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# NUTRITION FOR A HEALTHY HEART – VIEW OF A NUTRITION SCIENTIST

MDA Webinar, 5th September 2020

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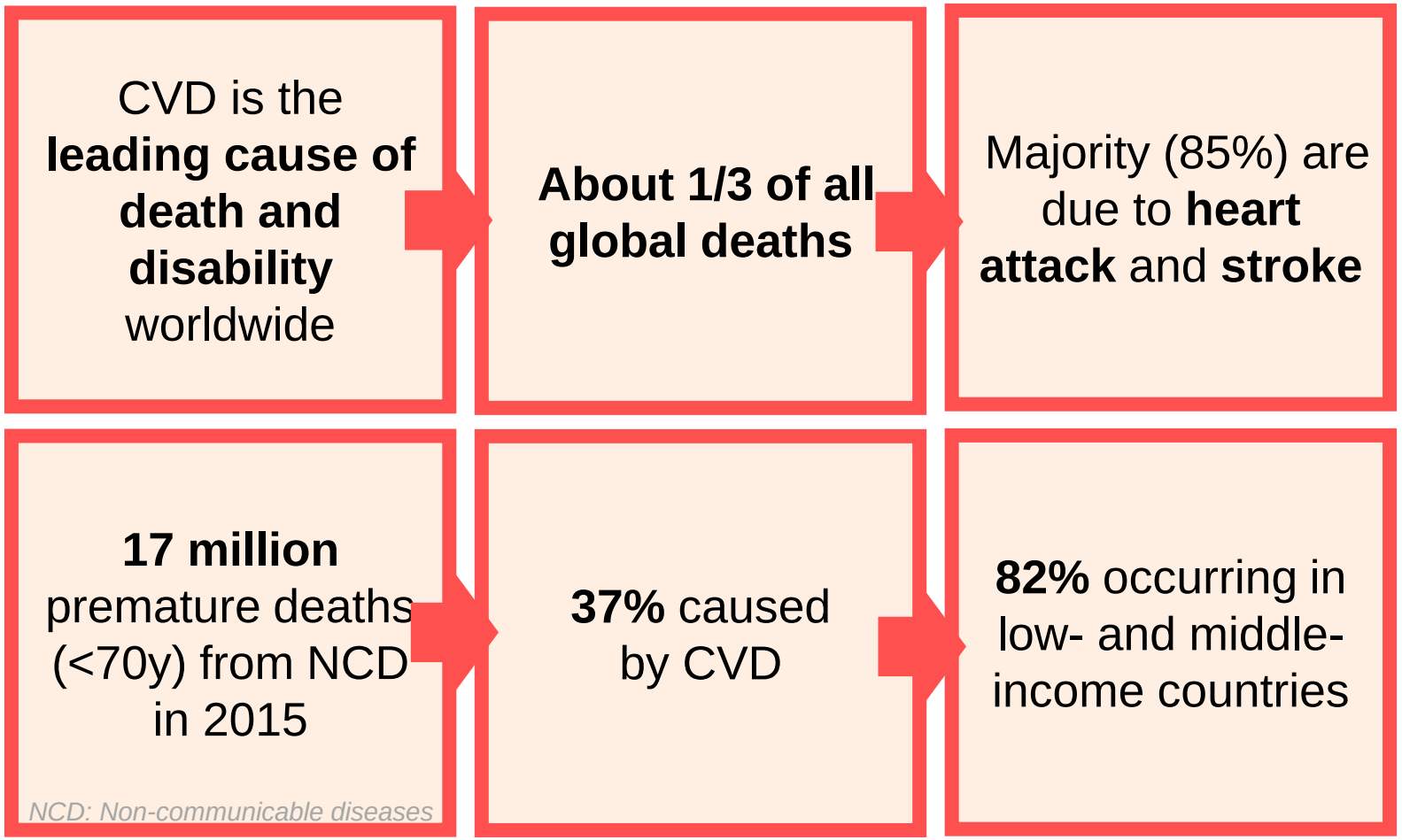
# Outline

- 1. CARDIOVASCULAR DISEASES: WHY A PUBLIC HEALTH CONCERN?
- 2. DIETARY PATTERNS: WHICH ONES ARE BENEFICIAL TO HEART HEALTH?
- 3. NUTRITION TO SUPPORT HEART HEALTH IN MALAYSIA: WHAT DOES SCIENCE SAY?
- 4. FUNCTIONAL INGREDIENTS FOR HEART HEALTH: WHAT'S NEW?

# 1

# CARDIOVASCULAR DISEASES: WHY A PUBLIC HEALTH CONCERN?

# Cardiovascular disease (CVD) by the numbers

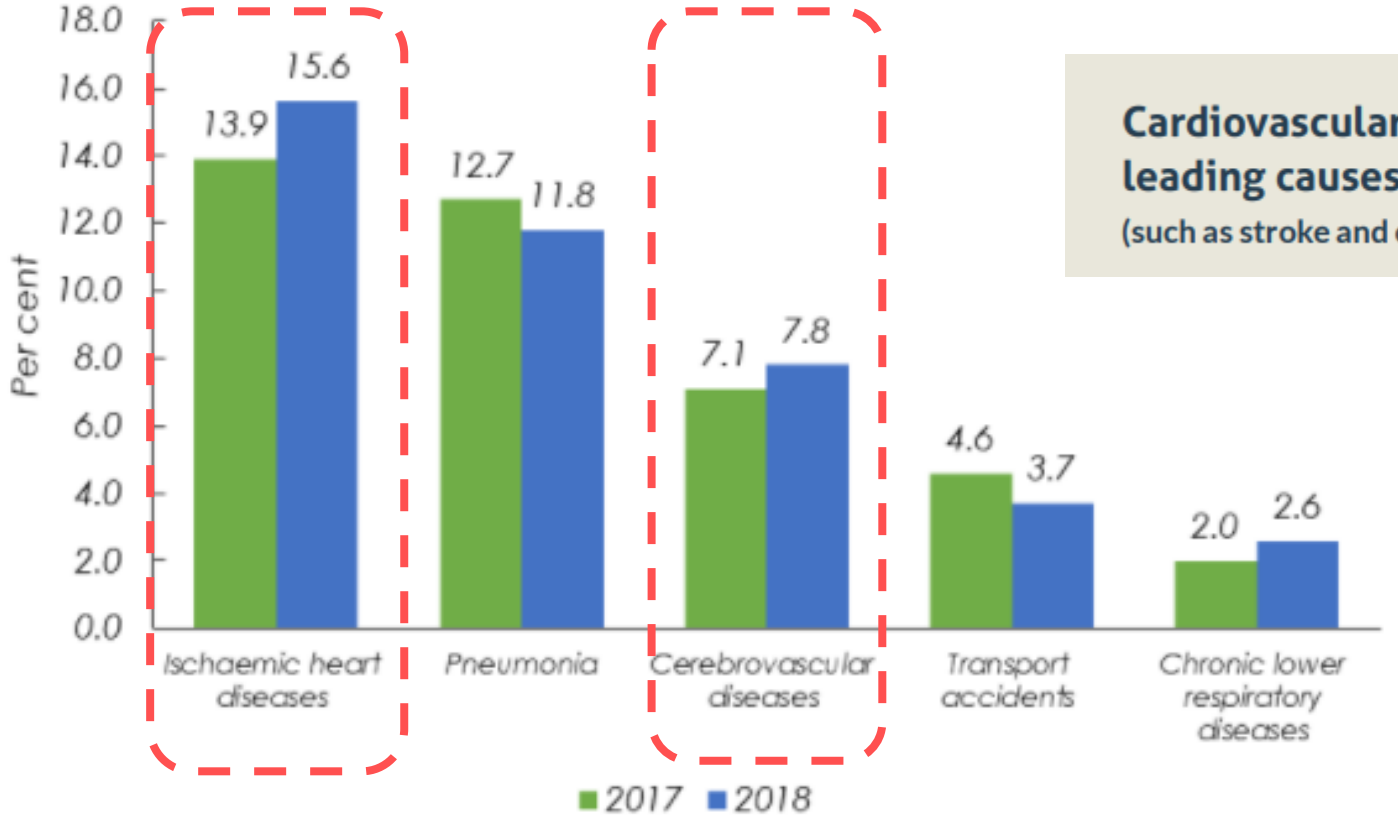



*Adapted from: World Health Organization. Factsheet Cardiovascular Disease. Last update: May 2017*



Research and Development

# Ischemic heart disease and cerebrovascular disease: among main causes of death in Malaysia (23.4% in 2018)




**Cardiovascular diseases (CVDs) are the leading causes of death in Malaysia**

(such as stroke and coronary heart diseases)

DEPARTMENT OF STATISTICS MALAYSIA
OFFICIAL PORTAL
The Source of Malaysia's Official Statistics

