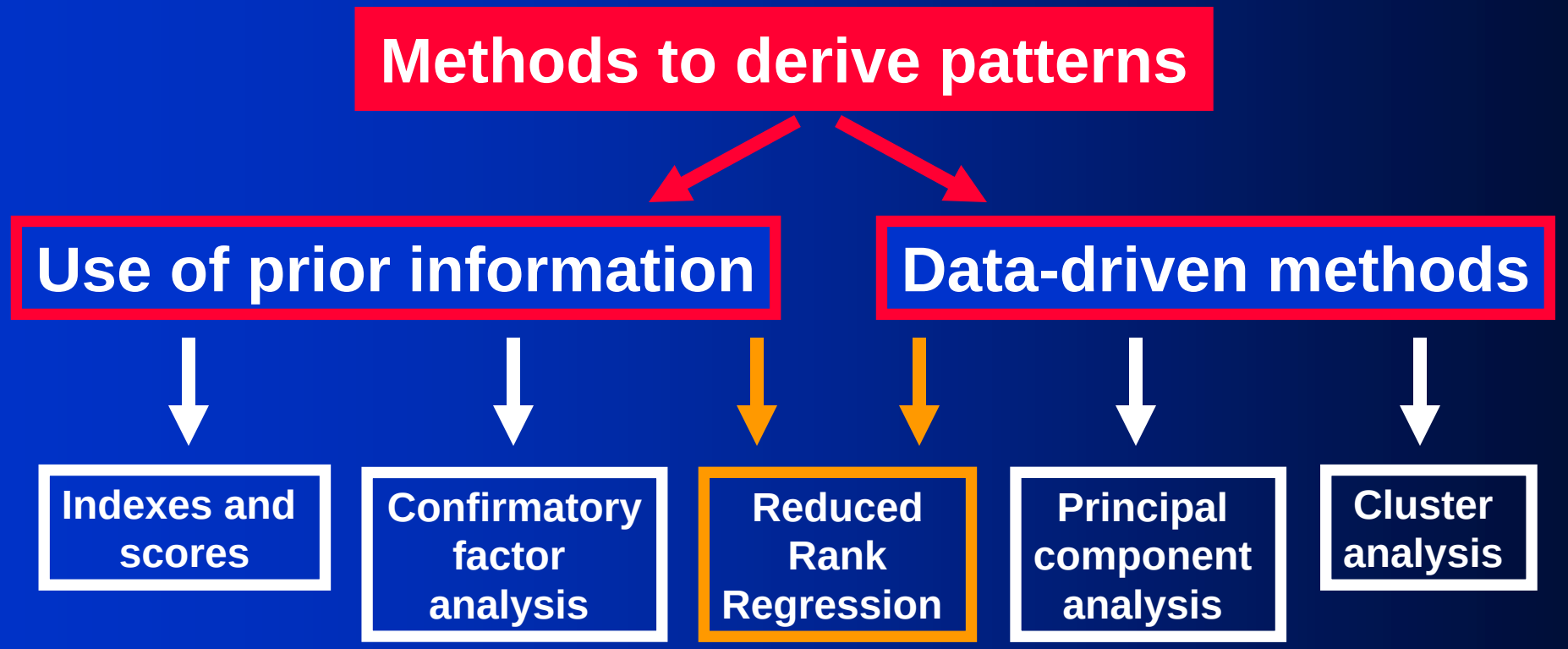
Volume 101, Issue 5, May 2015, Pages 899-900

Dietary patterns: from nutritional epidemiologic analysis to national guidelines [2]

Cespedes Elizabeth M [1], Hu Frank B [1]

A dietary pattern describes the overall diet; the foods, food groups, and nutrients included; their combination and variety; and the frequency and quantity with which they are habitually consumed.

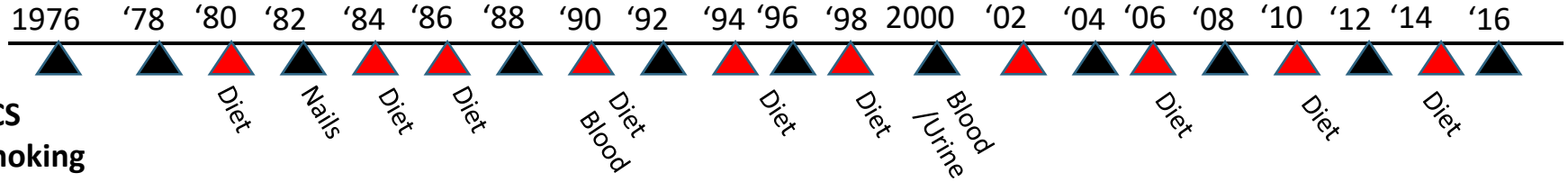
Dietary Pattern Methods



Popular diets: Keto, intermittent fasting, gluten-free

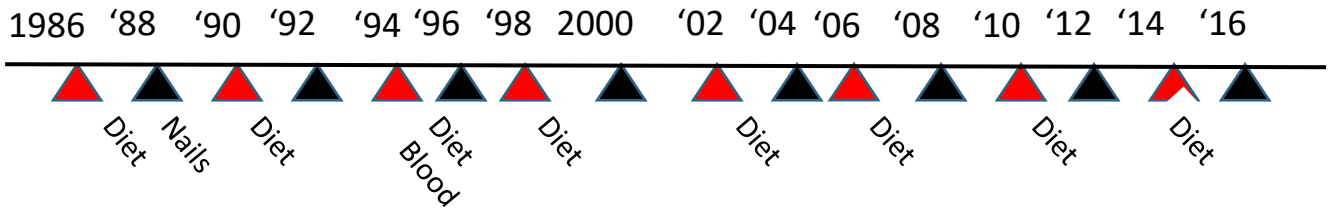
Traditional eating patterns

Nurses' Health Study (n=121,700)

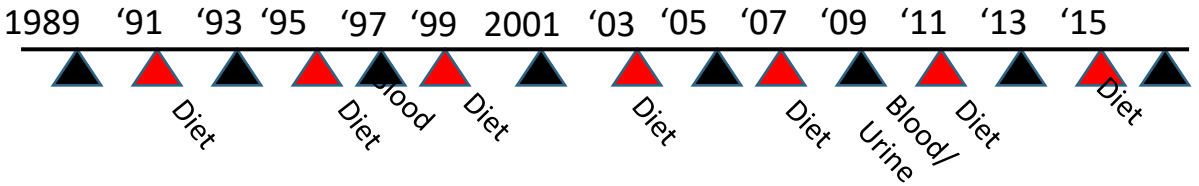


OCS
Smoking
Weight/Ht
Med Hx

Health Professionals Follow-up Study (n=52,000)



Nurses' Health Study II (n=116,000)



Biorepository: Blood, DNA, urine, stool, saliva, toenails, tumor tissues

Investigators: Frank Speizer, Bernie Rosner, Meir Stampfer, Graham Colditz, David Hunter, JoAnn Manson, Sue Hankinson, Eric Rimm, Edward Giovannucci, Alberto Ascherio, Gary Curhan, Charles Fuchs, Fran Grodstein, Michelle Holmes, Donna Spiegelman, Frank Hu, Heather Eliassen, Lorelei Mucci, Walter Willett

