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Milk Processing, the Dairy Matrix and Health: What Does the Evidence Tell Us?

Prof Renée Blaauw

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Discussion points

- Dietary risk factors for disease burden.
- Dairy and its relevance to health outcomes.
 - Uniqueness of the dairy matrix.
 - Factors impacting role of dairy in health outcomes
- Current evidence linking dairy intake to chronic disease risk.
- Role of dairy within healthy dietary patterns.
- Practical implications for healthcare professionals.

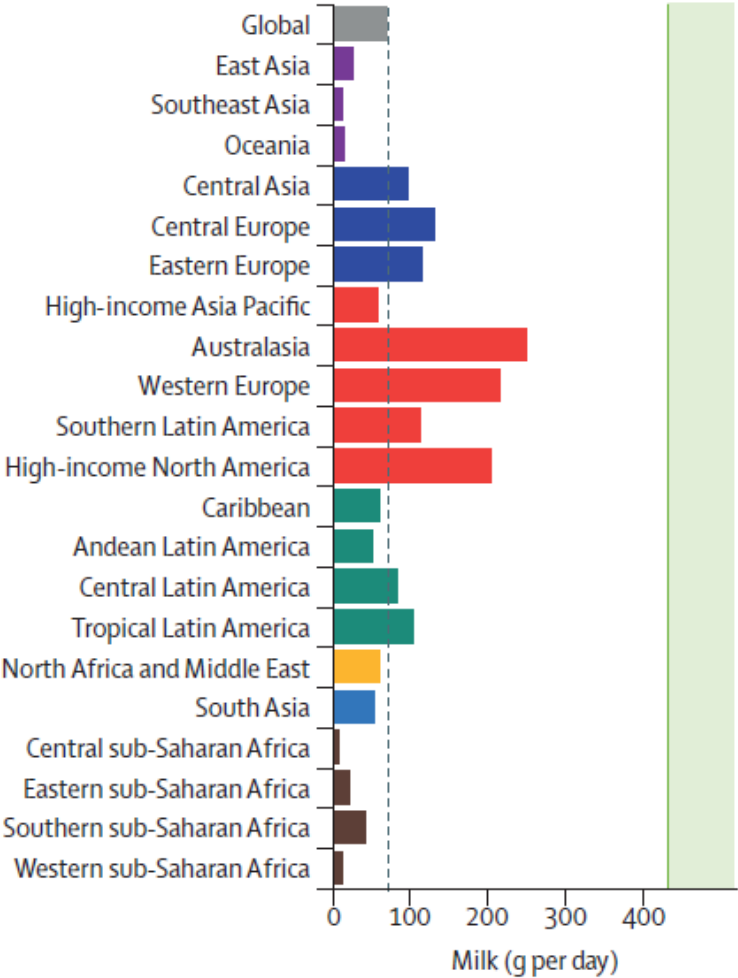
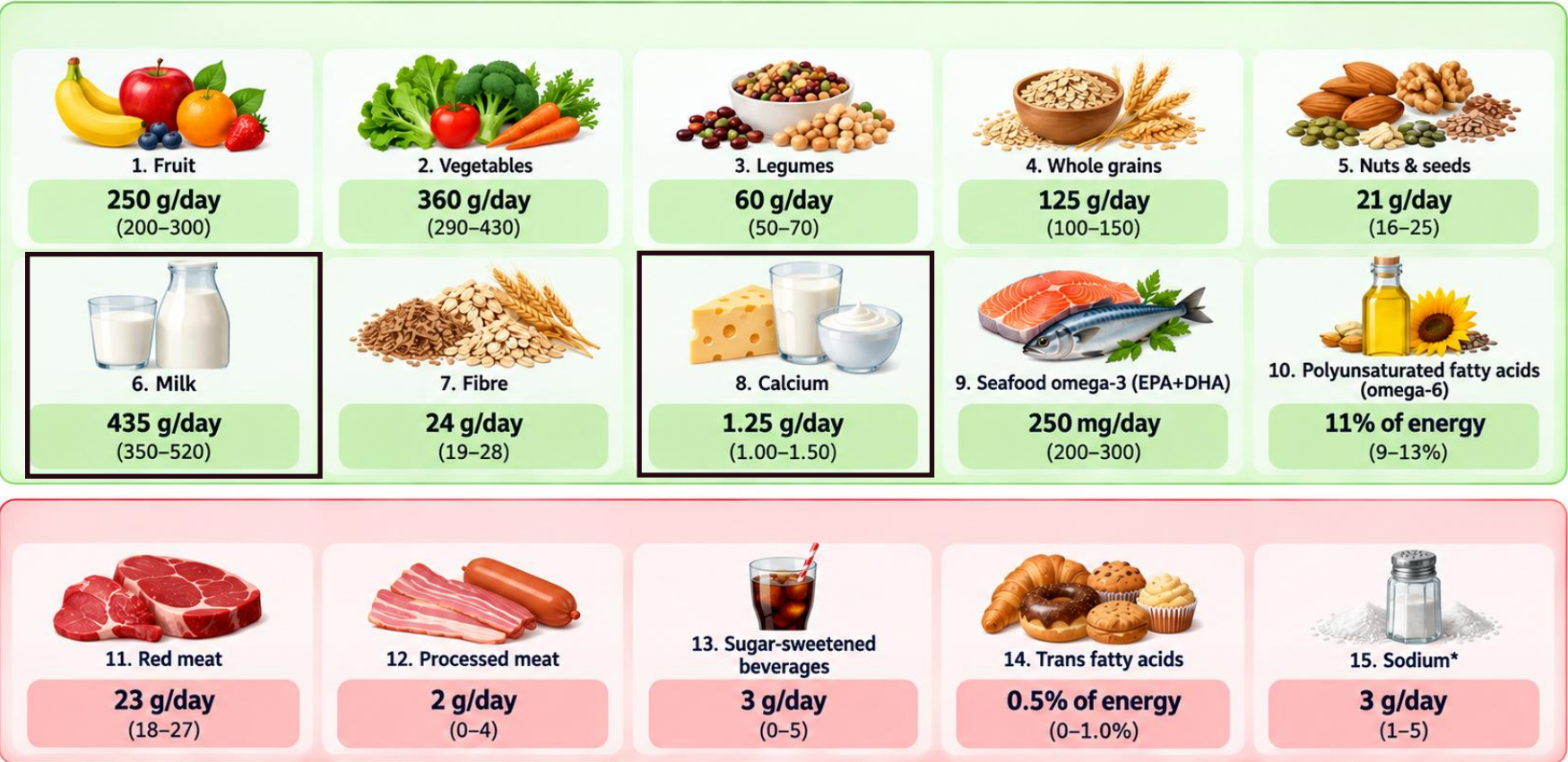
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Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017