# Key factors contributing to the development of CVD

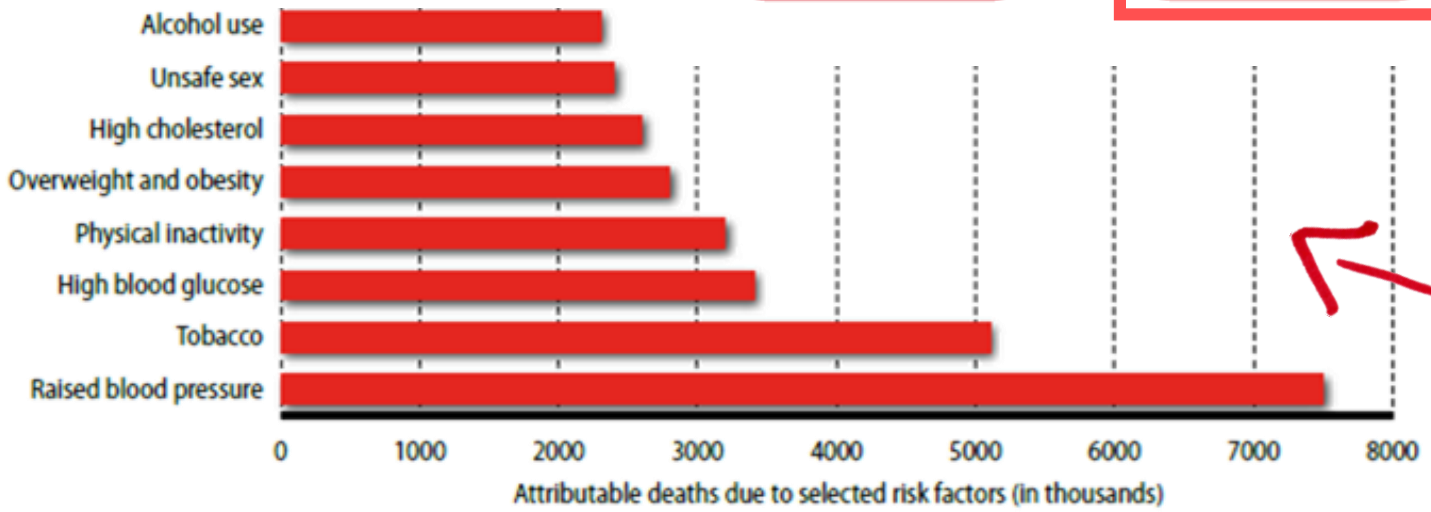
Prominent role

**Social determinants and drivers**
- Globalization
- Urbanization
- Ageing
- Income
- Education
- Housing

**Behavioural risk factors**
- Unhealthy diet
- Tobacco use
- Physical inactivity
- Harmful use of alcohol

**Metabolic risk factors**
- High blood pressure
- Obesity
- High blood sugar (diabetes)
- High blood cholesterol

**Cardiovascular disease**
- Hearts attacks
- Strokes
- Heart failure
- Kidney disease




*WHO (2009). Global health risks: Mortality and burden of disease attributable to selected major risks*



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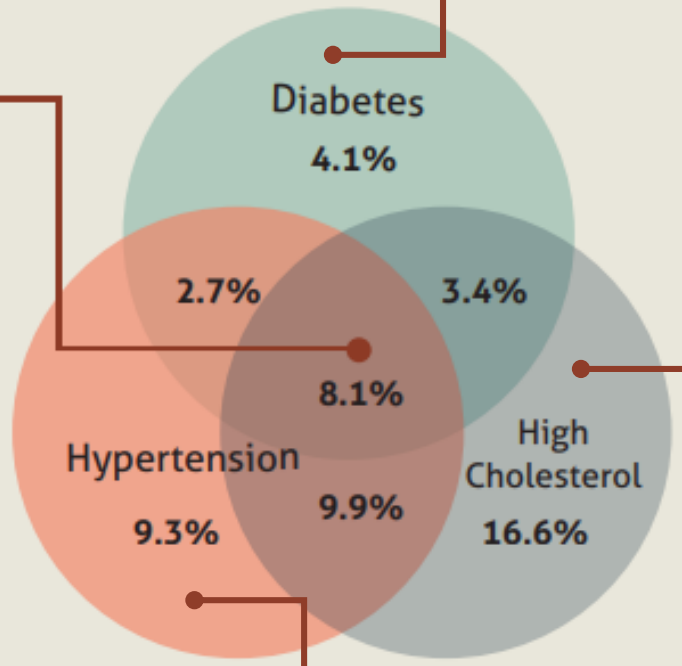
# Prevalence of cardiovascular risk factors in Malaysia (NHMS 2019)

**Reference:** National Health and Morbidity Surveys (NHMS) 2019

**1.7 million** people in Malaysia currently live with **three major risk factors**

**3.4 million** people in Malaysia currently live with **two major risk factors**




**Diabetes: 1 in 5 adults**

**High cholesterol: 4 in 10 adults**

**Overweight/Obese: 1 in 2 adults**

**Hypertension: 3 in 10 adults**

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# Dietary habits & lifestyle could play a key role in addressing CVD risk factors


**Reference:** National Health and Morbidity Surveys (NHMS) 2019



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# KEY MESSAGES

- **CVD is the leading cause of (premature) death and disability worldwide (including Malaysia)..**
- **A large proportion of CVD leads to heart attacks and strokes.**
- **There is strong scientific evidence that behavioural and metabolic risk factors play a key role in the development of atherosclerosis.**
- **Prevention through changes in dietary habits & lifestyle is the cornerstone of decreasing global burden of CVD.**

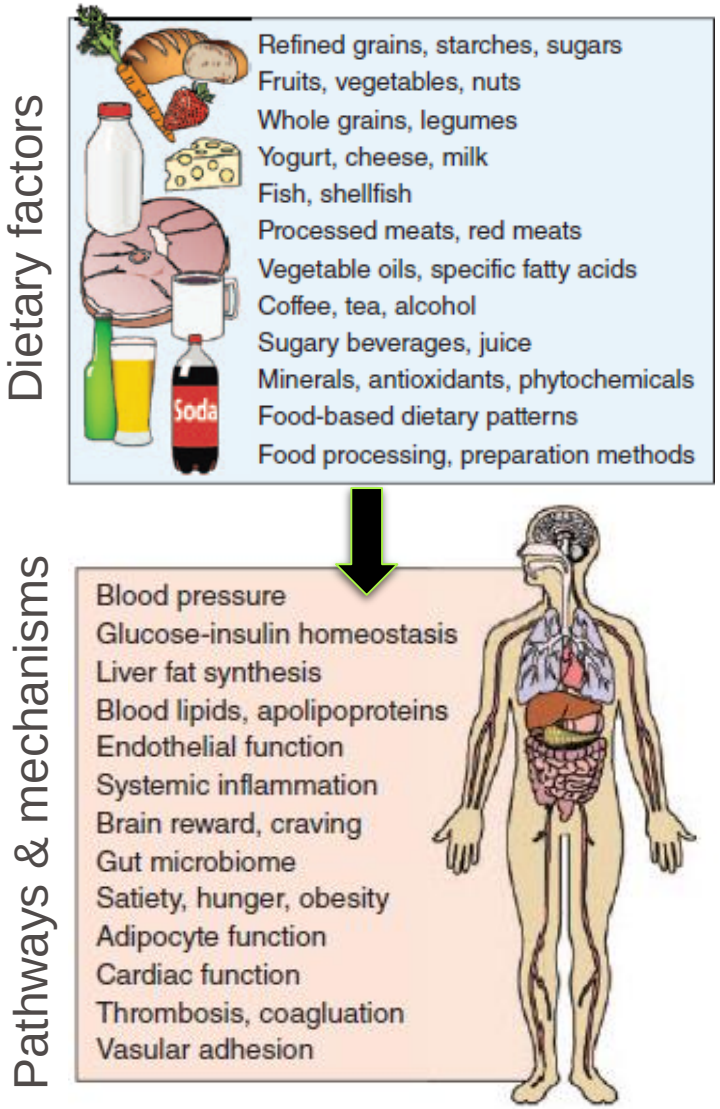
# 2

# DIETARY PATTERNS: WHICH ONES ARE BENEFICIAL TO HEART HEALTH?

# Existing guidelines for the primary and secondary prevention of CVD are based predominantly on single nutrients or foods

| Energy | Fibre | Added sugars | Total fat | SFA | TFA | Sodium | Alcohol | Foods to emphasize | Foods to limit |
|---|---|---|---|---|---|---|---|---|---|
| **European Guidelines on CVD prevention in clinical practice (European Society of Cardiology, 2016)**<br>*Piepoli et al., European Heart Journal, 2016* | | | | | | | | | |
| Limited to the amount of energy needed to maintain (or obtain) a healthy weight, that is, a BMI >20.0 but <25.0 kg/m$^2$ | 30-45 g/d preferably from wholegrain products | Quoting WHO (intake <10% of energy from sugar (mono- and disaccharides), including added sugars as well as sugars present in fruits and fruit juices | For prevention of CVD, the types of FA consumed are more important than the total fat content | <10% of total energy intake, through replacement by polyunsaturated fatty acids. | As little as possible, preferably no intake from processed food, and <1% of total energy intake from natural origin | <2000 mg/d | Limited to 2 glasses/d (20 g/d of alcohol) for men and 1 glass/d (10 g/d of alcohol) for women | • Fruits > 200 g/d (2–3 servings)<br>• Vegetables > 200 g/d (2-3 servings)<br>• Fish 1–2 times per week, one of which to be oily<br>• Unsalted nuts: 30 g/d | • Sugar-sweetened soft drinks<br>• Alcoholic beverages limited to 2 glasses per day (20 g/d of alcohol) for men and 1 glass per day (10 g/d of alcohol) for women |
| **Guideline on lifestyle management to reduce CV risk (American Heart Association/American College of Cardiology, 2013)**<br>*Eckel et al., Circulation, 2014* | | | | | | | | | |
| The caloric intake should be appropriate for the individual (eg, restricted for those attempting weight loss). | Not specified | Not specified | Not specified (DASH reference: 26-27% of calories) | 5-6% of calories | Reduce % of calories from trans fat | • Reduce intake by at least 1000 mg/d<br>• <2400 mg/d<br>• Further reduction to 1500 mg/d is desirable | Not specified | • Vegetables<br>• Fruits<br>• Whole grains<br>• Low-fat dairy<br>• Poultry<br>• Fish<br>• Legumes,<br>• Non tropical vegetable oils & nuts | • Sweets<br>• Sugar-sweetened beverages<br>• Red meat<br>• Processed foods |

# Shifting from single nutrients or foods to dietary patterns




*Source: Mozaffarian (2016), Circulation*

- Our health is likely not influenced by single nutrients, but by specific foods and overall dietary patterns
- Few people understand or can accurately estimate without guidance their daily consumption of nutrients
- There is a complex interplay between matrices, processing, and preparation which strongly influence health effects of foods
- Dietary patterns = quantities, proportions, variety or combinations of different foods and beverages in diets, and the frequency with which they are habitually consumed (DGAC, 2015)