Dietary patterns

37 food groups

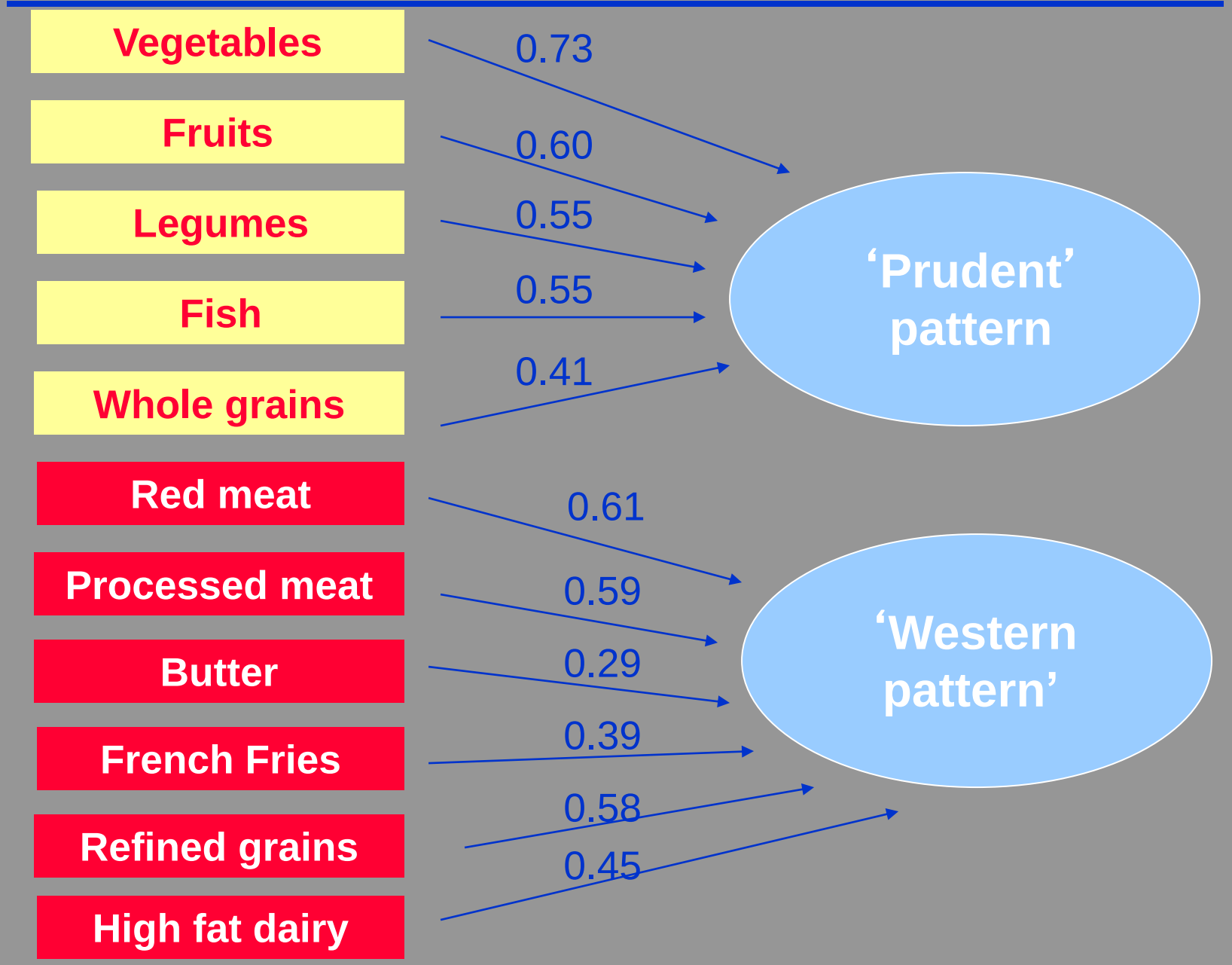
Processed meats
Red meats
Organ meats
Fish and other seafood
Poultry
Eggs
Butter
Margarine
Olive oil
Low-fat dairy products
High-fat dairy products
Liquor
Wine
Beer
Tea
Coffee
Fruit
Fruit juices
Cruciferous vegetables
Dark-yellow vegetables
Tomatoes
Green, leafy vegetables
Legumes
Other vegetables
Potatoes
French fries
Whole grains
Refined grains
Pizza snacks
Nuts
Sugar beverages
Diet beverages
Salad dressing
Mayonnaise, creamy dressings
Cream soup
Other soup
Sweets and desserts
Condiments

Principal component analysis →

‘Prudent’ pattern

‘Western’ pattern

Factor loadings for main foods in each pattern



Diet Quality Indices

Mediterranean diet index

Healthy eating index (HEI)

Alternate HEI (AHEI)

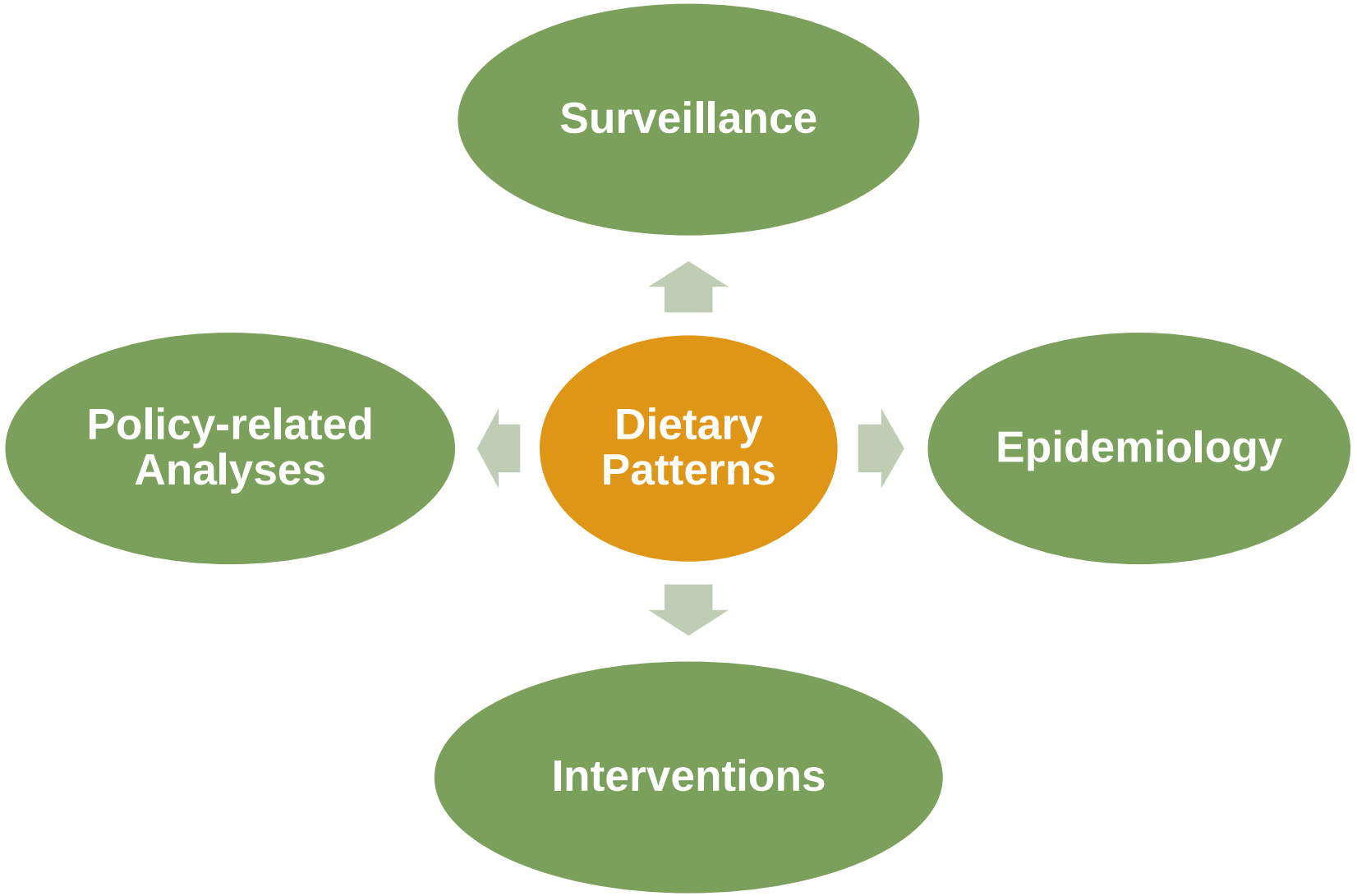
Low carbohydrate diet index

DASH index

Plant-based diet indices

MIND diet

Planetary Health Diet



Susan M Krebs-Smith

Dietary Quality Assessment: The Alternate Healthy Eating Index (AHEI)-2010

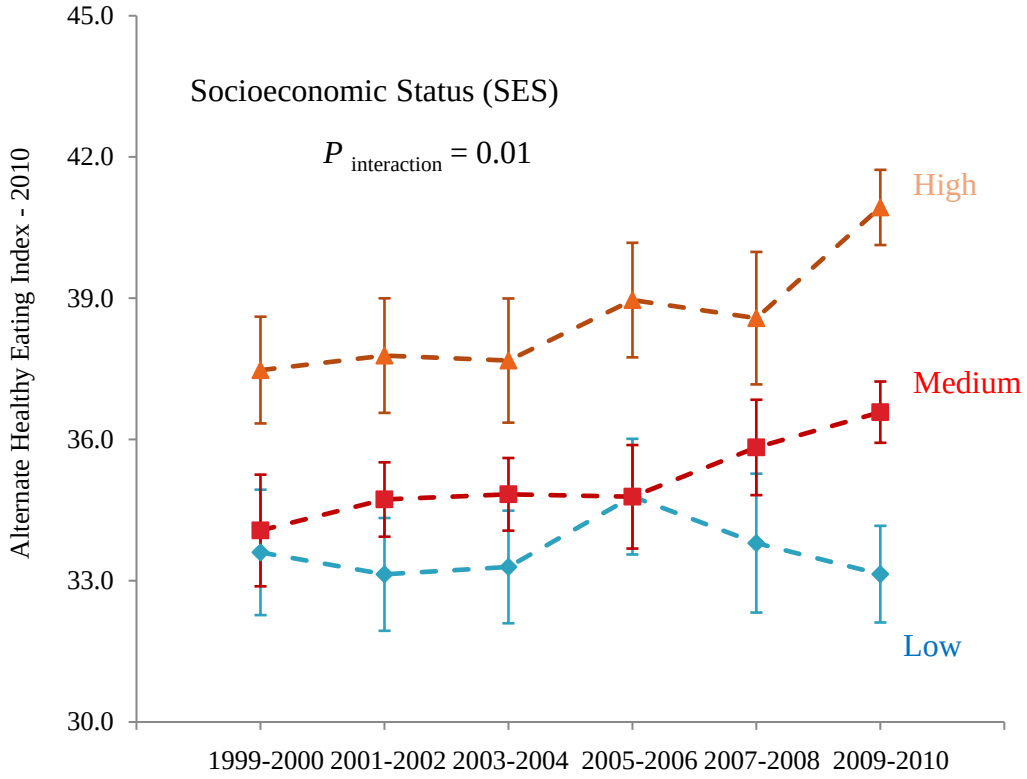
- A validated,11-dimension dietary quality score
- Food groups and nutrients consistently associated with chronic disease risk
- Every component scored from 0 (worst) to 10 (best)
- Total score ranged from 0 (non-adherence) to 110 (perfect adherence)