15 dietary risk factors: optimal intake levels

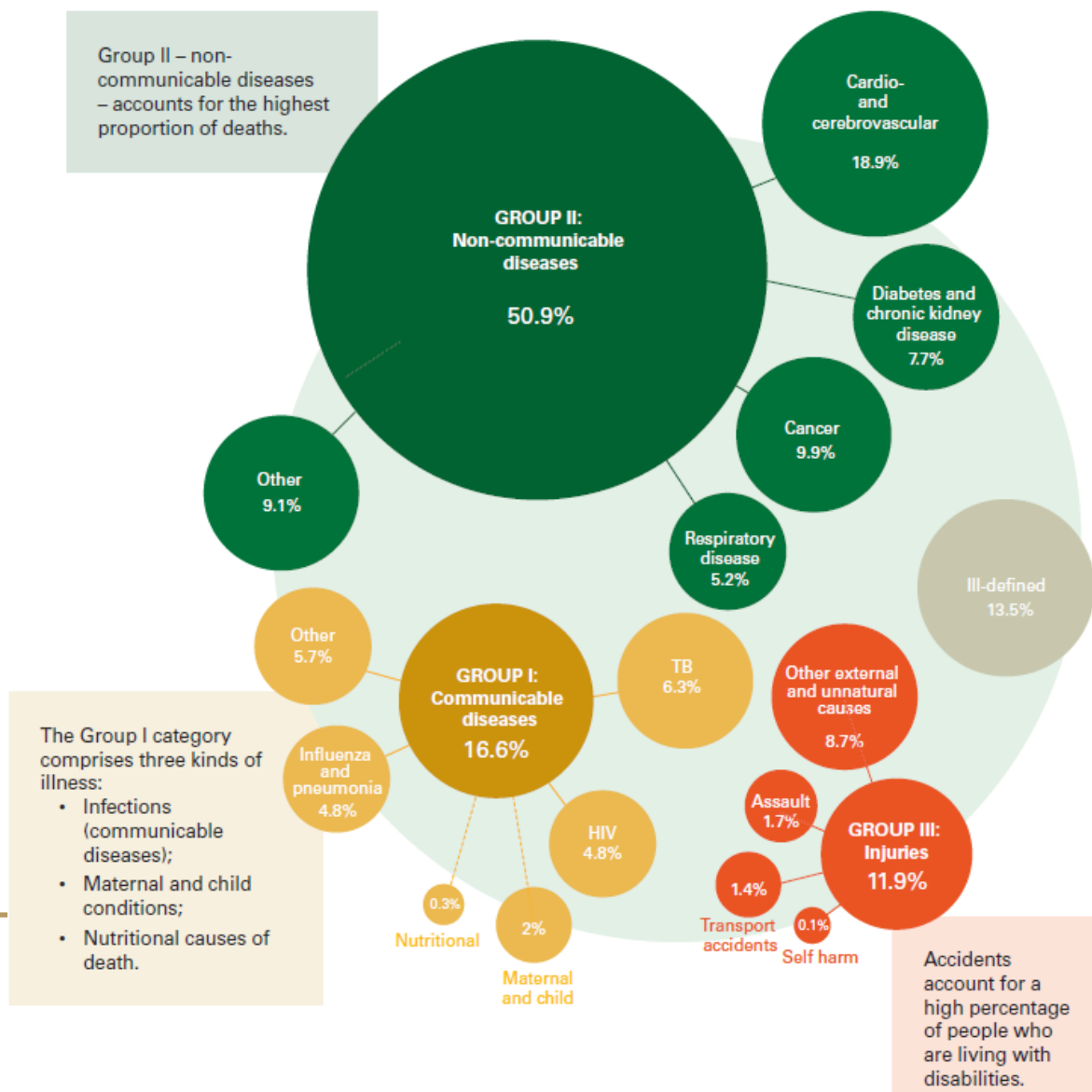
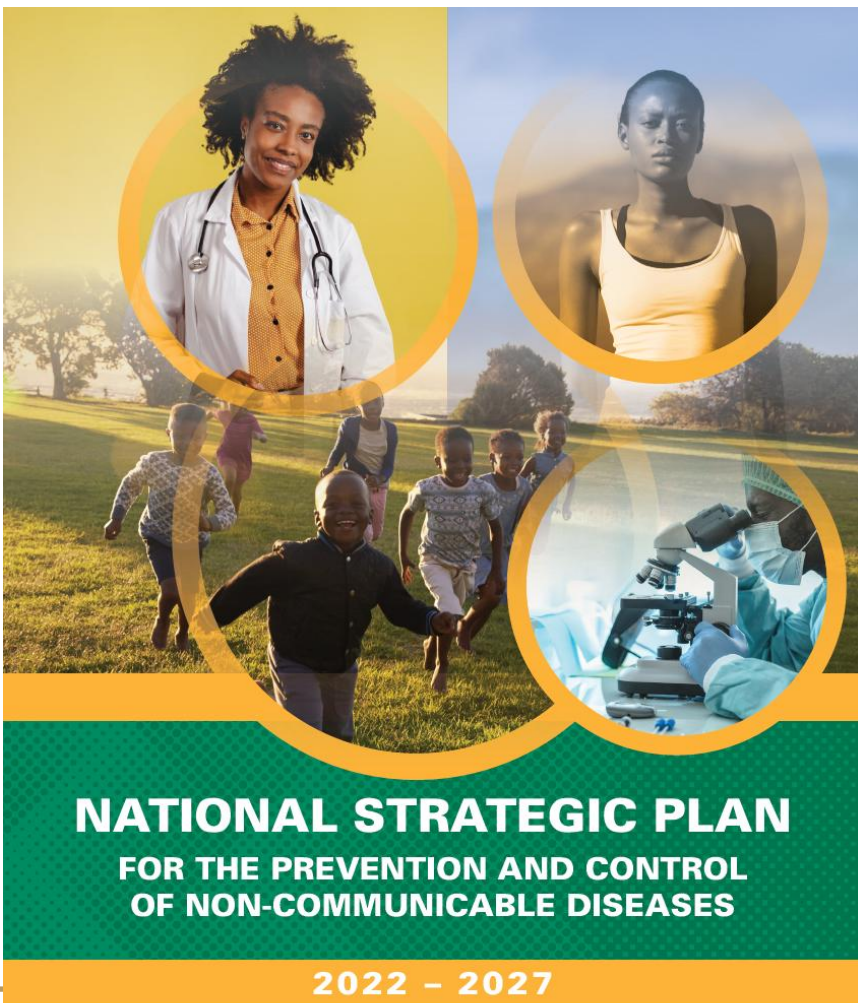
Theoretical minimum-risk exposure levels used in GBD 2017



Source: GBD 2017 Diet Collaborators. *Lancet*. 2019;393:1958–1972. doi:10.1016/S0140-6736(19)30041-8.