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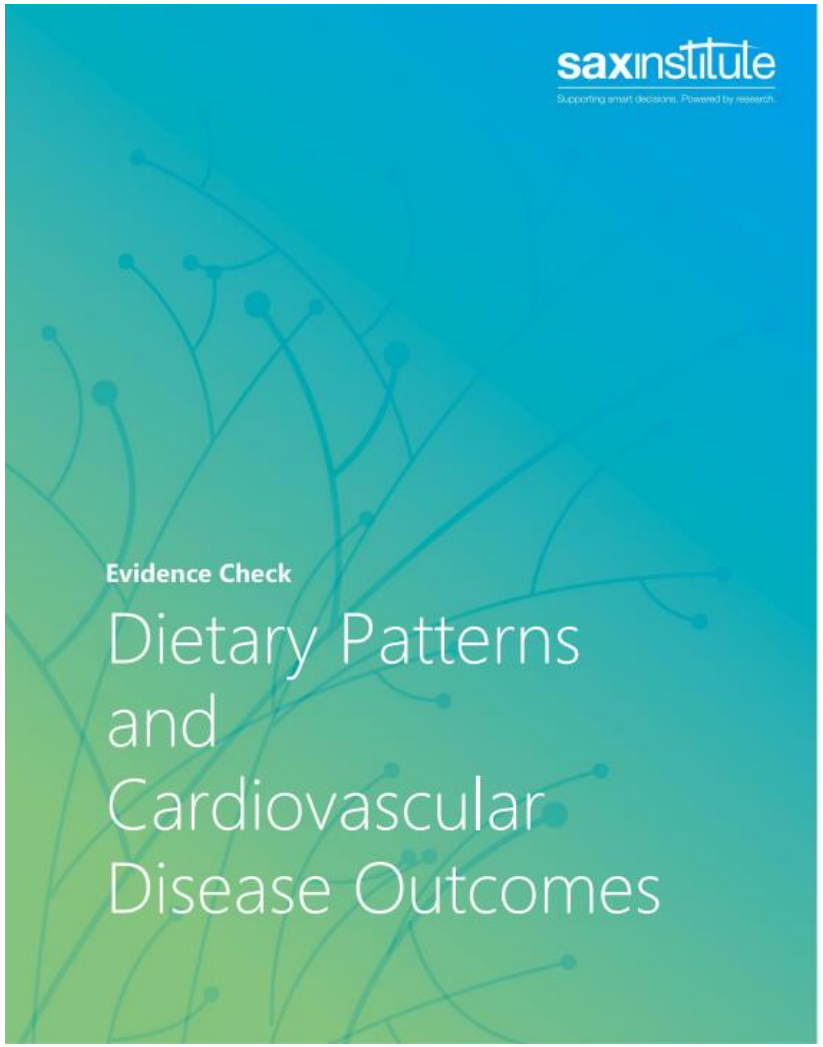
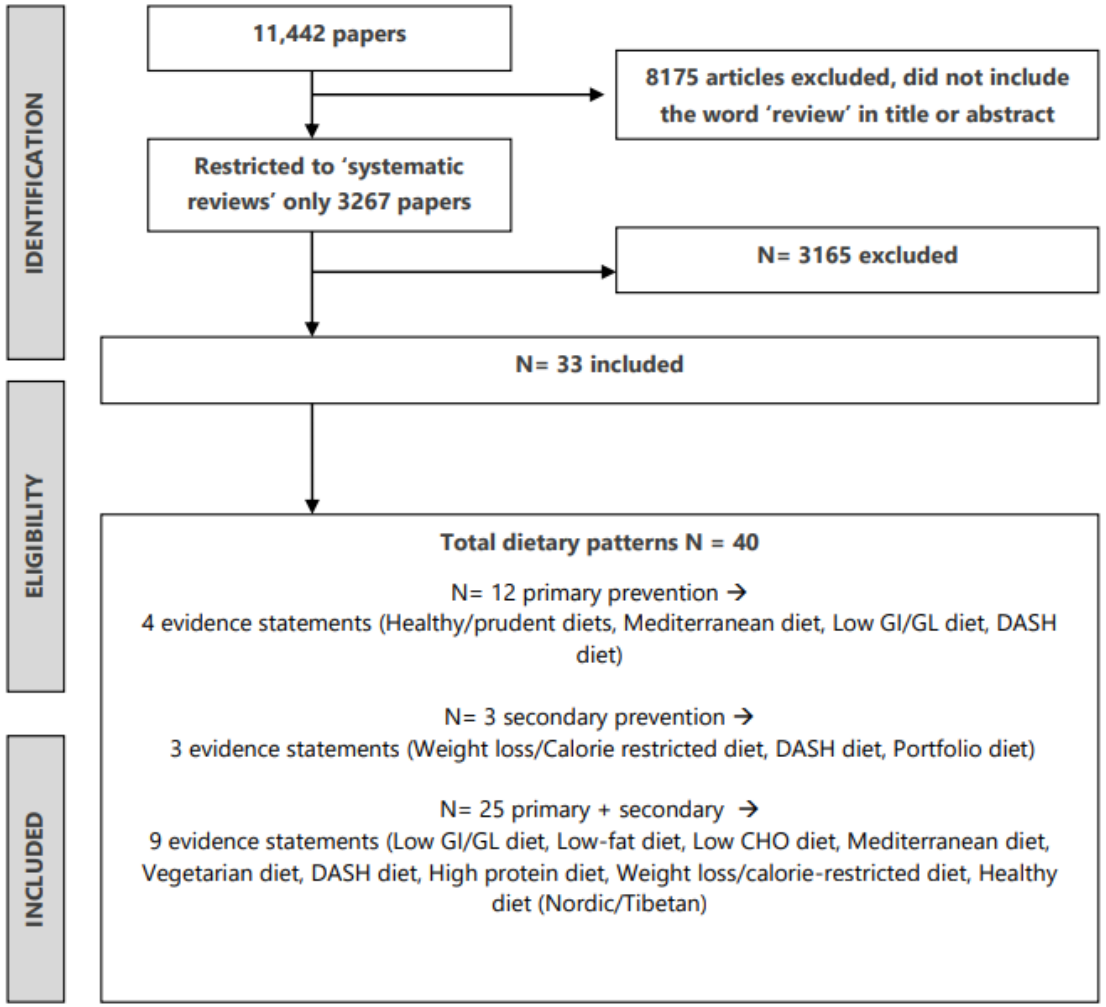
# Systematic review assessing the science behind dietary patterns & CVD risk




Collins C, Burrows T, Rollo M. Dietary Patterns and Cardiovascular Disease Outcomes: an Evidence Check rapid review, for the National Heart Foundation of Australia (2017)



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# Grading of the scientific evidence supporting the identified dietary patterns

- Primary CVD prevention

| | Blood pressure | Blood lipids | Weight or body composition | CVD events and/or mortality |
|---|---|---|---|---|
| A | • DASH | | | • DASH |
| B | | | | • Healthy/prudent |
| C | • Mediterranean | • Low GI/GL | | • Mediterranean |
| D | | | | |

- Secondary CVD prevention

| | Blood pressure | Blood lipids | Weight or body composition | CVD events and/or mortality |
|---|---|---|---|---|
| A | | | | |
| B | | • Portfolio | | |
| C | • DASH,<br>• Weight loss or calorie-restriction | | • Weight loss or calorie-restriction | |
| D | | | | |

A = Body of evidence can be trusted to guide practice

B = Body of evidence can be trusted to guide practice in most situations

C = Body of evidence provides some support for recommendation(s) but care should be taken in its application

D = Body of evidence is weak and recommendation must be applied with caution

Adapted from: Collins C, Burrows T, Rollo M. Dietary Patterns and Cardiovascular Disease Outcomes: an Evidence Check rapid review, for the National Heart Foundation of Australia, 2017.



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# Grading of the scientific evidence supporting the identified dietary patterns

- Combined primary & secondary CVD prevention

| | Blood pressure | Blood lipids | Weight or body composition | CVD events and/or mortality |
|---|---|---|---|---|
| A | | | | |
| B | • Low-CHO<br>• Vegetarian<br>• DASH<br>• Weight loss or calorie restriction (DBP only) | • Low-fat<br>• DASH<br>• Weight loss or calorie restriction | • DASH | |
| C | • Mediterranean<br>• Nordic | • Low GI<br>• Mediterranean<br>• High protein<br>• Nordic | | • Mediterranean |
| D | • Weight loss or calorie restriction (SBP only) | | | |

Adapted from: Collins C, Burrows T, Rollo M. Dietary Patterns and Cardiovascular Disease Outcomes: an Evidence Check rapid review, for the National Heart Foundation of Australia, 2017.

A = Body of evidence can be trusted to guide practice
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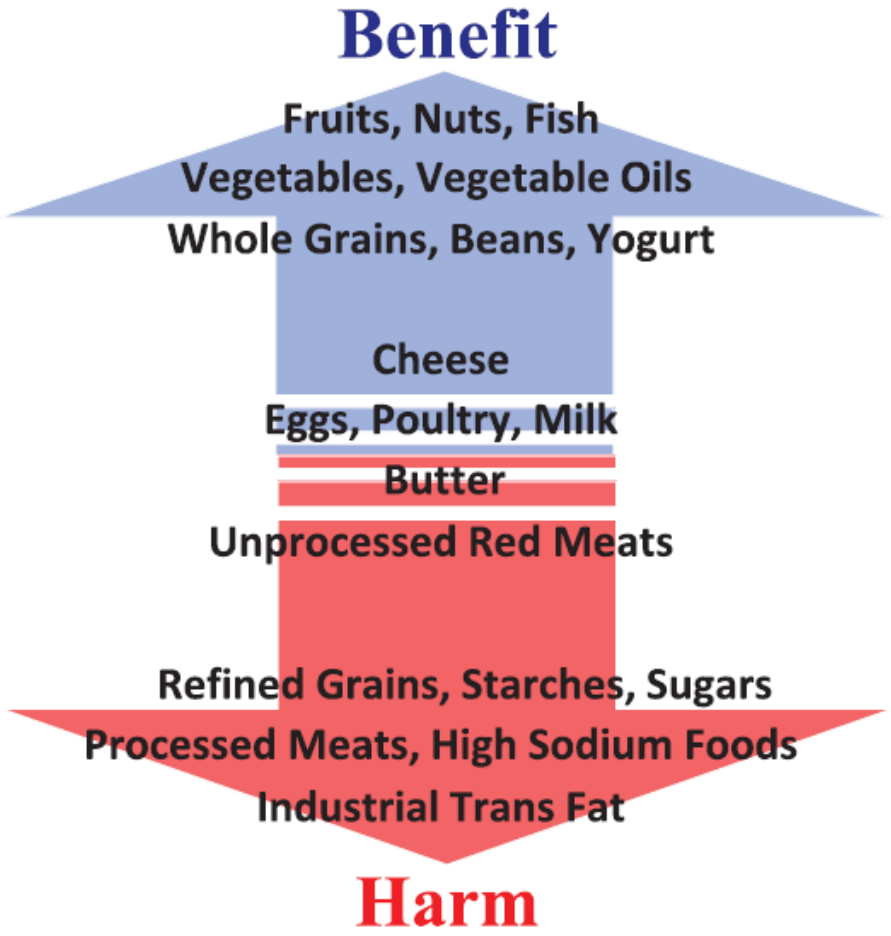
# Food composition of the different heart-friendly dietary patterns