- Higher score, Higher intake:
  1. *Vegetables (excluding potatoes and juices)*
  2. *Fruits (excluding juices)*
  3. *Whole grains*
  4. *Nuts and legumes*
  5. *Long-chain (n-3) fats (EPA + DHA)*
  6. *Polyunsaturated fat (PUFA)*
  7. *Moderate alcohol*

- Higher score, Lower intake:
  7. *Sugar-sweetened beverage and fruit juices*
  8. *Red/processed meat*
  9. *trans fat*
  10. *Sodium*

Chiuve SE, et al. J Nutr 2012.
McCullough, ML, et al. Am J Clin Nutr 2002

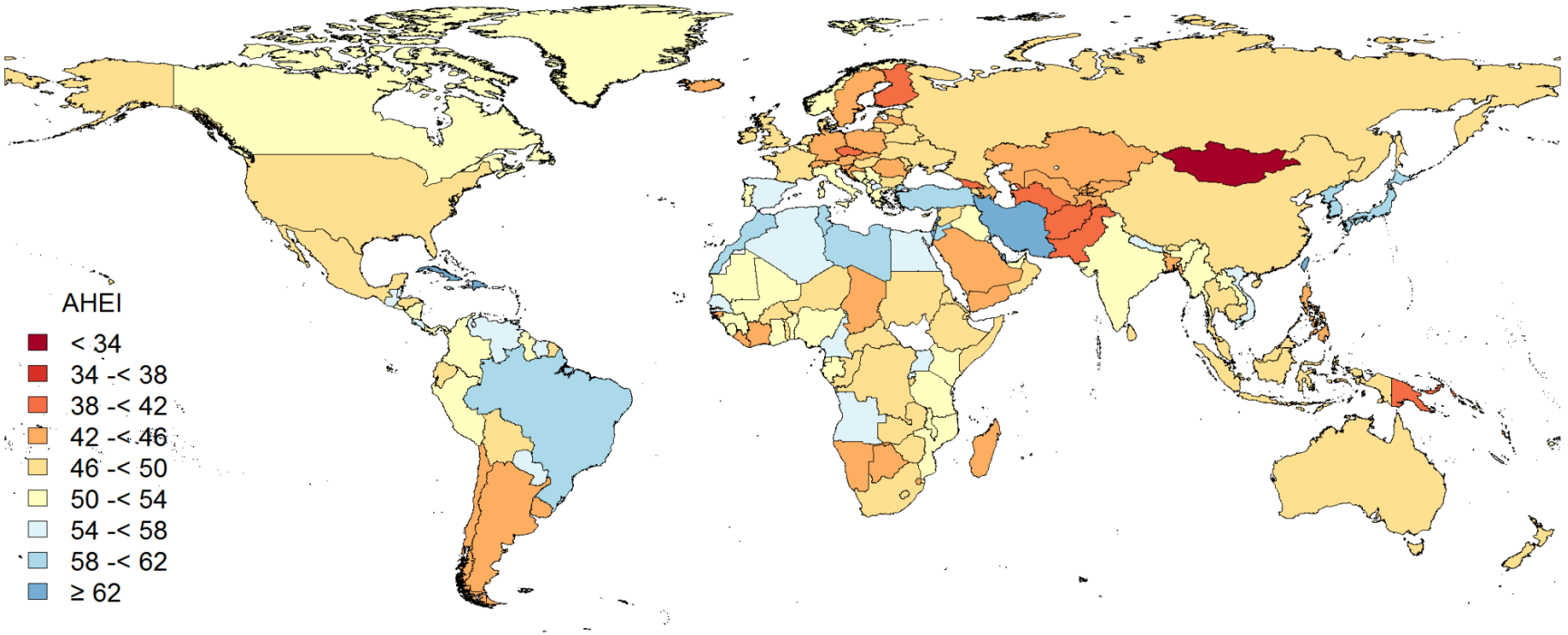
Time trends of AHEI according to SES in NHANES



- High SES: improvement in dietary quality accelerated over time
- Low SES: No significant improvement
- The gaps between high and low SES groups significantly widened: 3.5 in 1999-2000; 6.1 in 2009-2010

Wang et al. Health Aff (Millwood). 2015

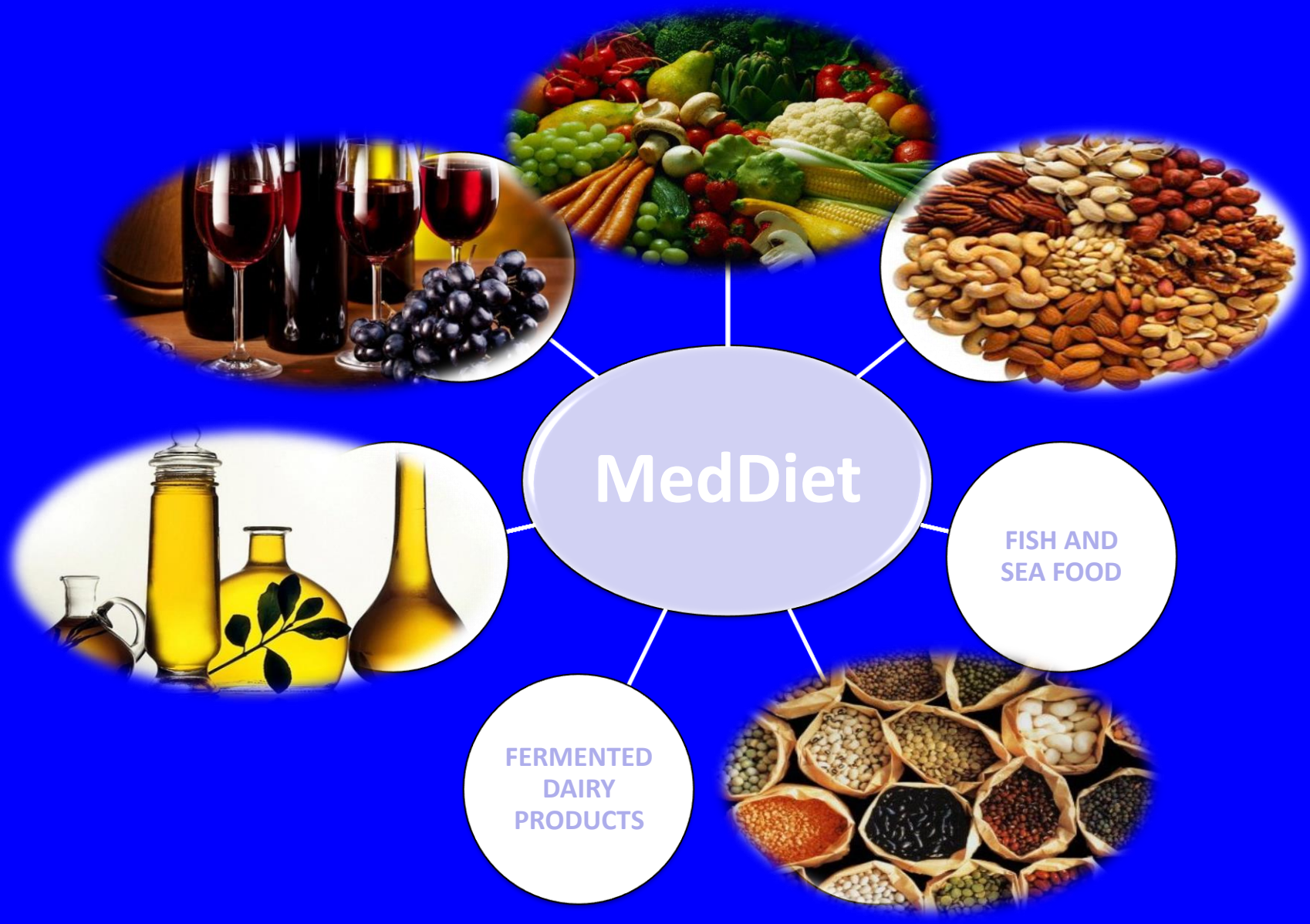
Global Diet Quality Map (2017)



Coastal Mediterranean nations, the Caribbean region, and Eastern Asia (except China and Mongolia) had a higher AHEI score, whereas Central Asia, the South Pacific, and Eastern and Northern Europe had a lower score.