*The GBD analysis used a broad 1–5 g/day uncertainty range for sodium.

Non-communicable disease burden in SA



Cardiometabolic risk factors

Dyslipidemia

Raised LDL-
cholesterol

Decreased HDL-
cholesterol

Raised Triglycerides

Clinical features

Insulin resistance

Subclinical
inflammation

Hypertension

Vascular dysfunction

Impaired coagulation

Lifestyle-related

Obesity

Inactivity

Smoking

Alcohol

Unhealthy diet

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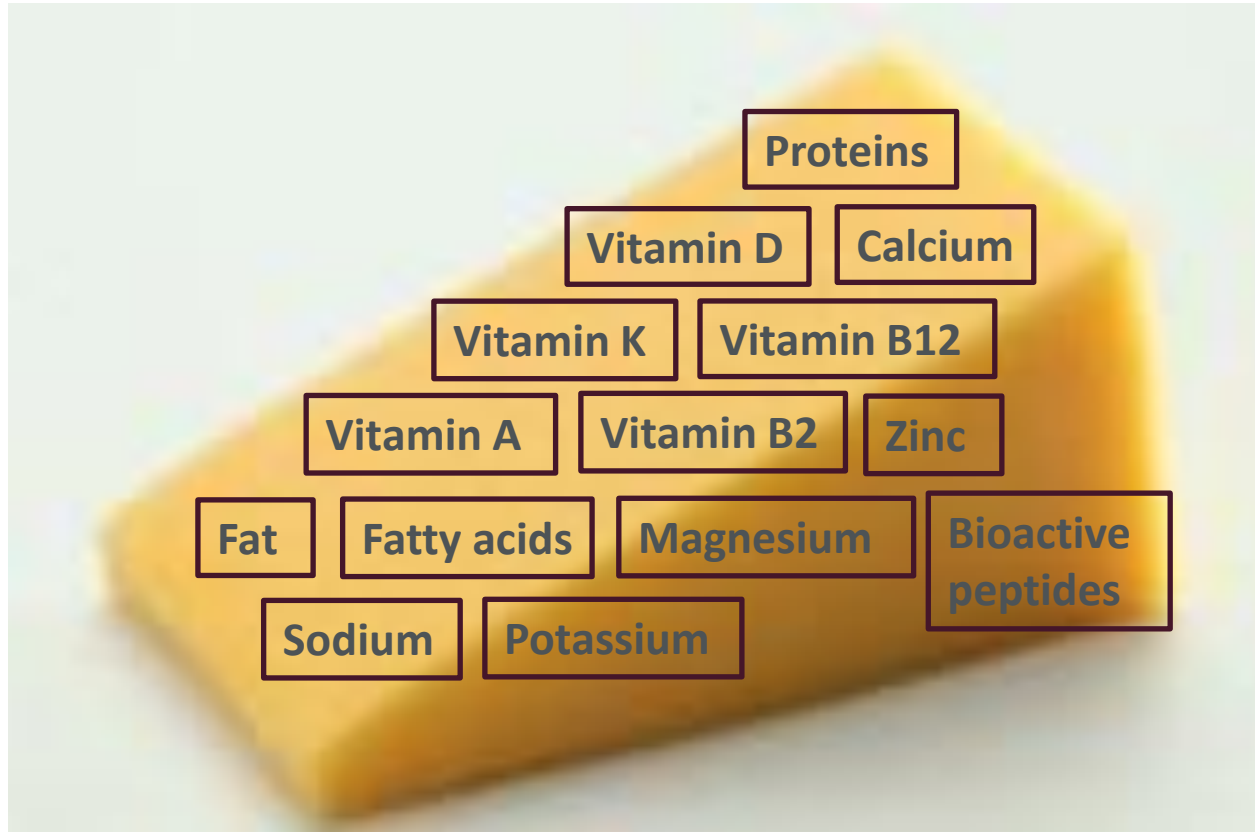
Nutritional composition of dairy