| | Healthy-prudent | Med V1 | Med V2 | Vegetarian | DASH | Nordic | Tibetan | Portfolio |
|---|---|---|---|---|---|---|---|---|
| **Fruits** | X | X | X | X | X | X | X | X |
| **Vegetables** | X | X | X | X | X | X | X | X |
| **Whole grains/cereals** | X | X | X | X | X | X | X | X |
| Fish/seafood | X | X | X | | X | X | | |
| Low-fat dairy | X | X | X | | X | X | | |
| Poultry | X | | | | X | | | |
| **Beans/legumes** | X | X | X | X | X | | X | X |
| Nuts/seeds | | | X | | X | X | | X |
| Olive oil | X | X | X | | | | | |
| Rapeseed oil | | | | | | X | | |
| Alcohol (wine) | | X | X | | | | | |
| Meat/meat products | | | | | | | X | |
| Micronutrients | | | | | X | | | |
| Plant sterols | | | | | | | | X |
| Limit on saturated fat | | X | | | X | | | X |
| Limit on refined sugars | | | X | | | | | |
| Limit on sodium | | | | | X | | | |
| Limit on meat | | X | X | X | | | | X |

Adapted from: Collins C, Burrows T, Rollo M. Dietary Patterns and Cardiovascular Disease Outcomes: an Evidence Check rapid review, for the National Heart Foundation of Australia, 2017.

# Dietary principles for heart healthy diets




*Source: Mozaffarian (2016), Circulation*

- Diets can be adapted to follow these dietary principles
- Adapting single attributes may not confer the expected benefit, if the diet is otherwise inappropriate
- Some populations that previously consumed cardioprotective diets have introduced foods not traditionally consumed (e.g. high in sugars and saturated fats) losing to some extent the health benefits of their diet



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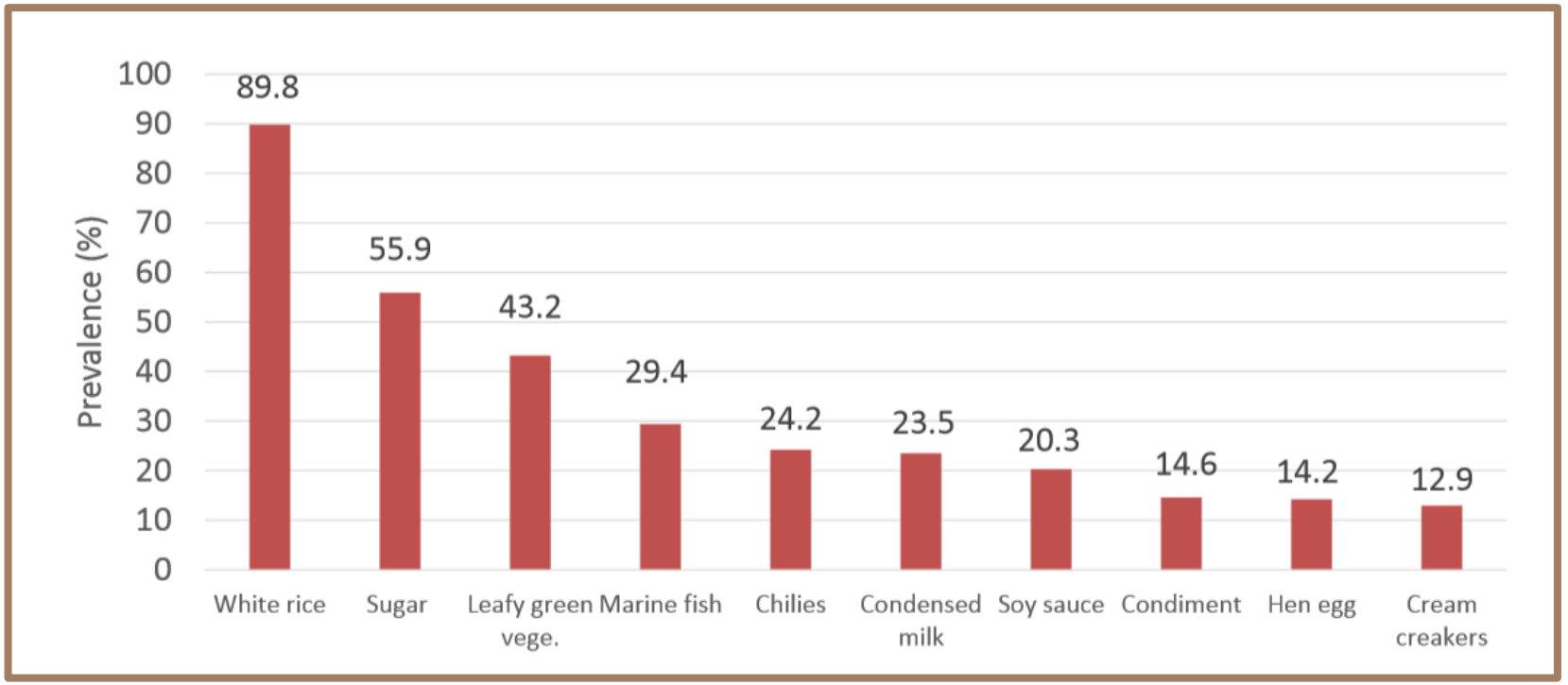
# KEY MESSAGES

- **Research places emphasis today on whole dietary patterns, rather than single nutrients or foods.**
- **There is scientific evidence supporting the positive impacts of dietary patterns (DASH, Portfolio, Mediterranean) on CVD risk factors – hypertension, dyslipidemia and weight gain – to prevent occurrence of cardiovascular events (e.g. heart attack or stroke), or progression of CVD.**
- **Common attributes of these dietary patterns include plenty of vegetables and fruit, some intact whole grains in place of refined grains, legumes, nuts, seeds, and other sources of healthy fats such as oily fish, as well as non-processed lean meats or poultry and/or dairy foods**