J of Nutrition, 2019

Components of the Mediterranean Diet high in plant-based foods



Mediterranean diet and chronic disease prevention

- The evidence to support health benefits of Mediterranean dietary pattern is strong
- There is no single Mediterranean diet because the Mediterranean region encompasses diverse food cultures and culinary techniques and styles.
- The core principles of the Mediterranean diet can be found in other populations such as traditional Asian and Latin American diets
- Adaption of these core principles to an individual's own food preferences, health conditions, and cultural traditions

JAMA Internal Medicine | Original Investigation

Healthy Eating Patterns and Risk of Total and Cause-Specific Mortality

Zhilei Shan, MD, PhD; Fenglei Wang, PhD; Yanping Li, MD, PhD; Megu Y. Baden, MD, PhD; Shilpa N. Bhupathiraju, PhD; Dong D. Wang, MD, ScD; Qi Sun, MD, ScD; Kathryn M. Rexrode, MD, MPH; Eric B. Rimm, ScD; Lu Qi, MD, PhD; Fred K. Tabung, PhD; Edward L. Giovannucci, PhD; Walter C. Willett, MD, DrPH; JoAnn E. Manson, MD, DrPH; Qibin Qi, PhD; Frank B. Hu, MD, PhD

- A comparative analysis of four eating patterns:
  - HEI-2015: Dietary Guidelines for Americans (2015)
  - Mediterranean diet
  - Healthy plant-based diet
  - AHEI: Harvard Healthy Eating Plate

- Greater adherence to any of the four patterns is associated with 20% lower mortality
- Healthy eating patterns not only reduce CVD and cancer mortality but also mortality due to neurological and respiratory diseases
- These patterns can be tailored to individual food and cultural preferences and health conditions

Annals of Internal Medicine®

Search Journal

LATEST ISSUES IN THE CLINIC JOURNAL CLUB MULTIMEDIA CME / MOC AUTHORS / SUBMIT

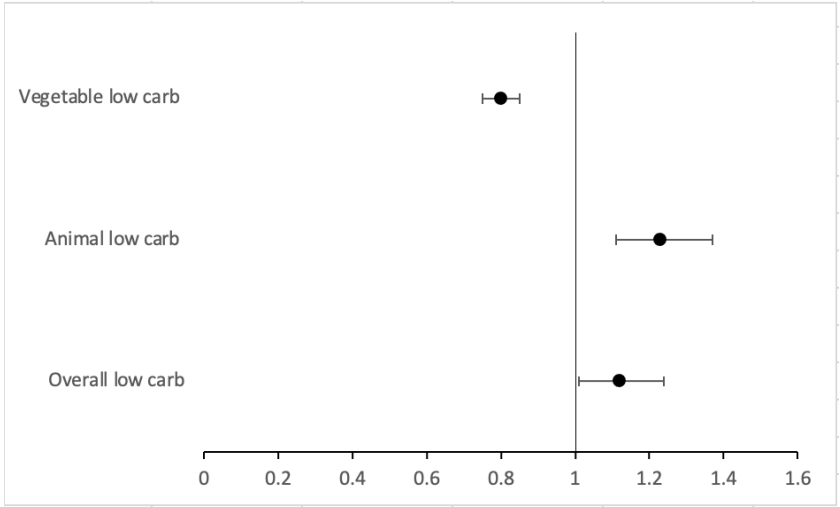
Articles | 7 September 2010

Low-Carbohydrate Diets and All-Cause and Cause-Specific Mortality

Two Cohort Studies

Teresa T. Fung, ScD, Rob M. van Dam, PhD, Susan E. Hankinson, ScD, Meir Stampfer, MD, DrPH, Walter C. Willett, MD, DrPH, and Frank B. Hu, MD, PhD View fewer authors

Author, Article, and Disclosure Information

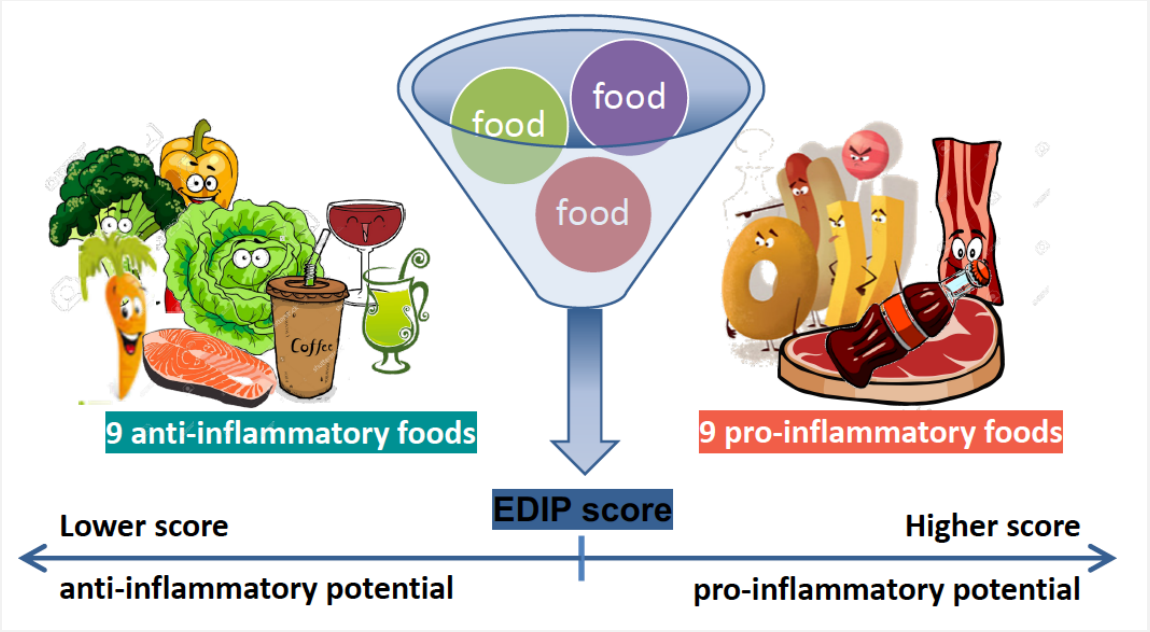


The Empirical Dietary Inflammatory Pattern (EDIP)

Development

Fred K Tabung, et. al., JN, 2016

- We used reduced rank regression + stepwise linear regression
- To regress 3 biomarkers (CRP, IL6, & TNFa-R2) on 39 pre-defined food groups
- 18 food groups (9 pro-inflammatory and 9 anti-inflammatory) were selected



Validation

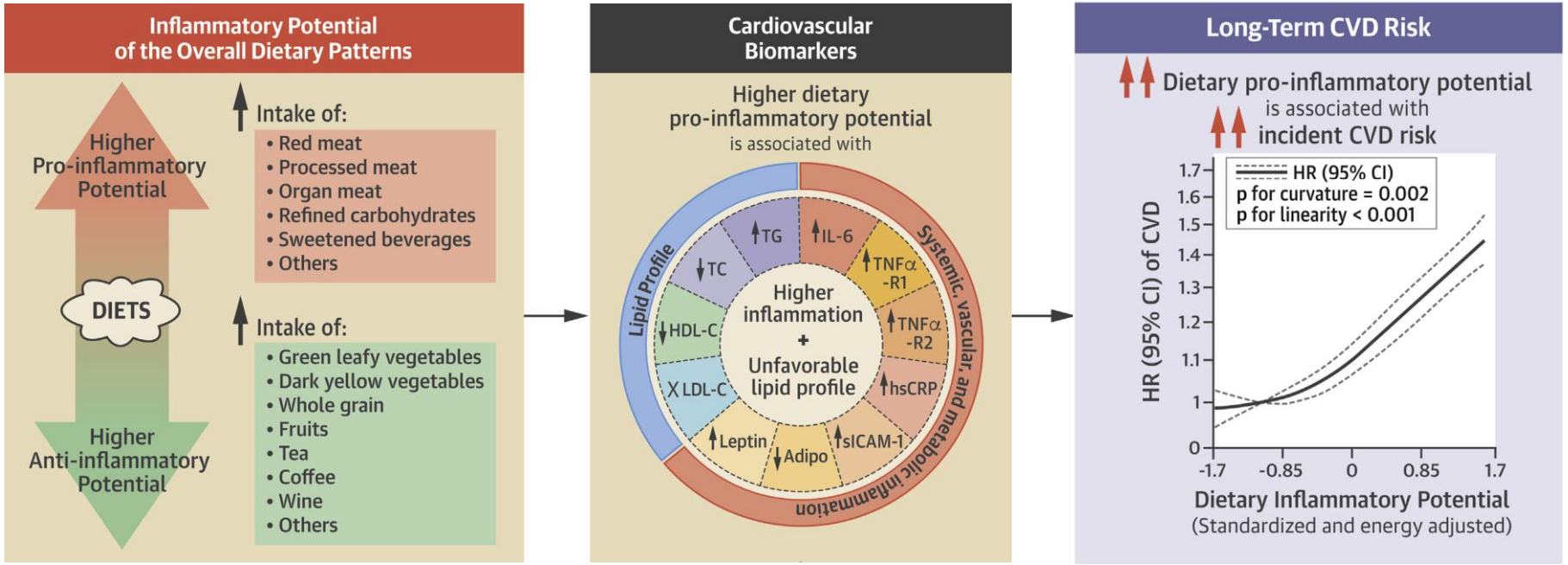
Fred K Tabung, et. al. JN, 2017
Fred K Tabung, et. al., JN, 2018
Jun Li, et al., JACC, 2020

- EDIP shows strong associations with levels of inflammatory biomarkers in multiple large population cohorts

In 3 large US prospective observational cohorts

(210,145 participants, 15,837 incident CVD cases during up to 32 years of follow-up),

higher dietary pro-inflammatory potential (assessed by EDIP) is associated with higher CVD risk