Fat

Fatty acids

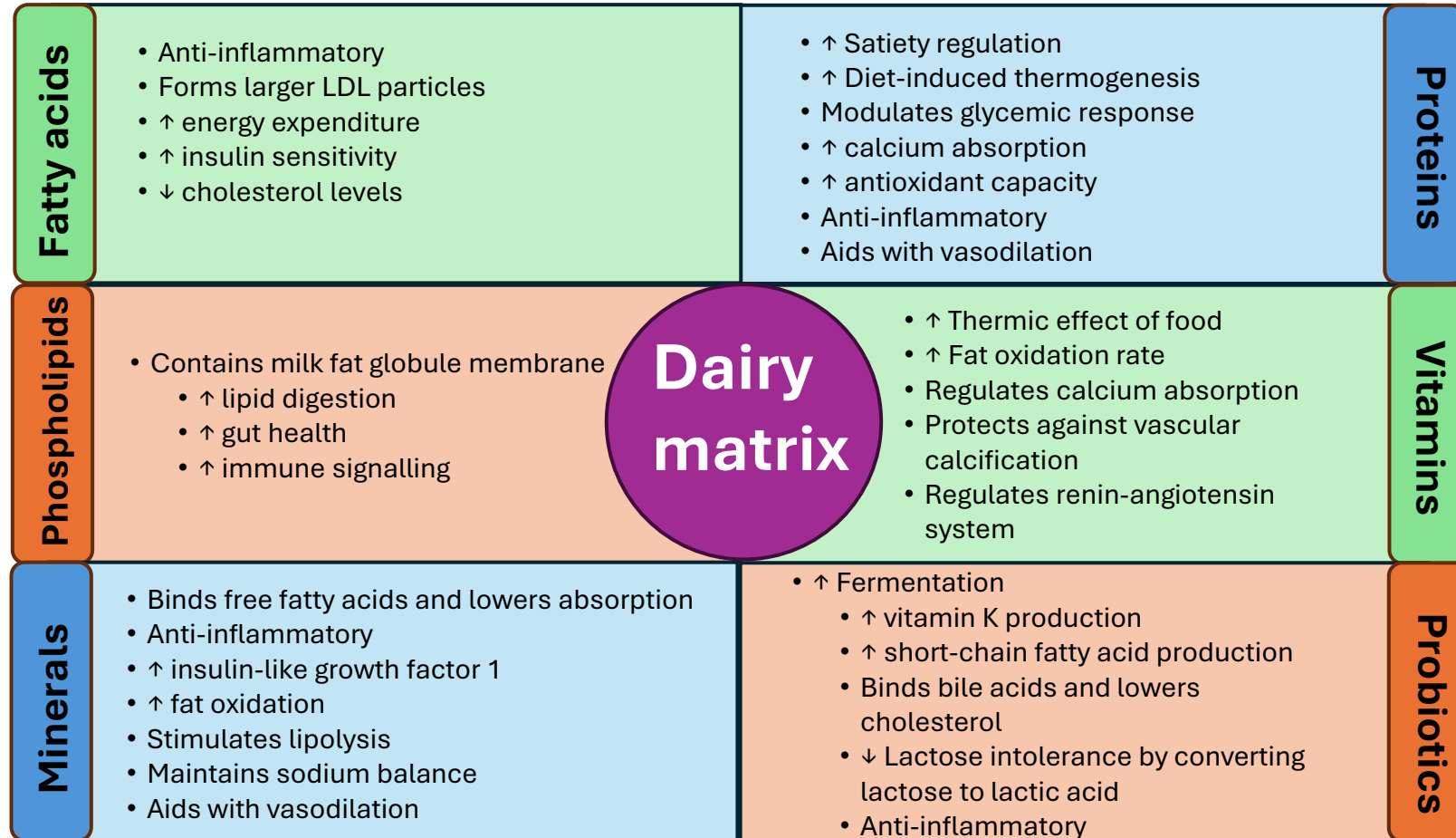
Nutritional composition of dairy



Dairy matrix

“the unique structure of a dairy food, its components (e.g., nutrients and non-nutrients), and how they interact”

Dairy matrix

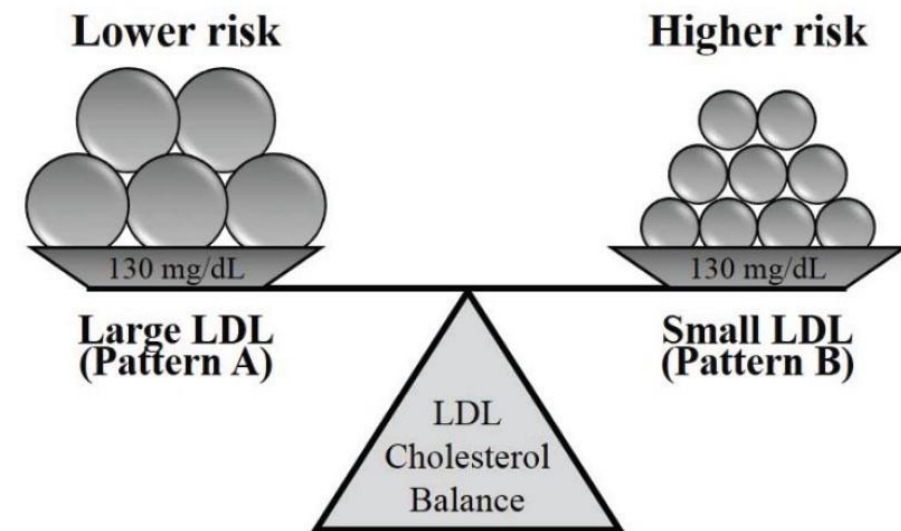


Discussion points

- Dietary risk factors for disease burden.
- Dairy and its relevance to health outcomes.
 - Uniqueness of the dairy matrix.
 - Factors impacting role of dairy in health outcomes
 - LDL-cholesterol particle size
 - Role of fermentation
 - Effect of inflammation
 - Nutrient adequacy
 - Frequency of intake
 - Milk processing
- Current evidence linking dairy intake to chronic disease risk.
- Role of dairy within healthy dietary patterns.
- Practical implications for healthcare professionals.

LDL-cholesterol Particle size

- Although intake of saturated fatty acids in **dairy products** leads to an increase in LDL-cholesterol, it does not increase the amount of small, dense particles, but rather the formation of **larger LDL particles**.
- Larger LDL particles are less atherogenic and thus less strongly linked to CVD due to
 - higher affinity for LDL receptors
 - decreased susceptibility to oxidation