# 3

# NUTRITION TO SUPPORT HEART HEALTH IN MALAYSIA: WHAT DOES SCIENCE SAY?

# Key findings from Malaysian Adults Nutrition Survey (MANS) 2014

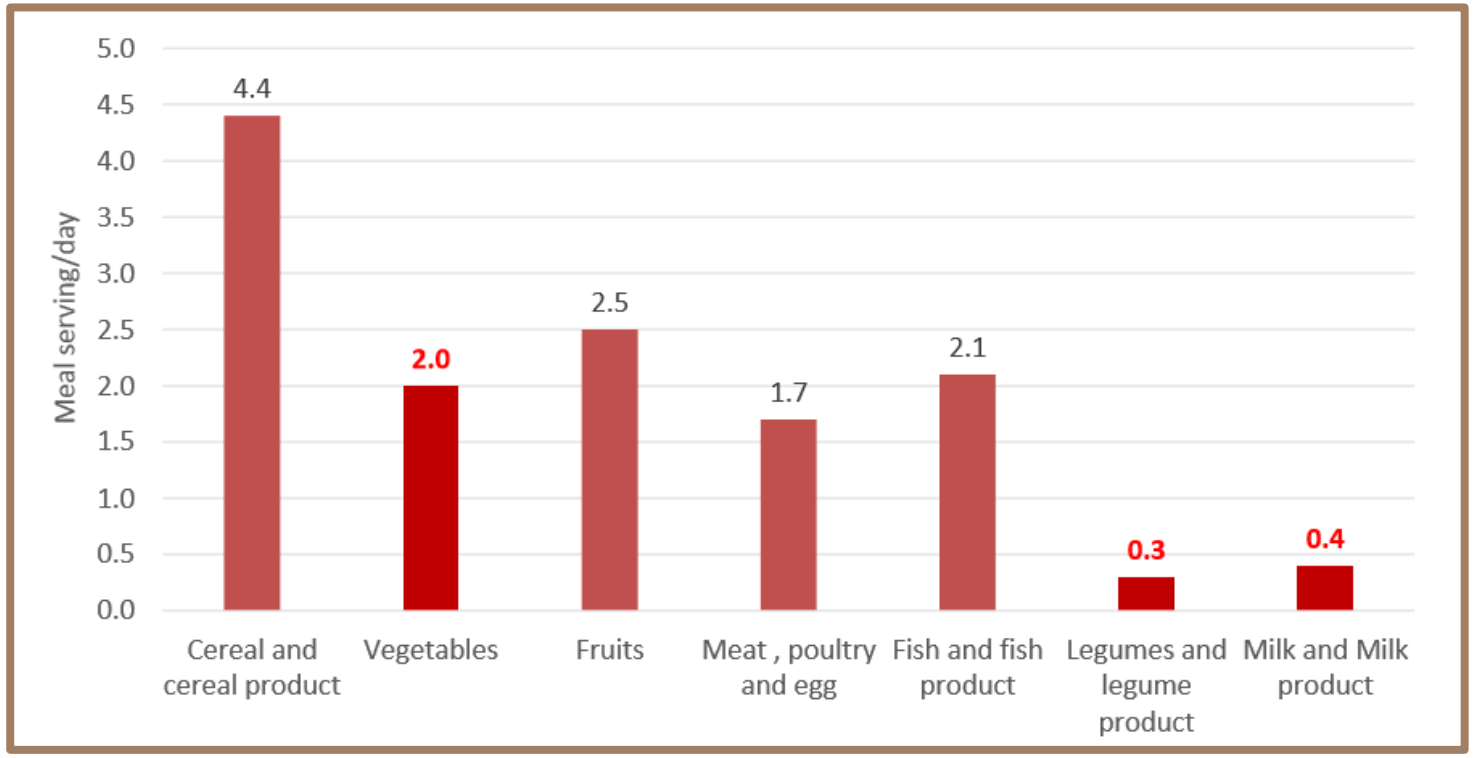



Prevalence of the top ten foods consumed daily among Malaysian adults

**White rice and sugar among top 10 foods consumed**

**Reference:** Mohamad Hasnan Bin Ahmad (Nutritionist), Ministry of Health, Kuala Lumpur

# Key findings from Malaysian Adults Nutrition Survey (MANS) 2014

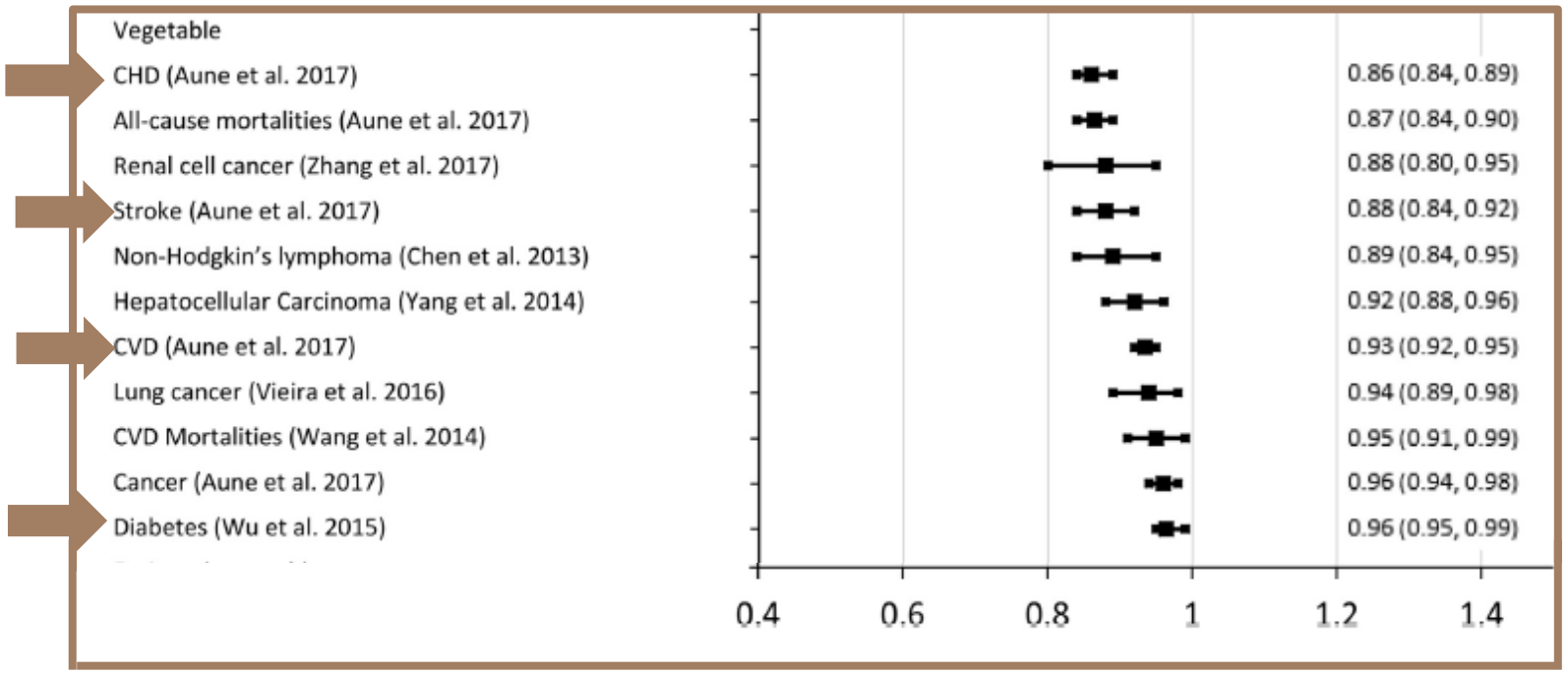



Mean daily intake (serving) according to food groups among Malaysian adults

**Insufficient intake of vegetables, legumes and dairy products among Malaysian adults (vs. Malaysia Food Pyramid recommendations)**

**Reference:** Mohamad Hasnan Bin Ahmad (Nutritionist), Ministry of Health, Kuala Lumpur

# Cardiometabolic benefits of vegetable intake (systematic review of meta-analyses)




*Sau Chun Yip (2019). J Acad Nutr Diet. 2019*

- Increasing vegetable intake to current dietary guideline recommended intake levels could potentially markedly reduce burden of diseases.
- For the first 100 g/day of vegetable intakes, there was (among others) a decreased risk for:
  - CHD (-14%)
  - stroke (-12%)
  - CVD (-7%)
  - diabetes (-4%)



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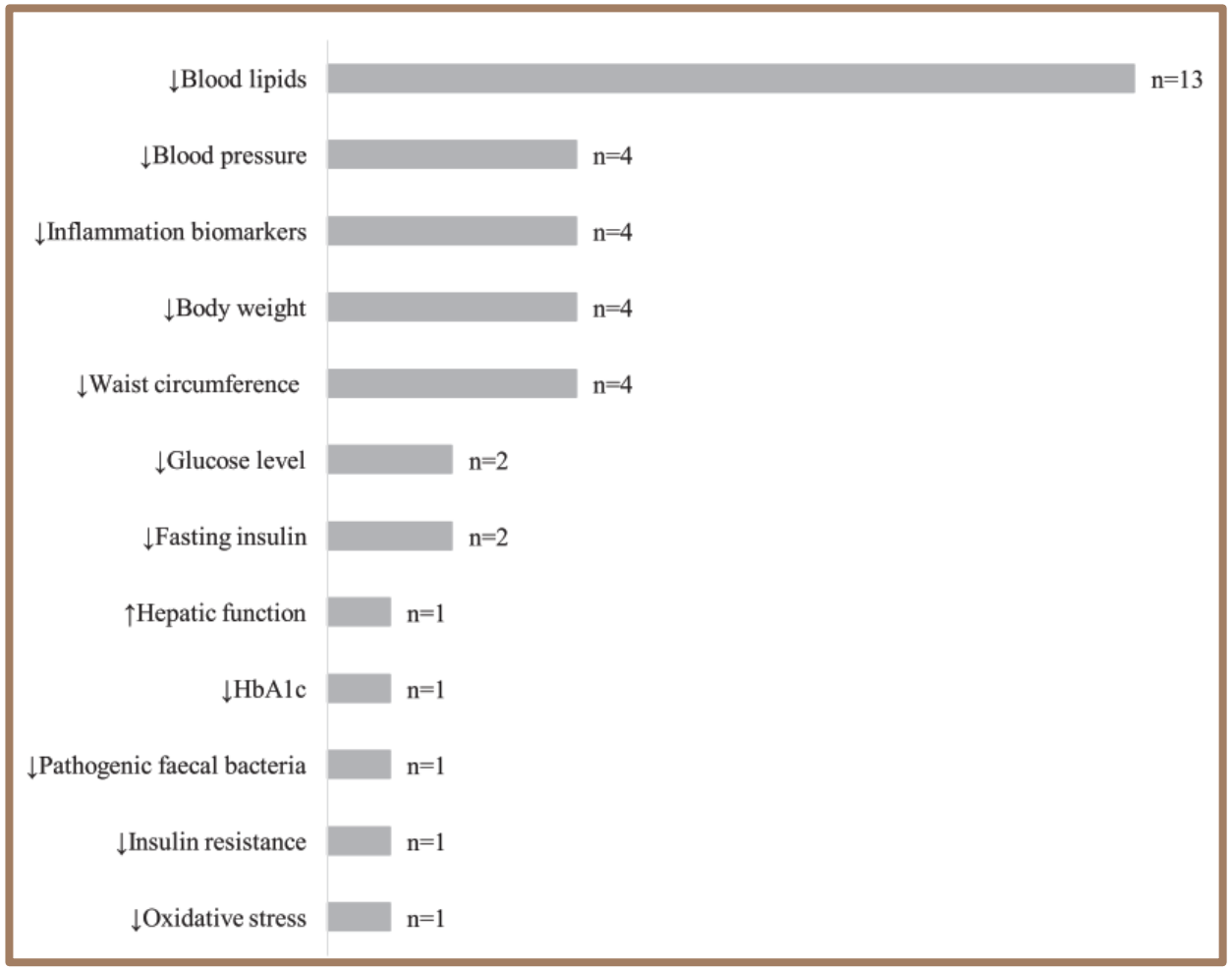
# Cardiometabolic benefits of pulse intake (systematic review of RCTs)




*Feirrera et al. (2020) Critical Review in Food Science and Nutrition*

- Data supports the presence of pulses in traditional pulse-eating communities, and their reintroduction into more Western diet-based countries.
- Positive effects were observed with intakes of 150g/day (about 1.5 servings) of cooked pulses.
- Pulse nutrient-dense profile, including high-fiber content, is believed to be the key factor of their observed health benefits.