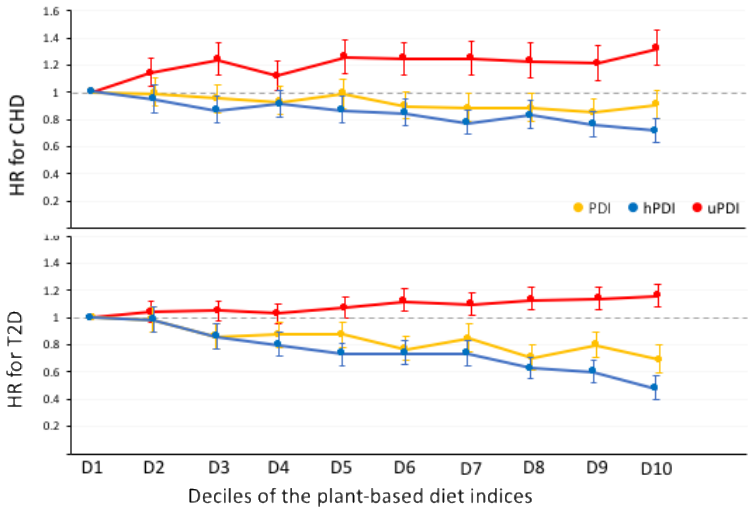
Li, J. et al. J Am Coll Cardiol. 2020

Plant-based diets vs. “vegetarian” diets

Foods excluded in different types of dietary patterns

	RED MEAT & POULTRY	FISH & SEAFOOD	EGGS	DAIRY
NON-VEGETARIAN				
PESCO-VEGETARIAN	⊘			
LACTO-OVO-VEGETARIAN	⊘	⊘		
LACTO-VEGETARIAN	⊘	⊘	⊘	
VEGAN	⊘	⊘	⊘	⊘

Not all plant-based diets are healthy



Satija et al, J Am Coll Cardiol 2017
Satija et al. PLoS Medicine 2016

- Healthy plant-based diets rich in whole grains, fruits/vegetables, nuts/legumes, oils, coffee/tea are associated with lower T2D, CVD, and mortality risk
- Unhealthy plant-based diets high in sweetened beverages, refined grains, potatoes/fries, sweets are associated with increased risk of chronic diseases and mortality – worse than animal food-based diets
- These findings underscore the quality of plant foods in our diet

Global Diet Quality Score

October 2021 • Volume 151 • Number 10S

JN
THE JOURNAL OF NUTRITION
A Publication of the American Society for Nutrition • https://academic.oup.com/jn

The Global Diet Quality Score (GDQS): A New Method to Collect and Analyze Population-Based Data on Diet Quality

Supplement Coordinators/Guest editors:
Megan Deitchler, PhD
Intake – Center for Dietary Assessment, FHI Solutions
and
Sabri Bromage, ScD
Harvard T.H. Chan School of Public Health

Photo credit: Anatta Tan / Shutterstock

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intake | HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH Department of Nutrition | Instituto Nacional de Salud Pública

The Global Diet Quality Score: Data Collection Options and Tabulation Guidelines

April 2021

Introduction

Poor quality diets are associated with adverse health outcomes related to both undernutrition and overnutrition and are a leading cause of disease globally (Global Burden of Disease [GBD] 2016). Yet, until recently, we have lacked a standard, relatively simple, and validated method for routinely measuring diet quality[1] in population-based surveys across contexts (Miller et al. 2020), and therefore have lacked a means by which to assess and track this critical dimension of health and well-being.

In 2018, *Intake* – Center for Dietary Assessment launched a 2-year research initiative[2] to support a consortium of researchers at the Harvard T.H. Chan School of Public Health Department of Nutrition and the National Public Health Institute (INSP), Mexico, to develop and validate metrics of diet quality that would be appropriate for collection through routine population-based surveys and that would be fit for purpose for inclusion in global monitoring frameworks.

The work entailed constructing a set of candidate food group-based metrics that account for the quantity of consumption in the scoring method. Secondary food frequency questionnaire (FFQ) and quantitative 24-hour dietary recall datasets across different regions of the world were analyzed over the course of the 2-year research initiative to examine the association of each candidate metric with a range of diet quality outcomes related to nutrient adequacy and noncommunicable disease (NCD) risk. The inclusion of two cohort datasets in the analyses (one from Mexico and one from the United States) allowed for the evaluation of the responsiveness of outcomes to changes in metric score over time and provided a rigorous design for examining the association of the candidate diet quality metrics developed with NCD risk-related outcomes.

From these analyses, an overall metric of diet quality — the Global Diet Quality Score (GDQS) — was identified. The GDQS was designed to be appropriate for use among non-pregnant, non-lactating women of reproductive age in low- and middle-income countries (LMICs) but has also been shown through secondary data analysis to be valid for use in high-income countries, thereby providing a simple, standardized metric appropriate for population-based measurement of diet quality globally.[3]

Measuring Diet Quality

Dimensions of a high-quality diet

- Provides nutrient adequacy
- Limits noncommunicable disease (NCD) risk

Challenges in measuring diet quality

- Lack of global standard metrics
- Global variation in diet patterns and food systems
- Global variation in burdens of malnutrition

Characteristics of existing diet quality metrics

- Focus on specific dimensions of diet quality or populations
- Overly complex or simplistic

Global Diet Quality Score

We developed a Global Diet Quality Score (GDQS) that is:

- Entirely food-based (no nutrients involved in scoring)
- Uses a modestly expanded food list relative to other metrics
- Incorporates a slightly more complex portion assessment

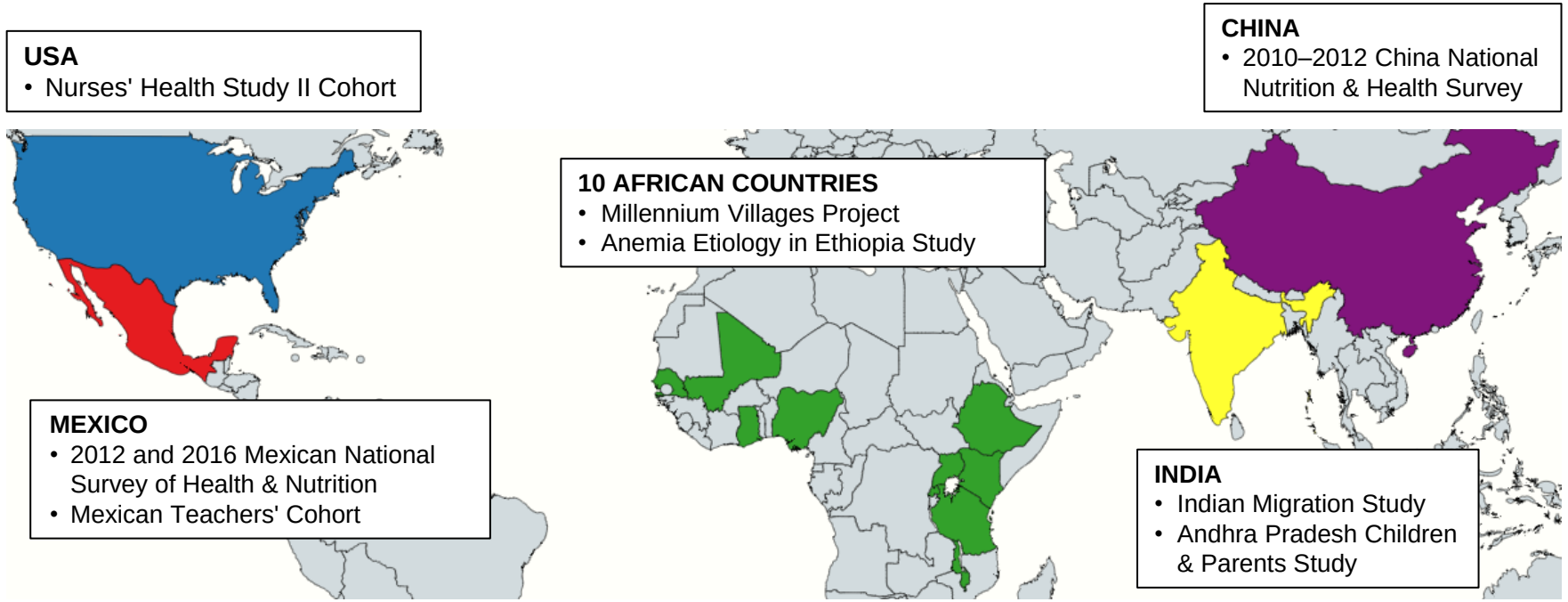
These features allow the GDQS to:

- Account for foods of nutritional importance globally
- Predict dimensions of both nutrient adequacy and NCD risk
- Avoid use of food composition data and keep things simple

GDQS Point Values

Food Group	Low	Moderate	High	
Legumes Nuts and seeds Dark green leafy vegetables	**0** points	**2** points	**4** points	
Deep orange fruits Citrus fruits Other fruits Whole grains Liquid oils Fish and shellfish Poultry and game meat Low fat dairy Eggs	**0** points	**1** point	**2** points	
Cruciferous vegetables Deep orange vegetables Other vegetables Deep orange tubers	**0** points	**0.25** points	**0.5** points	
High fat dairy	**0** points	**1** point	High: **2** points	Very high: **0** points
Red meat	**0** points	**1** point	**0** points	
Processed meat Refined grains and baked goods Sweets and ice cream Sugar-sweetened beverages Juice White roots and tubers Purchased deep fried foods	**2** points	**1** point	**0** points	