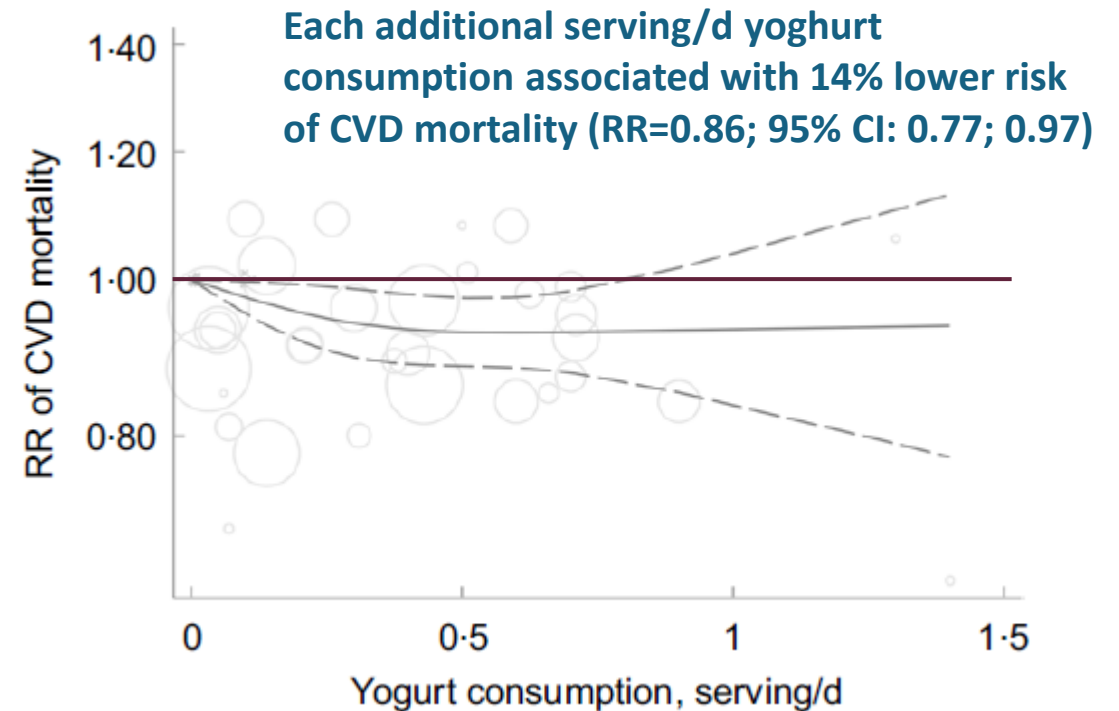
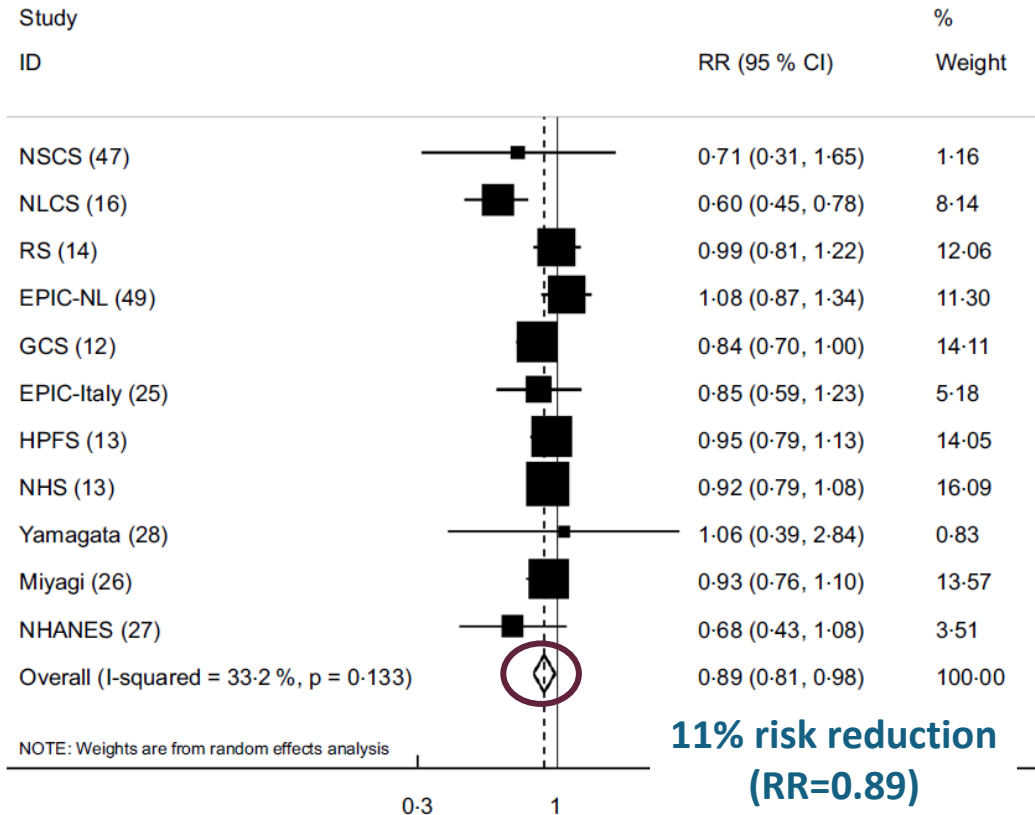
CVD = Cardiovascular disease; LDL = Low density lipoprotein

Role of fermentation and fermented foods

- **Fermentation assists with reducing inflammation**
 - Platelet-activating factor (PAF) is a pro-inflammatory phospholipid and dairy contains PAF inhibitors. As the level of fermentation increases, the PAF inhibitor activity increases.
- Fermented dairy products associated with:
 - Production of SCFA, especially butyrate (improve gut health; regulate cholesterol metabolism)
 - Increased calcium intake (binds free fatty acids)
 - High-quality protein (appetite control, increased satiety, diet-induced thermogenesis)
 - Vitamin K2 (protects against vascular calcification, increases calcium absorption)
 - Improved lactose intolerance (converts lactose to lactic acid)
 - Improved food security (extending shelf-life of products)

SCFA = Short-chain fatty acids

Yoghurt consumption and CVD mortality



Inverse association between yoghurt consumption and CVD mortality

CVD = Cardiovascular disease; RR = Relative risk

Effect on inflammation

- The presence of low-grade inflammation are linked to the development of CVD, MS, T2DM
- Long-chain SFA [palmitic (C16:0) and stearic (C18:0) acid] found in dairy products, have pro-inflammatory effects.
- However, intake of dairy
 - leads to lower levels of CRP, TNF α , IL6 and IL13
 - a neutral or beneficial effect on inflammation
 - Mainly found to overweight / obese populations
- Potential mechanisms by which dairy foods regulate immune function:
 - Improving intestinal barrier function
 - Stimulating immunocytes, which regulates flux of metabolites into the bloodstream
 - **Through dairy matrix, it modulates the effect of dairy fat and chronic disease risk**

CVD = Cardiovascular disease; MS = Metabolic syndrome; T2DM = Type 2 diabetes Mellitus; SFA = Saturated fatty acid, CRP = C-reactive protein; TNF = Tumor necrosis factor; IL – interleukin

Frequency of intake



Ma et al. *Nutrition & Metabolism* (2025) 22:156
<https://doi.org/10.1186/s12986-025-01060-6>

Nutrition & Metabolism

RESEARCH

Open Access



Dairy consumption and cardiovascular disease risk: a multi-level analysis with inflammatory biomarker mediation

Dose-response effect

Association with CVD incidence	Odds ratio (95% CI)	P-value
Rarely (less than 1 / week)	Reference	
Sometimes (at least weekly)	0.87 (0.77; 0.98)	0.019
Often (daily)	0.78 (0.69; 0.87)	<0.001