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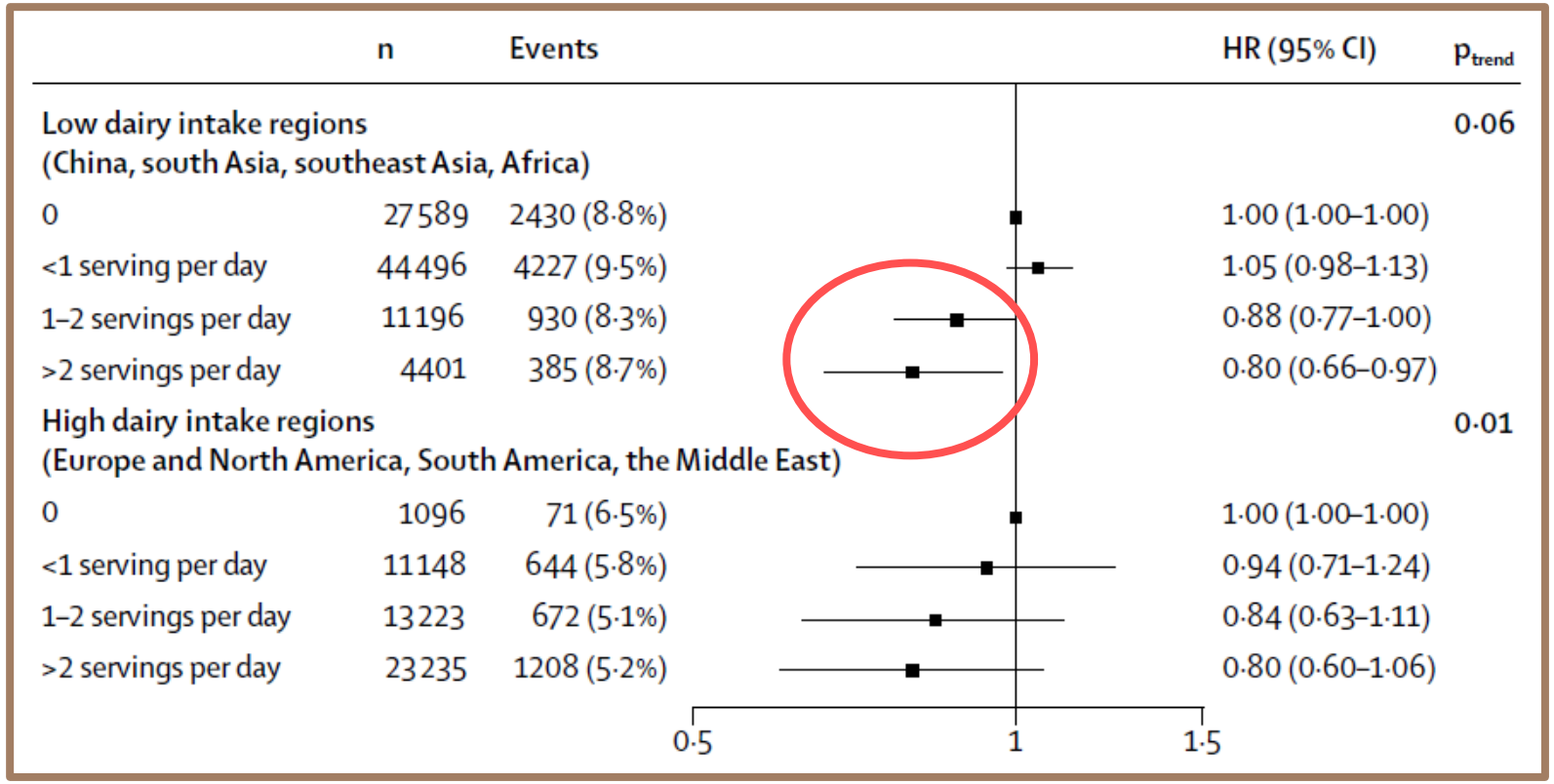
# Dairy intake and CVD risk in low & high dairy intake regions (large multinational prospective cohort study)




*Dehghan et al (2018). The Lancet.*

- Dairy products are a diverse food group that include fermented and cultured products with many different nutrients
- Higher dairy consumption was generally associated with lower risks of mortality and CVD, particularly stroke
- Consumption of dairy products should be encouraged in countries with low consumption of dairy and high risk of hypertension, both of which might be reduced by increasing dairy consumption

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# KEY MESSAGES

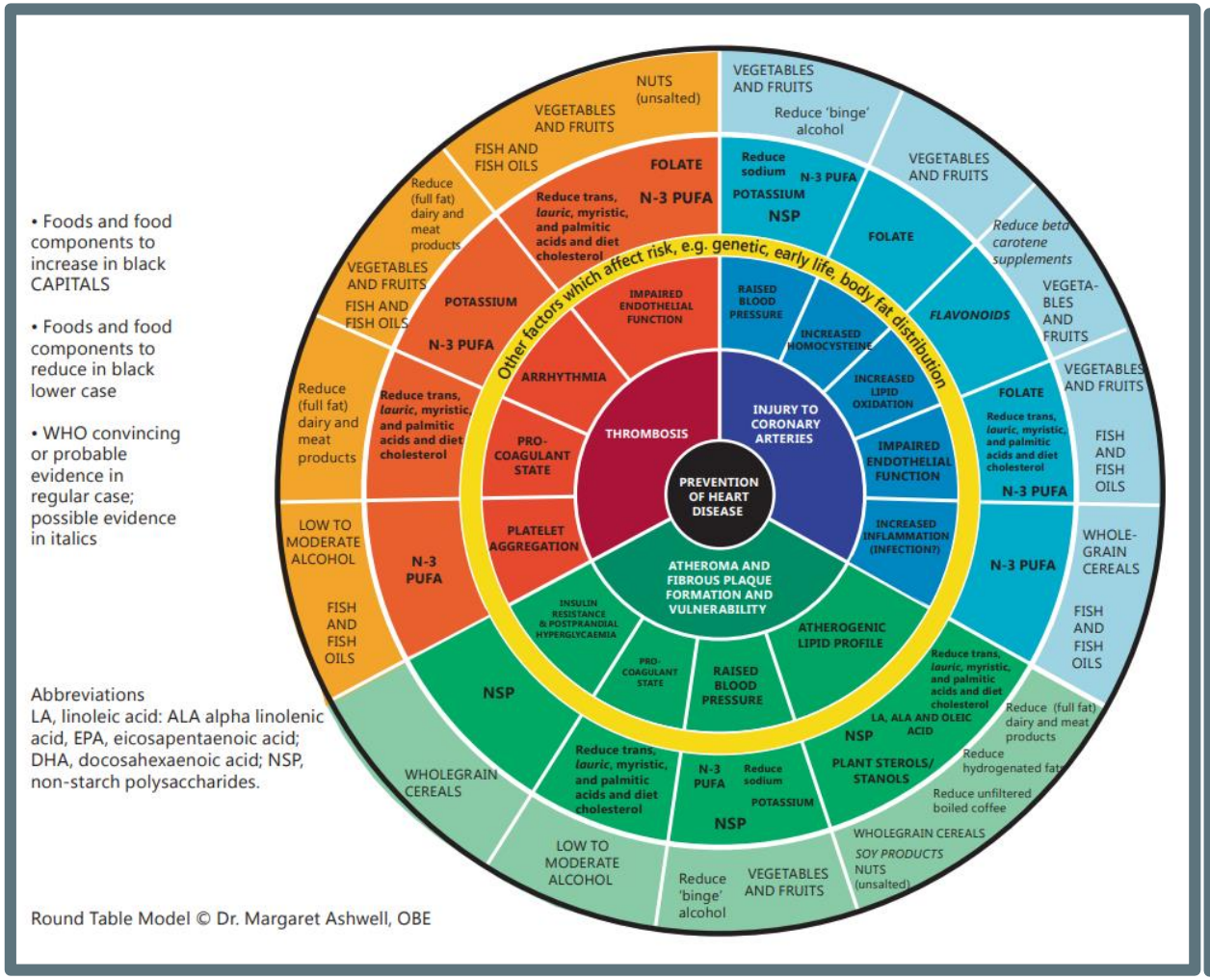
- **There is today too high intake of white rice and sugar & insufficient intake of vegetables, legumes and dairy products among Malaysian adults.**
- **There is scientific evidence to indicate that increasing intake of respectively vegetables, legumes and dairy products could contribute to benefit cardiometabolic health.**
- **The benefit regarding dairy products seem to be more prominent in low dairy intake regions possibly through a range of compounds and related mechanisms.**

# 4

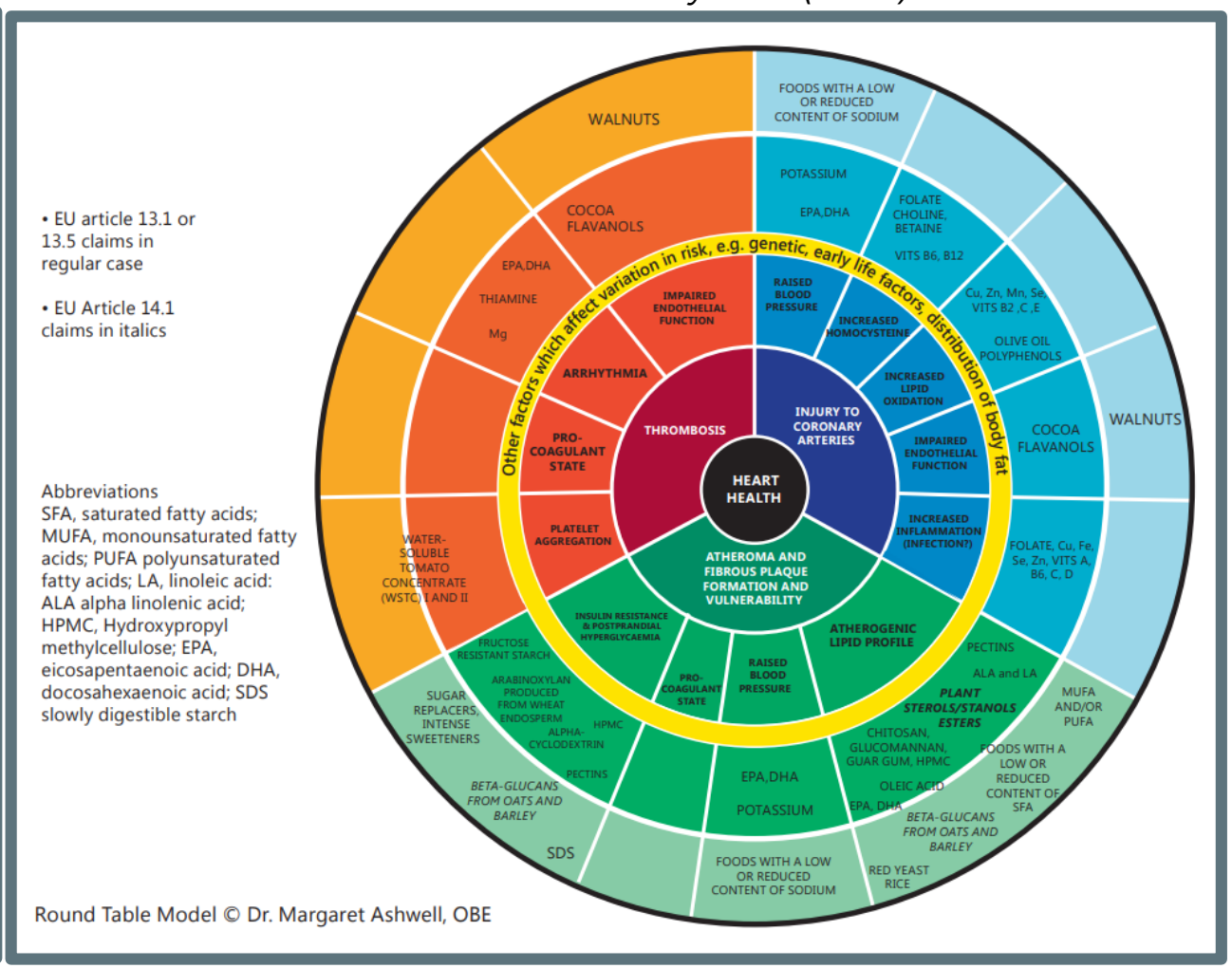
# FUNCTIONAL INGREDIENTS FOR HEART HEALTH: WHAT'S NEW?