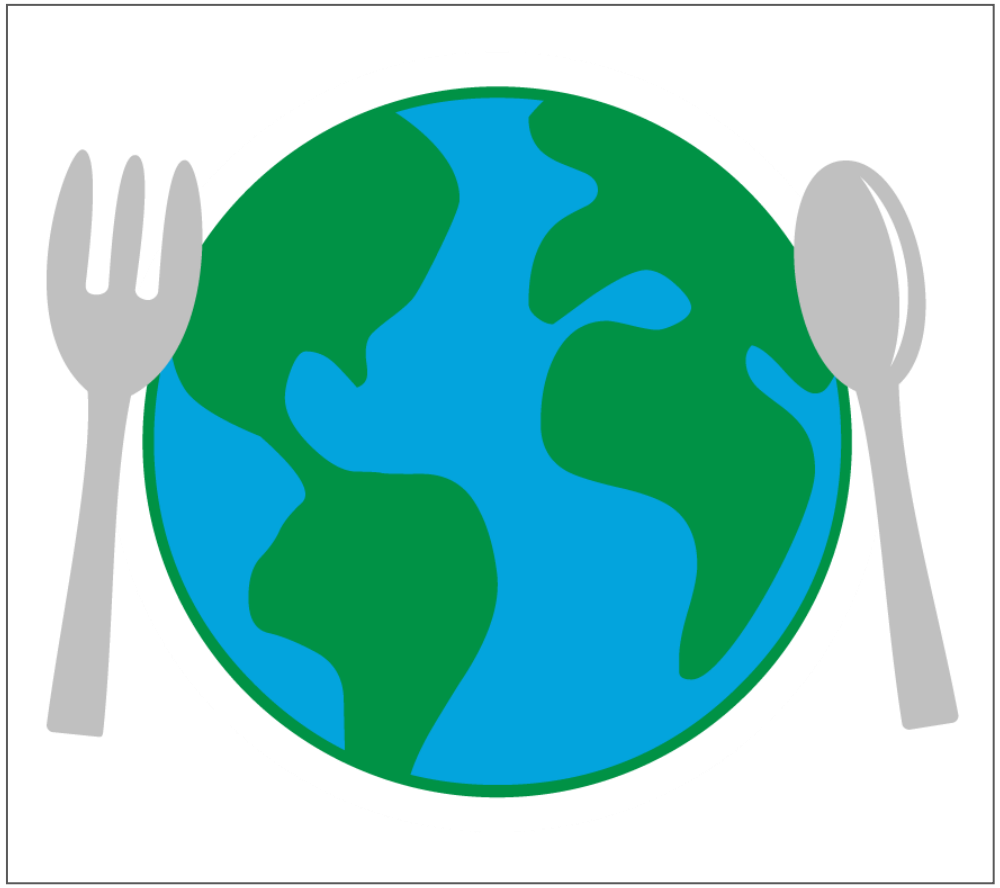
Datasets used to develop, evaluate, and refine metrics



Diet quality outcomes against which to evaluate metrics

- Nutrient intake: protein, fatty acids, fiber, 6 micronutrients (adjusted for total energy intake)
- Anthropometry: Body mass index, mid-upper arm circumference, waist circumference
- Biomarkers: Hemoglobin, ferritin, folate, vitamin B12, glucose, insulin, lipids, blood pressure
- Disease: Type 2 diabetes

Is a healthy diet for humans also beneficial for the health of the planet?



Health and environmental impacts of plant-rich dietary patterns: A U.S. prospective cohort study

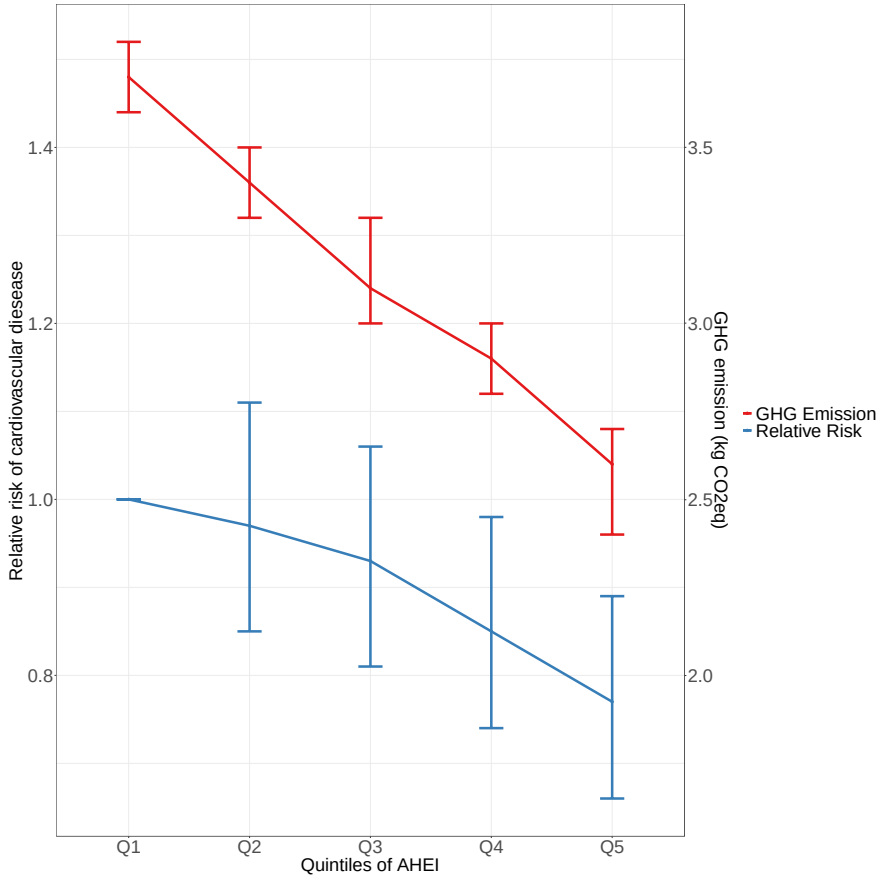
Higher score, Higher intake:

- Vegetables (excl. potatoes & juices)
- Fruits (excl. juices)
- Whole grains
- Nuts and legumes
- ϖ-3 fats (EPA + DHA)
- Polyunsaturated fat (PUFA)

Higher score, Lower intake:

- SSBs and juices
- Red/processed meat
- trans fat
- Sodium

Alcohol: J-shape scoring, moderate drinkers have the highest score



Musicus et al. Lancet Public Health 2022

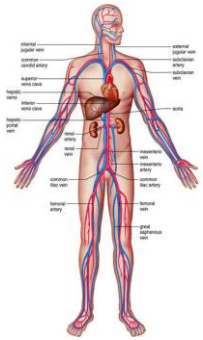
2015 DGAC Report: Dietary Patterns and Sustainability

- **Plant-based dietary pattern**
  - Vegetables, fruits, whole grains, legumes, nuts, and seeds
  - Less environmental impact than current average U.S. diet
  - U.S. population should eat more plant-based foods and less meat while decreasing total calories
    - Don’t need to go completely vegetarian
  - Example dietary patterns
    - Dietary-guidelines based
    - Healthy Vegetarian
    - Healthy Mediterranean-style
    - Dietary Approaches to Stop Hypertension (DASH)

Scientific Report of the 2015 Dietary Guidelines Advisory Committee. Part D. Chapter 5

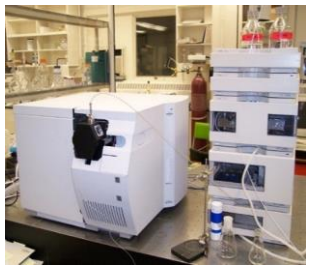
Metabolic Signatures of Dietary Patterns

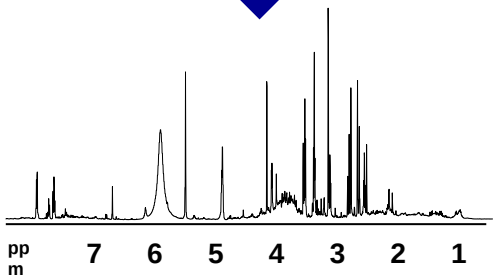
PREDIMED participants



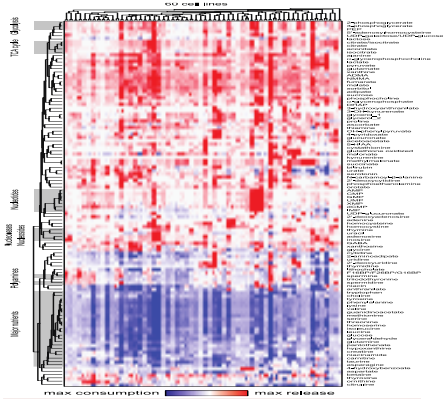
Plasma samples baseline, 1y

Analytical profiling: LC-MS/MS





Data processing & analysis



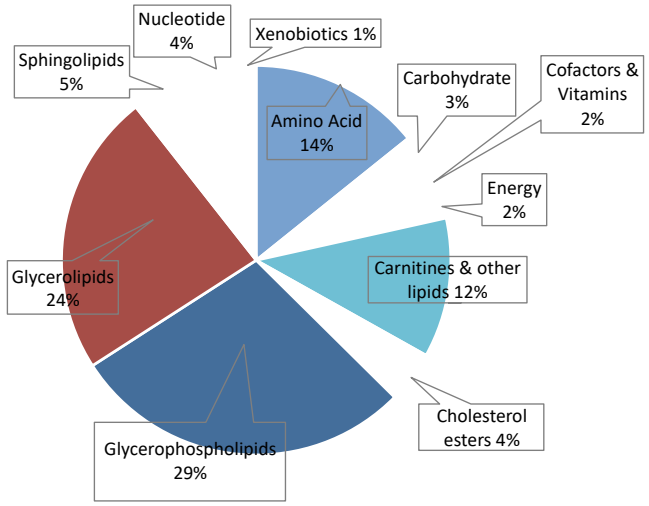
Statistical analysis

Metabolic Signatures of Adherence to Mediterranean Diet and CVD risk in Spanish and US populations