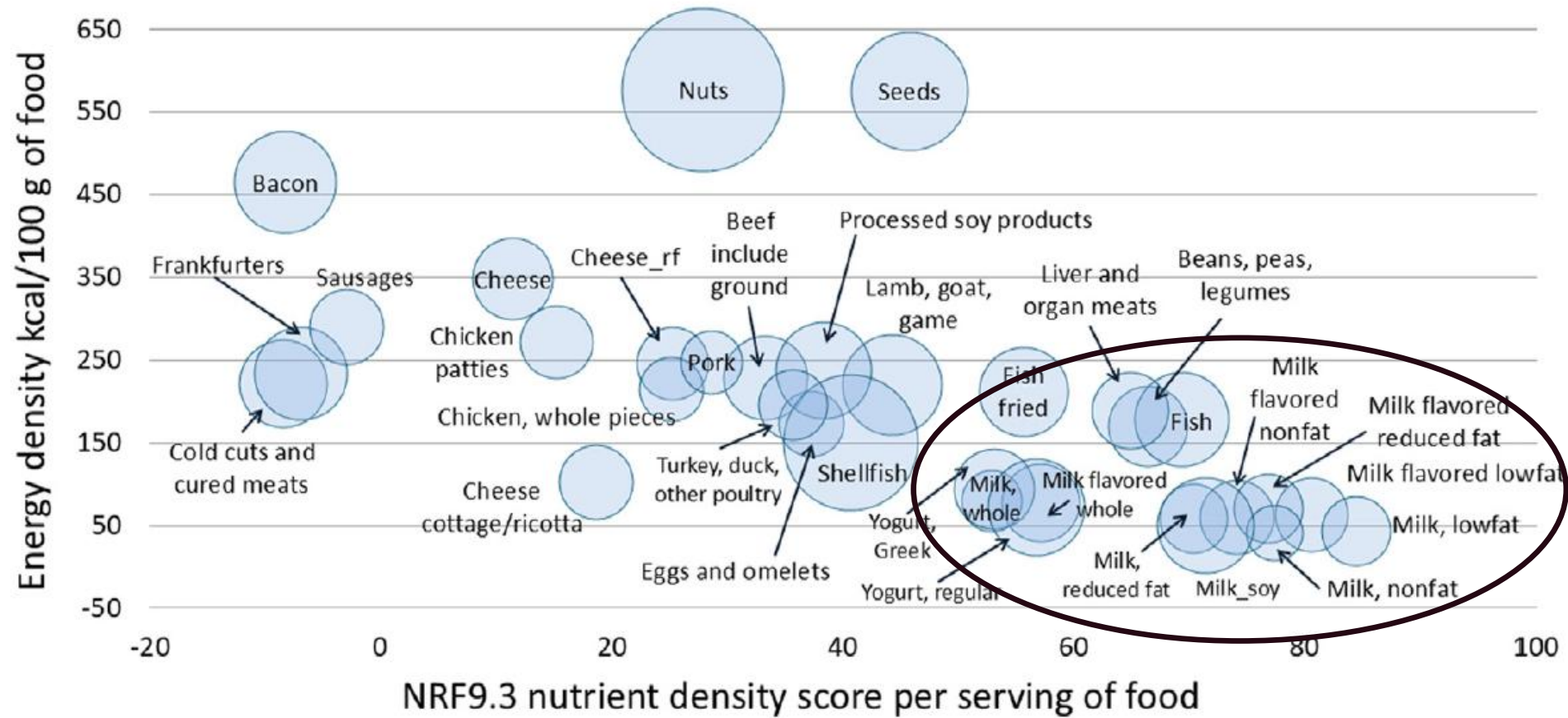
Duoyu Ma^{1†}, Xinyi Cheng^{1†}, Qing Fang¹, Shunyu Ni¹, Fan Wang¹ and Pengfei Hu^{2*}

- Milk intake offered protective effect against CVD, CHD and heart attack
 - Potentially through reduction in inflammatory biomarkers.
- Dose-response effect.

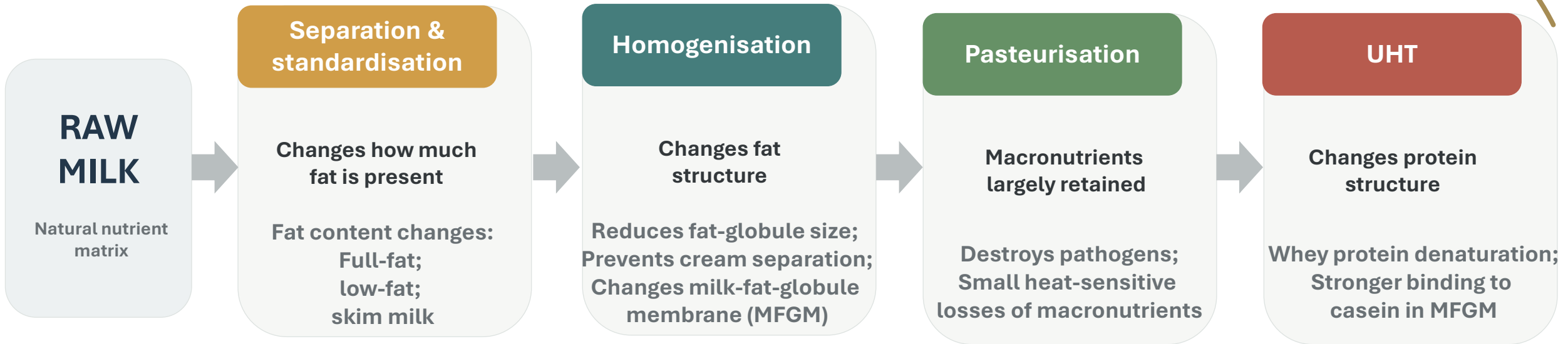
Frequency of milk intake, irrespective of fat content, was key determinant of CVD