# Empowering consumers choosing a healthy diet

*Source: Anne de la Hunty et al. (2014). Ann Nutr Metab*




## Dietary factors for prevention of heart disease (WHO recommendations)




## EU-authorized health claims related to heart health



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# Addressing three main vascular benefits

**Blood Lipids**
Minimize formation of plaques

**Blood pressure**
Minimize pressure on the arteries

**Blood Flow**
Ensure smooth circulation

# Ingredients with approved health claims

| BLOOD LIPIDS | BLOOD PRESSURE | BLOOD FLOW |
| --- | --- | --- |
| • Plant sterols/stanols<br>• Beta-glucans<br>• LA, ALA, OA<br>• Non-starch polysaccharides<br>• Pectins<br>• Chitosan<br>• Glucomannan<br>• Guar gum<br>• HPMC<br>• MUFA-PUFA<br>• Reduce SFA<br>• Red yeast rice | • Reduce sodium<br>• Potassium<br>• EPA & DHA | • Reduce trans, lauric, myristic, and palmitic acids<br>• Folate<br>• n-3 PUFA<br>• Cocoa flavanols<br>• Walnuts |

Main jurisdictions: Europe, US, Canada, Australia/New Zealand



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# Key functional ingredients targeting blood lipids

## PLANT STEROLS & STANOLS

- Plant sterols and stanols (1.5-3g/day) compete with cholesterol for absorption in the intestine and contribute to decrease LDL cholesterol by 7-12% in a dose-dependent manner, especially in individuals with higher cholesterol absorption and a lower rate of cholesterol synthesis
- Ref: EFSA scientific opinion, (2012): Fumeron et al. (2017)

## BETA-GLUCANS

- Oat beta-glucans (3g/day) contribute to reduce both total and LDL cholesterol by 0.30 mmol/L and 0.25 mmol/L, respectively.
- Ref: Whitehead et al., meta-analysis of RCT (2014)

## GARLIC (AGED)

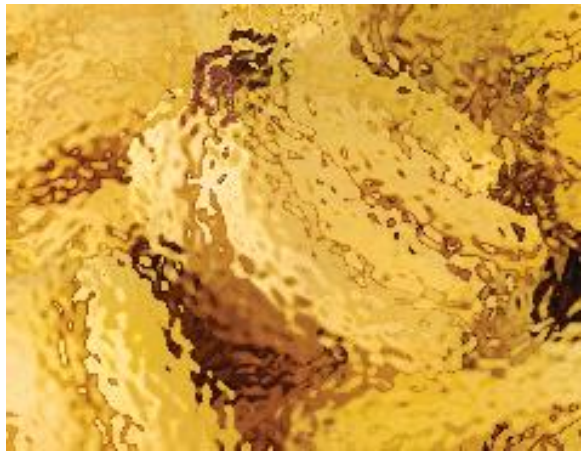
- Garlic (0.5-1g/day) is effective in reducing both total and LDL cholesterol by 17 mg/dL and 9 mg/dL respectively, in individuals with elevated total cholesterol levels.
- Ref: Ried et al., meta-analysis of RCT (2013)

## ARTICHOKE

- Supplementation with artichoke extract (0.5-2.7 g/day) was associated with a significant reduction in total and LDL cholesterol, and triglycerides of 17 mg/dL, 15 mg/dL and 9 mg/dL respectively.
- Ref: Sahebkar et al., meta-analysis of RCT (2018)

# Key functional ingredients targeting blood pressure (BP)

## POTASSIUM



- Potassium supplementation (>3.5g/day) decreases systolic and diastolic BP (4.48 and 2.96 mmHg, respectively). The effect is more prominent in high sodium consumers, untreated hypertensive subjects, and those in the lowest category of potassium intake.
- Ref:  Filippini et al., meta-analysis of RCT (2017)

## OMEGA-3 FATTY ACIDS

- Omega-3 fatty acids (EPA+DHA) (mean dose: 3.8g/day) reduce systolic and diastolic BP (1.52 and 0.99 mmHg, respectively). The strongest effects are observed among untreated hypertensive subjects.
- Ref: Miller et al., meta-analysis of RCT (2014)

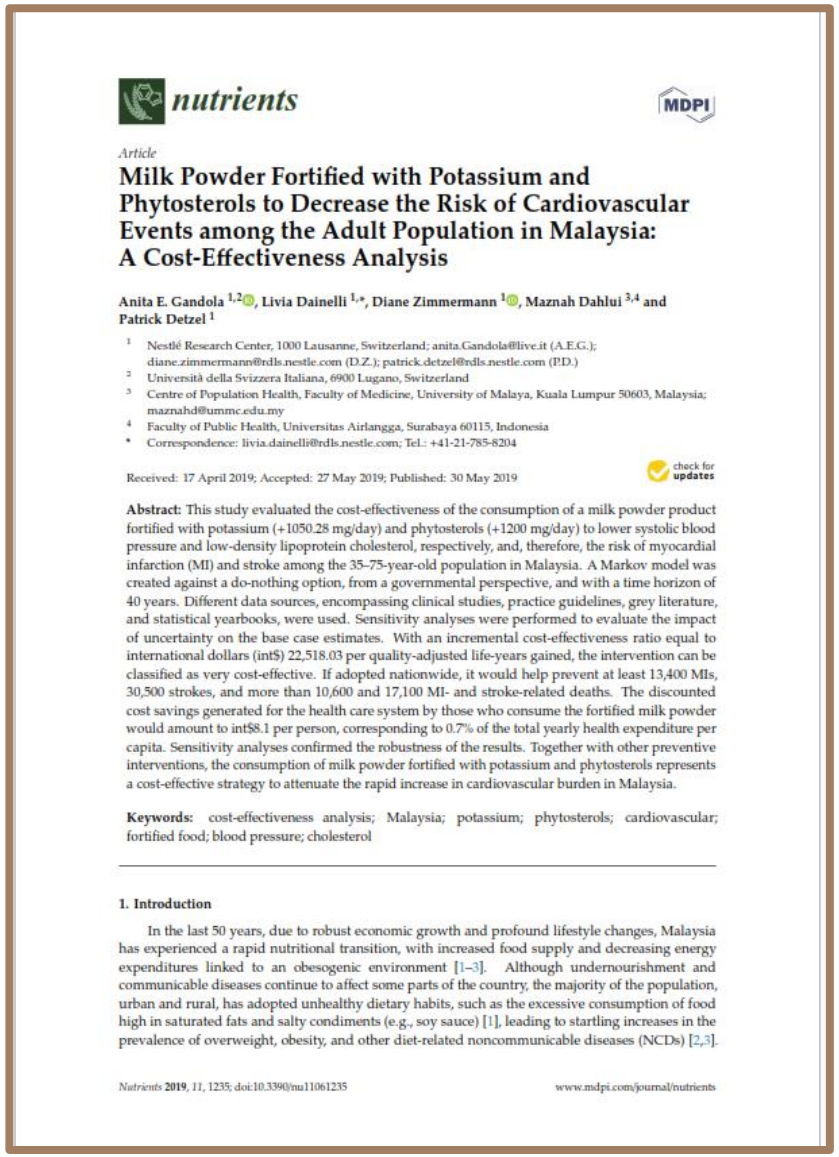
## DIETARY FIBRE

- Fiber intake, especially viscous soluble fiber (median dose: 8.7g/day) reduces systolic and diastolic BP (1.59 and 0.39 mmHg, respectively). Reductions in BP tended to be larger in older and in hypertensive populations than in younger and in normotensive ones.
- Ref: Streppel et al., meta-analysis of RCT (2005), Khan et al., meta-analysis of RCT (2018)

## VITAMIN C

- Vitamin C supplementation (median dose: 500 mg/day) reduces systolic and diastolic BP (3.84 and 1.48 mmHg, respectively).
- Ref: Juraschek et al., meta-analysis of RCT (2012)

# Cost-effectiveness analysis in Malaysia: Milk powder fortified with phytosterols & potassium



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MDPI

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**Milk Powder Fortified with Potassium and Phytosterols to Decrease the Risk of Cardiovascular Events among the Adult Population in Malaysia: A Cost-Effectiveness Analysis**


**Anita E. Gandola [1,2], Livia Dainelli [1,*], Diane Zimmermann [1], Maznah Dahlui [3,4] and Patrick Detzel [1]**

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Received: 17 April 2019; Accepted: 27 May 2019; Published: 30 May 2019

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**Abstract:** This study evaluated the cost-effectiveness of the consumption of a milk powder product fortified with potassium (+1050.28 mg/day) and phytosterols (+1200 mg/day) to lower systolic blood pressure and low-density lipoprotein cholesterol, respectively, and, therefore, the risk of myocardial infarction (MI) and stroke among the 35–75-year-old population in Malaysia. A Markov model was created against a do-nothing option, from a governmental perspective, and with a time horizon of 40 years. Different data sources, encompassing clinical studies, practice guidelines, grey literature, and statistical yearbooks, were used. Sensitivity analyses were performed to evaluate the impact of uncertainty on the base case estimates. With an incremental cost-effectiveness ratio equal to international dollars (int$) 22,518.03 per quality-adjusted life-years gained, the intervention can be classified as very cost-effective. If adopted nationwide, it would help prevent at least 13,400 MIs, 30,500 strokes, and more than 10,600 and 17,100 MI- and stroke-related deaths. The discounted cost savings generated for the health care system by those who consume the fortified milk powder would amount to int$8.1 per person, corresponding to 0.7% of the total yearly health expenditure per capita. Sensitivity analyses confirmed the robustness of the results. Together with other preventive interventions, the consumption of milk powder fortified with potassium and phytosterols represents a cost-effective strategy to attenuate the rapid increase in cardiovascular burden in Malaysia.