Metabolomic profiling

BROAD INSTITUTE

3 methods;
302 named metabolites
after quality control

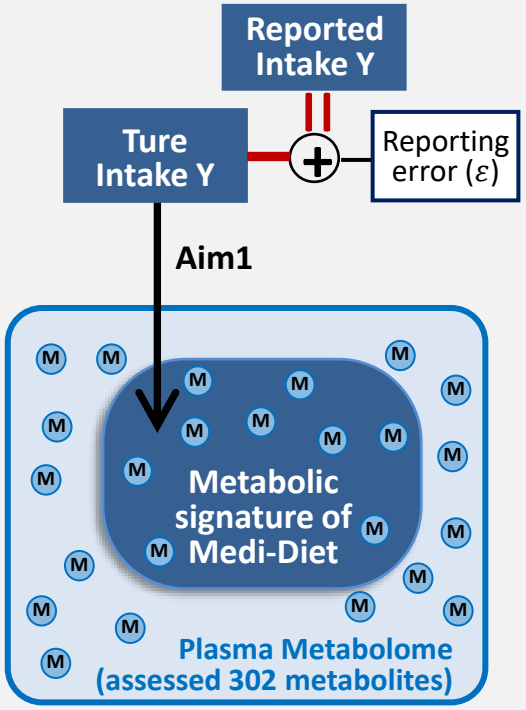


Medi-Diet adherence

A **14-item Mediterranean Diet Adherence Screener**
(MEDAS, range 0-14)

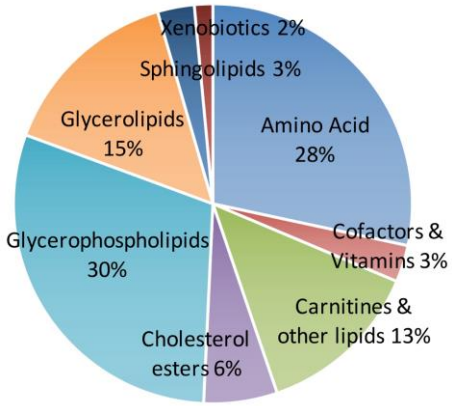
Dietary recommendations	Goals (yes-1, no-0)
Olive oil	as main culinary fat
Olive oil	≥4 tbsp/day
Nuts	≥3 servings/wk
Fresh fruits	≥3 servings/day
Vegetables	≥2 servings/day
Fish & Seafood	≥3 servings/wk
Legumes	≥3 servings/wk
Sofrito	≥2 servings/wk
White meat	Instead of red meat
Wine with meals	≥7 glasses/wk
Soda drinks	<1 drink/day
Commercial sweets	<2 servings/wk
Spread fats	<1 serving/day
Red/processed meats	<1 serving/day

Li J, et al, Eur Heart J. 2020

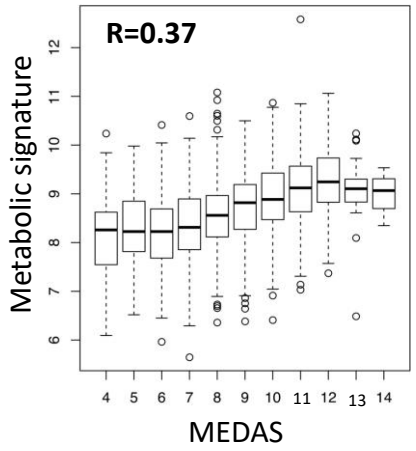


Metabolic signature of the MedDiet

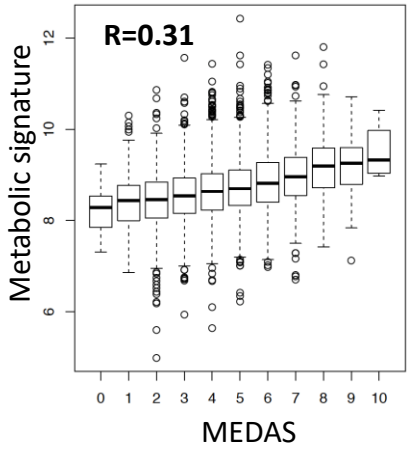
Metabolic signature:
a composite of
67 metabolites



Training set
The PREDIMED study (n=1859)

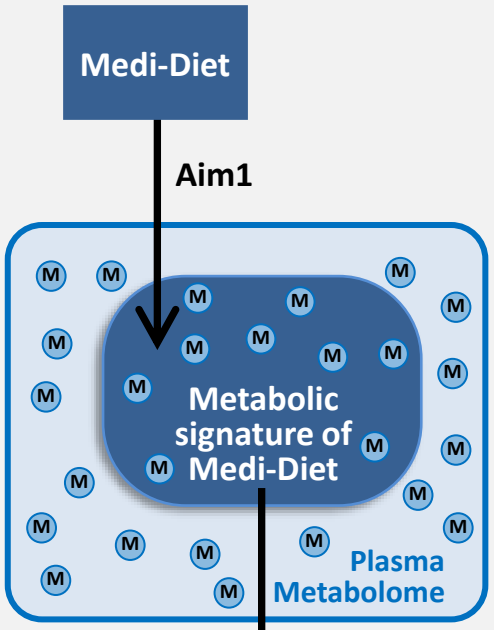


Testing set
The NHS/HPFS (n=6868)



- ❑ Included metabolites are **biologically plausible**
- ❑ **Robust correlations** with MEDAS in all cohorts

Li J, et al, Eur Heart J. 2020



Metabolic signature of MedDiet and CVD risk

Table. Hazard ratios (HRs) of CVD risk per SD increment in MEDAS or the metabolic signature

Analysis Model	MEDAS		Metabolic signature	
	HR (95%CI)	P	HR (95%CI)	P
PREDIMED baseline MEDAS/signature & 227 incident CVD events				
Multivariable Model	0.77 (0.64-0.93)	0.008	0.71 (0.58-0.87)	<0.001
MV + mutual adjustment	0.86 (0.70-1.07)	0.17	0.73 (0.59-0.91)	0.004
NHS/HPFS baseline MEDAS/signature & 351 incident CVD events				
Multivariable Model	0.92 (0.82-1.03)	0.13	0.85 (0.76-0.94)	0.001
MV + mutual adjustment	0.97 (0.86-1.09)	0.56	0.85 (0.77-0.95)	0.004

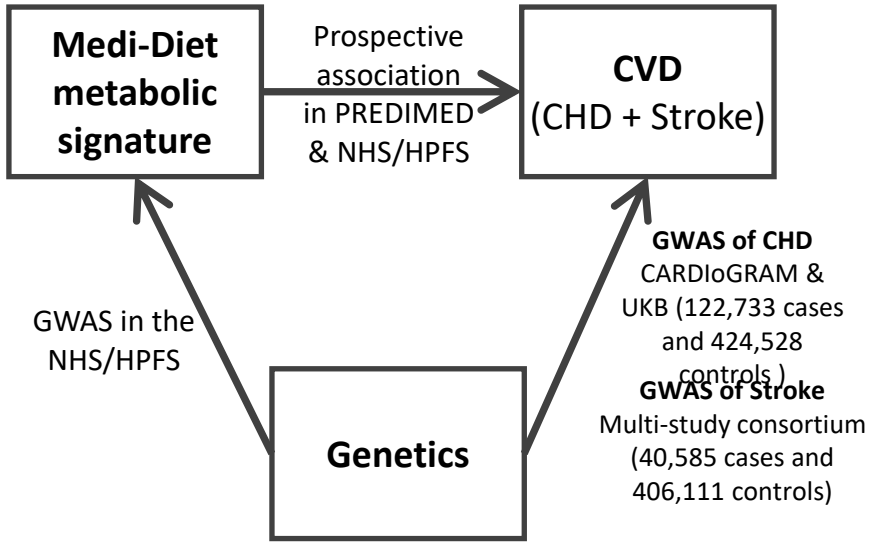
In PREDIMED: Stratified by study centers and intervention arms; and adjusted for age, sex, BMI, smoking, diabetes, dyslipidemia, hypertension, and family history of premature CHD.

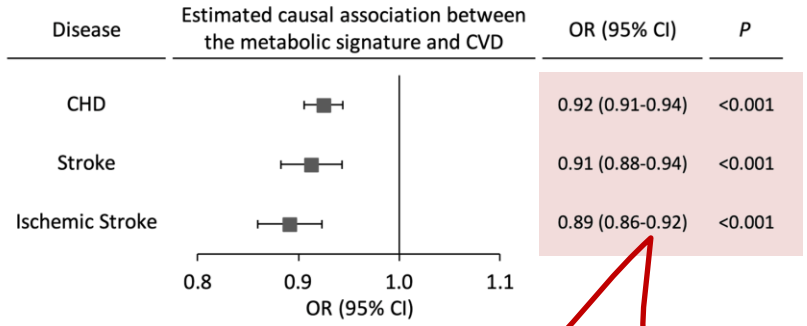
In NHS/HPFS: Stratified by study cohorts, sub-studies, and case-control status in original sub-studies, and adjusted for age, fasting status, and aspirin use at blood draw, BMI, smoking, physical activity, diabetes, dyslipidemia, hypertension, and family history of premature CHD.