CVD = Cardiovascular disease; CHD = Coronary heart disease

Nutrient adequacy



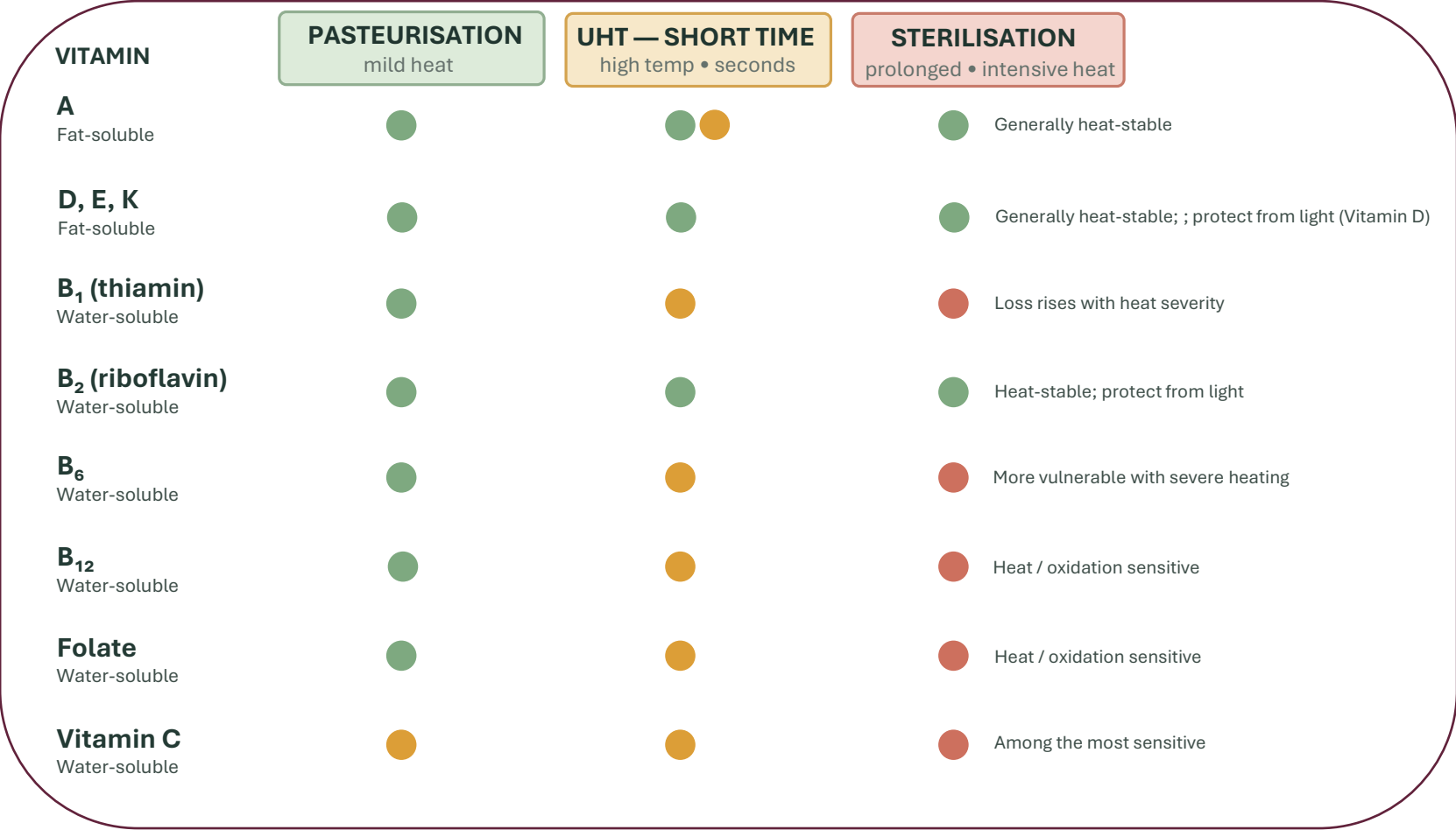
Milk processing and macronutrients



Macronutrient content is largely retained, while the physical dairy matrix is progressively modified.

UHT = Ultra-high temperature

Effect of heat treatment on vitamins of milk



Heat Treatments	Temperature–Time Combination Required	Time
Thermization	57–68 °C	5 s–30 min
Flash pasteurization	72–80 °C	15–30 s
Extended shelf life pasteurization (ESLP)	125–140 °C	1–10 s
HTST	72–74 °C	15–20 s
Ultra-high-temperature (UHT) indirect heating	130–145 °C	5–20 s
Ultra-high-temperature (UHT) direct heating	142–150 °C	2–6 s
Sterilization	110–120 °C or 125 °C	10–20 min 5 min
Innovative steam injection (ISI)	160–180 °C	0.1 s

● stable / minimal change ● increasing vulnerability ● greatest concern with severe heat

Effect of heat treatment on vitamins of milk



VITAMIN	PASTEURISATION mild heat	UHT — SHORT TIME high temp • seconds	STERILISATION prolonged • intensive heat
A Fat-soluble	●	●●	● Generally heat-stable
D, E, K Fat-soluble	●	●	● Generally heat-stable; ; protect from light (Vitamin D)
B₁ (thiamin) Water-soluble	●	●	● Loss rises with heat severity
B₂ (riboflavin) Water-soluble	●	●	● Heat-stable; protect from light
B₆ Water-soluble	●	●	● More vulnerable with severe heating
B₁₂ Water-soluble	●	●	● Heat / oxidation sensitive
Folate Water-soluble	●	●	● Heat / oxidation sensitive
Vitamin C Water-soluble	●	●	● Among the most sensitive

THE IMPORTANT NUANCE

- **Pasteurisation**
Usually causes little change in most vitamins.
 - **Short-time UHT**
Preserves most vitamins relatively well.
 - **Severe heating**
Disproportionately affects water-soluble vitamins.
-
- After processing**
Light + packaging materials + storage duration can be more destructive than heat itself.

● stable / minimal change ● increasing vulnerability ● greatest concern with severe heat

Effect of heat treatment on micronutrients of milk

- Stable / minimal change
- Some processing-related change
- Heat / oxidation sensitive
- Especially light-sensitive

VITAMINS

MOST SENSITIVE

- Fat-soluble D, E, K → relatively stable
- Water-soluble vitamins → vulnerability rises with heat severity
- A, C, B₁, B₆, B₉, B₁₂ → more heat/oxidation-sensitive
- B₂ (riboflavin) → especially vulnerable to light exposure

MINERALS

HIGH STABILITY

- Ca, P, Mg, Na, K → not “destroyed” by heat
- Pasteurisation / short-time UHT → little overall change
- Severe heating → small losses can occur through precipitation / deposits
- Heat can alter mineral partitioning between soluble and colloidal phases

TRACE ELEMENTS

HIGH STABILITY

- Zn, Fe, Cu, Se → intrinsically heat-stable elements
- Direct thermal destruction is not expected
- Processing may redistribute elements through protein/mineral interactions
- Severe processing can contribute to minor losses with precipitated solids

Pasteurisation and short-time UHT preserve most micronutrients.