**Keywords:** cost-effectiveness analysis; Malaysia; potassium; phytosterols; cardiovascular; fortified food; blood pressure; cholesterol


**1. Introduction**

In the last 50 years, due to robust economic growth and profound lifestyle changes, Malaysia has experienced a rapid nutritional transition, with increased food supply and decreasing energy expenditures linked to an obesogenic environment [1–3]. Although undernourishment and communicable diseases continue to affect some parts of the country, the majority of the population, urban and rural, has adopted unhealthy dietary habits, such as the excessive consumption of food high in saturated fats and salty condiments (e.g., soy sauce) [1], leading to startling increases in the prevalence of overweight, obesity, and other diet-related noncommunicable diseases (NCDs) [2,3].



**Our cost-effectiveness study showed that milk fortified with phytosterols and potassium lower cardiovascular risk in adult in Malaysia and can help prevent 30500 strokes over 40 years**

***External collaboration*** : Dr. Maznah Dahlui , Centre of Population Health, Faculty of Medicine, University of Malaya, Kuala Lumpur,

**Why potassium ?**
Diets high in potassium have been associated with a lower risk of raised blood pressure.

**Why Phytosterols ?**
Phytosterols have been shown to lower blood cholesterol level.

**What does 'cost-effectiveness study' mean?**
Study found that consumption of milk powder fortified with potassium and phytosterols **would help prevent at least 13400 myocardial infarction (MI) (-7%), 30500 strokes (-20%), and more than 10600 and 17100 MI- and stroke-related deaths over 40 years, respectively.**

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# Key functional ingredients targeting endothelial function (blood flow)

## COCOA FLAVANOLS

- Cocoa flavanols (200 mg/day) contribute to the maintenance of normal endothelium-dependent vasodilation.
- Ref: EFSA scientific opinion (2014)

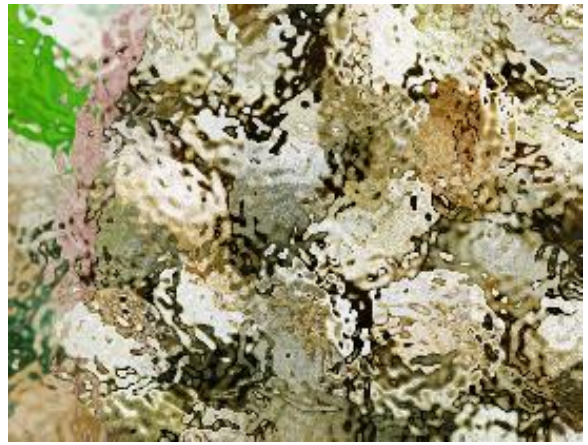
## WALNUTS

- Consumption of walnuts (30g/day) contributes to the maintenance of normal endothelium-dependent vasodilation.
- Ref: EFSA scientific opinion (2011)

## BEETROOT

- Inorganic nitrate and beetroot consumption is associated with an improvement in vascular function. These effects appear to be reduced in older subjects and in subjects with greater cardiometabolic risk.
- Ref: Lara et al., meta-analysis of RCT (2016)

## COFFEE POLYPHENOLS



- Short-term coffee intake seems to beneficially influence the endothelial function (as measured by flow-mediated dilation). These effects could be mediated by coffee chlorogenic acids.
- Ref: Jafari Azad et al., meta-analysis of RCT (2020), Mills et al., RCT (2017)

# Coffee intake acutely improves human vascular function

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Randomized Control Trials

## Mediation of coffee-induced improvements in human vascular function by chlorogenic acids and its metabolites: Two randomized, controlled, crossover intervention trials

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SUMMARY

*Background & aims:* Polyphenol intake has been linked to improvements in human vascular function, although data on hydroxycinnamates, such as chlorogenic acid (CGA) have not yet been studied. We aimed to investigate the impact of coffee intake rich in chlorogenic acid on human vascular function and whether CGAs are involved in potential effects.

*Methods:* Two acute randomized, controlled, cross-over human intervention trials were conducted. The impact of coffee intake, matched for caffeine but differing in CGA content (89, and 310 mg) on flow-mediated dilatation (FMD) was assessed in 15 healthy male subjects. In a second intervention trial conducted with 24 healthy male subjects, the impact of pure 5-caffeoylquinic acid (5-CQA), the main CGA in coffee (5-CQA: 450 mg and 900 mg) on FMD was also investigated.

*Results:* We observed a bi-phasic FMD response after low and high polyphenol (89 mg and 310 mg CGA) intake, with increases at 1 (1.10 ± 0.43% and 1.34 ± 0.62%, respectively) and 5 (0.79% ± 0.32 and 1.52% ± 0.40, respectively) hours post coffee consumption. FMD responses to coffee intake was closely paralleled by the appearance of CGA metabolites in plasma, notably 3-, 4- and 5-feruloylquinic acid and ferulic-4′-O-sulfate at 1 h and isoferulic-3′-O-glucuronide and ferulic-4′-O-sulfate at 5 h. Intervention with purified 5-CQA (450 mg) also led to an improvement in FMD response relative to control (0.75 ± 1.31% at 1 h post intervention, p = 0.06) and concomitant appearance of plasma metabolites.

*Conclusions:* Coffee intake acutely improves human vascular function, an effect, in part, mediated by 5-CQA and its physiological metabolites.

*Study registration:* The National Institutes of Health (NIH) on ClinicalTrials.gov NCT01813981 and NCT01772784.



*Abbreviations:* 3-CQA, 3-Caffeoylquinic acid; 3-FQA, 3 feruloylquinic acid; 4-CQA, 4-caffeoylquinic acid; 4-CQ1SL, 4-caffeoylquinic-1,5-lactone; 4-FQA, 4-feruloylquinic acid; 4-MeCinA, 4-methoxycinnamic acid; 5-CQA, 5-caffeoylquinic acid; 5-FQA, 5-feruloylquinic acid; Ach, acetylcholine; ANOVA, analysis of variance; C3S, caffeic-3′-O-sulfate; CA4S, caffeic-4′-O-sulfate; CGA, chlorogenic acid; CV, coefficient of variance; CE, collision cell entrance potential; CPX, collision cell entrance potential; DP, declustering potential; ESI, electrospray ionization; EDTA, ethylene-diamine-tetra-acetic acid; FA, ferulic acid; F4G, ferulic-4′-O-glucuronide; F4S, ferulic-4′-O-sulfate; FMD, flow mediated dilatation; HDL, high density lipoprotein; HSD, highest significant difference; HPC, high polyphenol coffee; IAUC, incremental area under the curve; iFA, isoferulic acid; iF3G, isoferulic-3′-O-glucuronide; iF3G, isoferulic-3′-O-glucuronide; iF4S, isoferulic-3′-O-sulfate; LDI, laser Doppler imaging; LC, liquid chromatography; LDL, low density lipoprotein; LPC, low polyphenol coffee; MS, mass spectrometry; mCo3S, m-coumaric acid-3′-O-sulfate; mCo3G, m-coumaric-3′-O-glucuronide; mCo3G, m-coumaric-3′-O-glucuronide; MeFA, methylferulic acid; NIH, National Institute of Health; NO, nitric oxide; PDBP, peripheral diastolic blood pressure; PSBP, peripheral systolic blood pressure; POC, proof of concept; SNP, sodium nitroprusside; SD, standard deviation; SEM, standard error of the mean.

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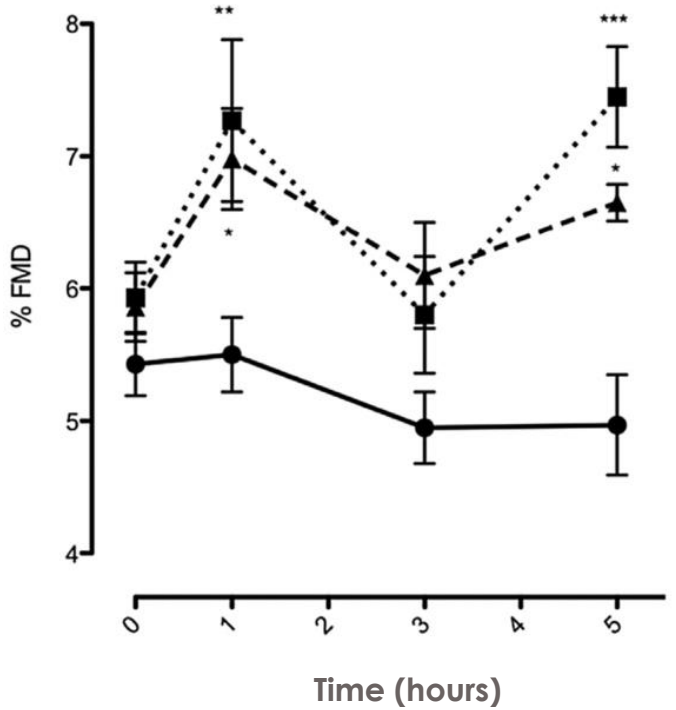
**Our intervention study showed that coffee intake rich in chlorogenic acid beneficially impacts the human vascular function, and suggested that compounds other than caffeine, likely chlorogenic acids and related metabolites may contribute to this effect.**

***External collaboration*** : Pr. Jeremy Spencer, Department of Food and Nutritional Sciences, School of Chemistry, Food and Pharmacy, University of Reading, UK




**Another manuscript submitted for publication (2020)**



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