Li J, et al, Eur Heart J. 2020

Two-sample Mendelian randomization analysis

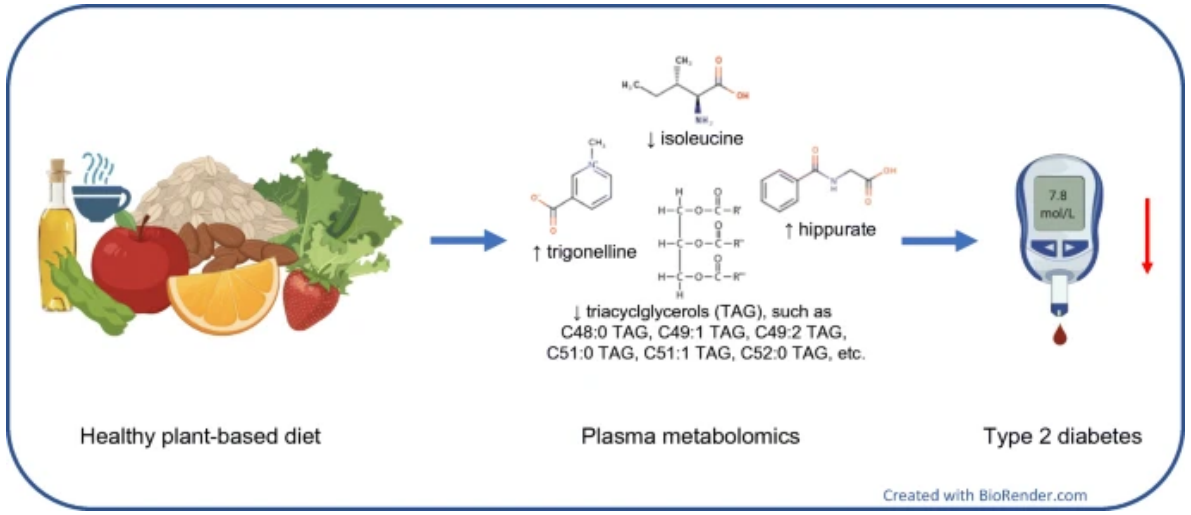
Potential casual associations between the metabolic signature and CVD risk





Each SD increment in the genetically inferred metabolic signature is associated with
a 8% ↓ of CHD risk &
a 9-11% ↓ of stroke risk

Plasma metabolite profiles related to plant-based diets and the risk of type 2 diabetes



Diabetologia (2022)

- Unique multi-metabolite profiles differed significantly between the healthy and unhealthy plant-based diets.
- hPDI is characterized by higher plasma trigonelline and hippurate, low levels of isoleucine and some lipid metabolites.
- Metabolite profile scores for hPDI were inversely associated with incident T2D independent of BMI, and other diabetes risk factors.
- Support the beneficial role of healthy plant-based diets in diabetes prevention and provide new insights into mechanisms

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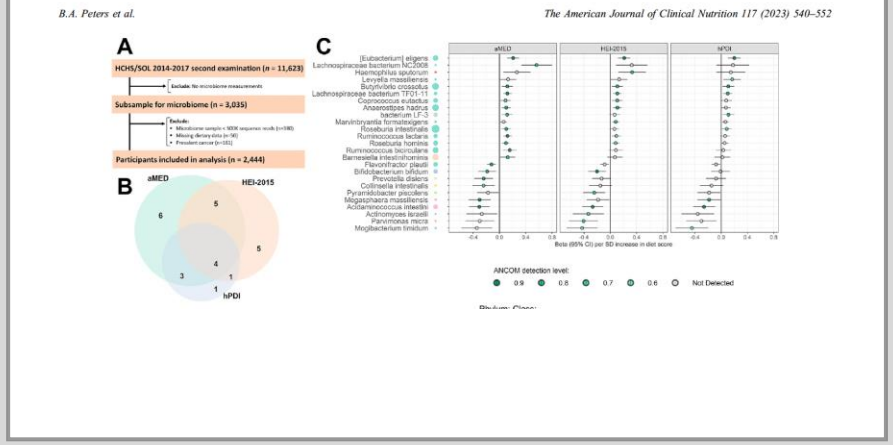
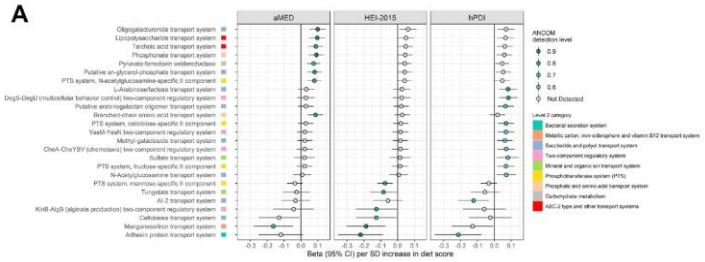
Original Research Article

Healthy dietary patterns are associated with the gut microbiome in the Hispanic Community Health Study/Study of Latinos

Brandilyn A. Peters [1,*], Jiaqian Xing [1], Guo-Chong Chen [1], Mykhaylo Usyk [2], Zheng Wang [1], Amanda C. McClain [3], Bharat Thyagarajan [4], Martha L. Daviglus [5], Daniela Sotres-Alvarez [6], Frank B. Hu [7], Rob Knight [8], Robert D. Burk [1,9], Robert C. Kaplan [1,10], Qibin Qi [1]

Healthy dietary patterns (aMED, HEI-2015, hPDI) in this population are associated with a higher abundance of fiber-fermenting Clostridia species in the gut microbiome, consistent with previous studies in other racial/ethnic groups. Gut microbiota may be involved in the beneficial effect of higher diet quality on cardiometabolic disease risk.





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Article | Published: 11 February 2021

The gut microbiome modulates the protective association between a Mediterranean diet and cardiometabolic disease risk

Dong D. Wang, Long H. Nguyen, Yanping Li, Yan Yan, Wenjie Ma, Ehud Rinott, Kerry L. Ivey, Iris Shai, Walter C. Willett, Frank B. Hu, Eric B. Rimm, Meir J. Stampfer, Andrew T. Chan & Curtis Huttenhower

Nature Medicine **27**, 333–343 (2021) | Cite this article

Fig. 4: The Mediterranean dietary pattern is associated with microbial processes involved in plant polysaccharide degradation and short-chain fatty acid production.

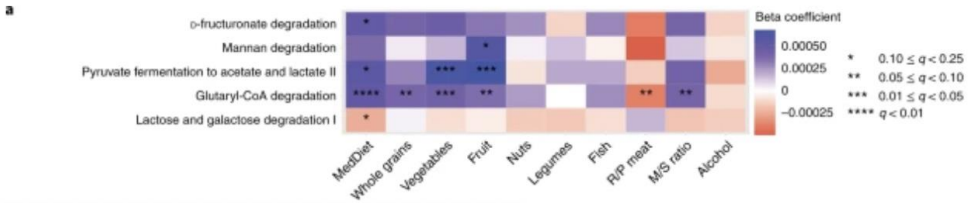
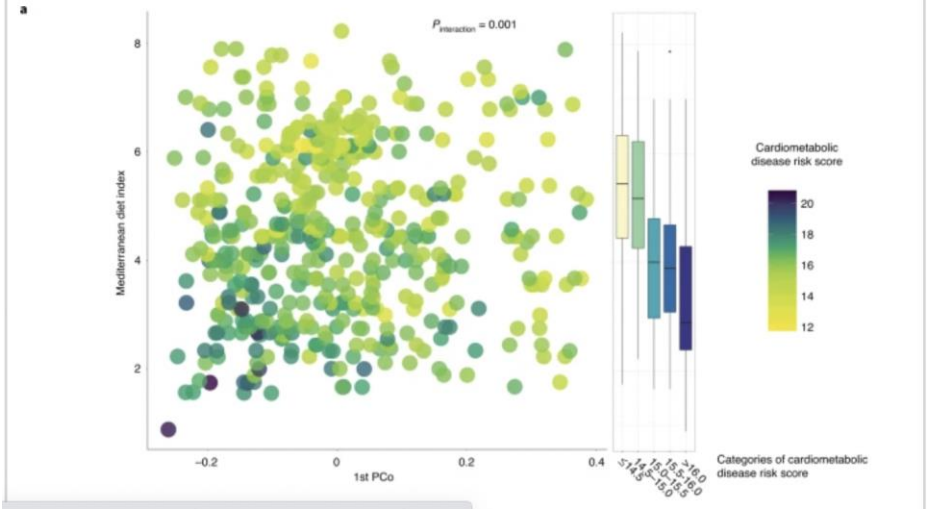


Fig. 5: *Prevotella copri* carriage modulates the protective association between the Mediterranean dietary pattern and cardiometabolic disease risk.



Conclusions

- Dietary patterns have become mainstream in nutritional epidemiology and dietary intervention studies
- Current dietary guidelines have shifted from individual nutrients or foods to overall healthy eating patterns.
- There is strong evidence from large cohort studies and RCTs that multiple dietary patterns are associated with lower risk of chronic diseases and mortality.
- Diet quality indices can be used to monitor population trends, evaluate the effectiveness of dietary interventions, and incorporate into policy analyses.
- Integrating various omics techniques into dietary pattern analyses can help to identify objective biomarkers and better understand biological mechanisms.
- Dietary pattern analysis is complementary to rather than replaces traditional nutrient or food analysis.
- Methods to derive dietary patterns need to more standardized to ensure consistency and comparability across studies.
- More studies need to be conducted in populations with diverse SES and race/ethnicity.

Acknowledgements