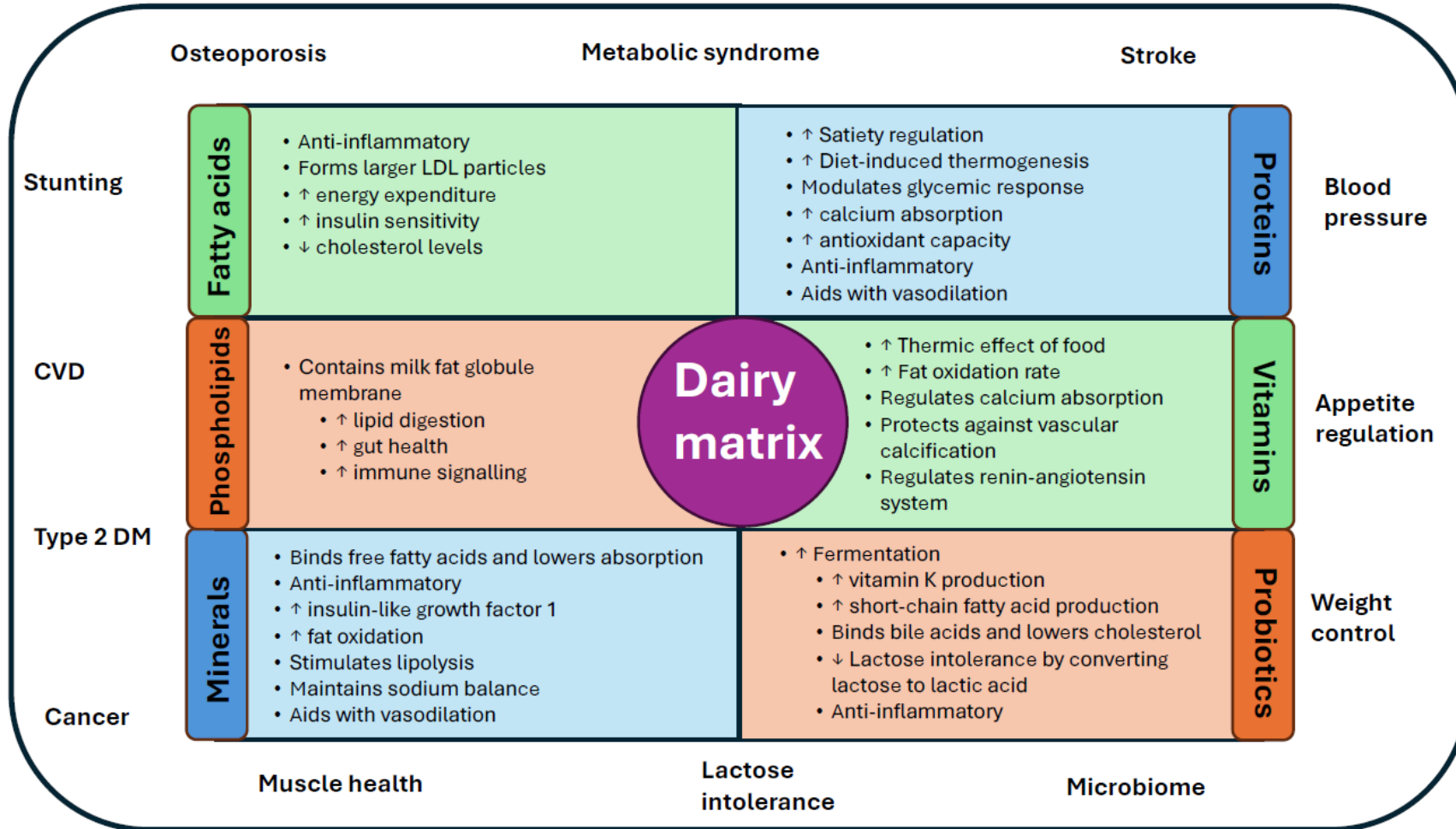
Loss of micronutrients can occur due to subsequent exposure to light and prolonged storage.

UHT = Ultra-high temperature

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Dairy matrix health effect



Dairy matrix health effects

refers to the impact of a dairy food on health that extends beyond its individual components.

Health benefits

281 health-related associations:

Reduced risk: 37,7%

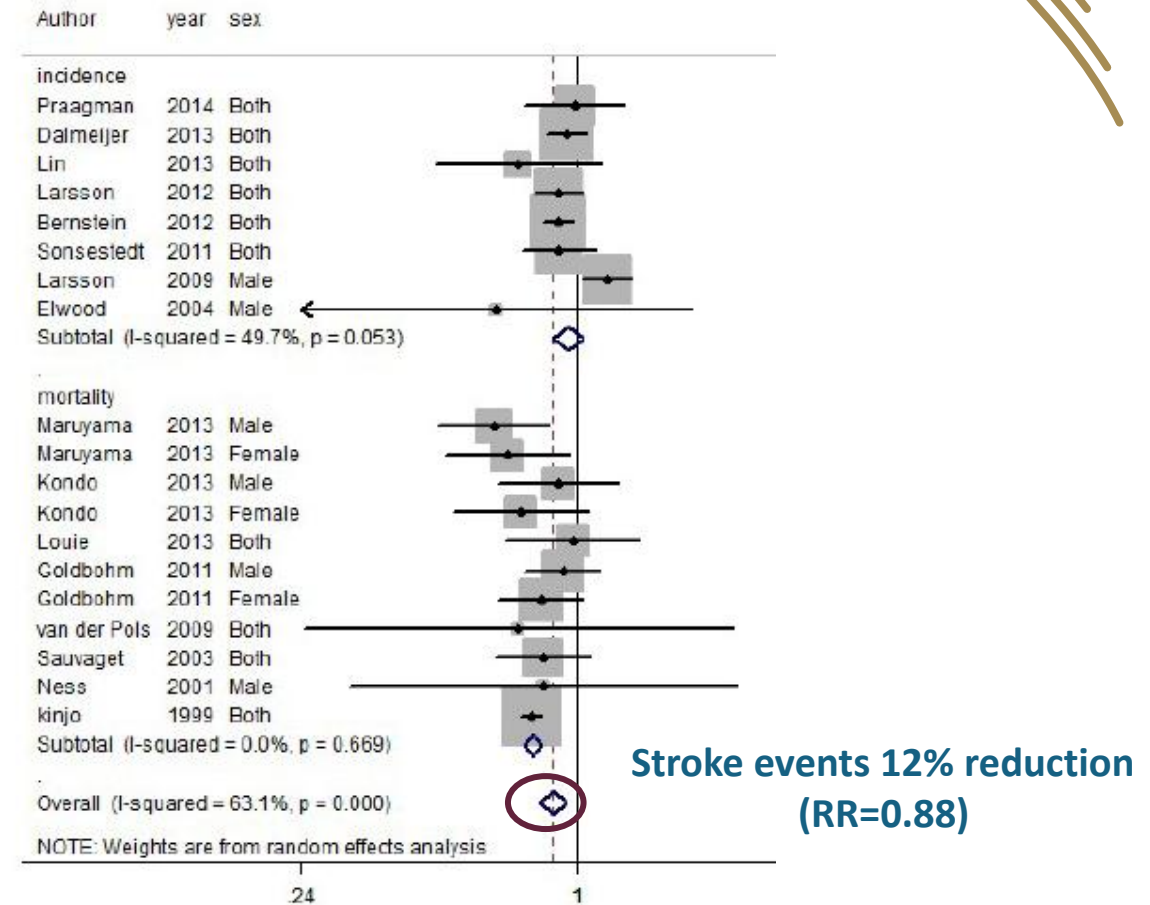
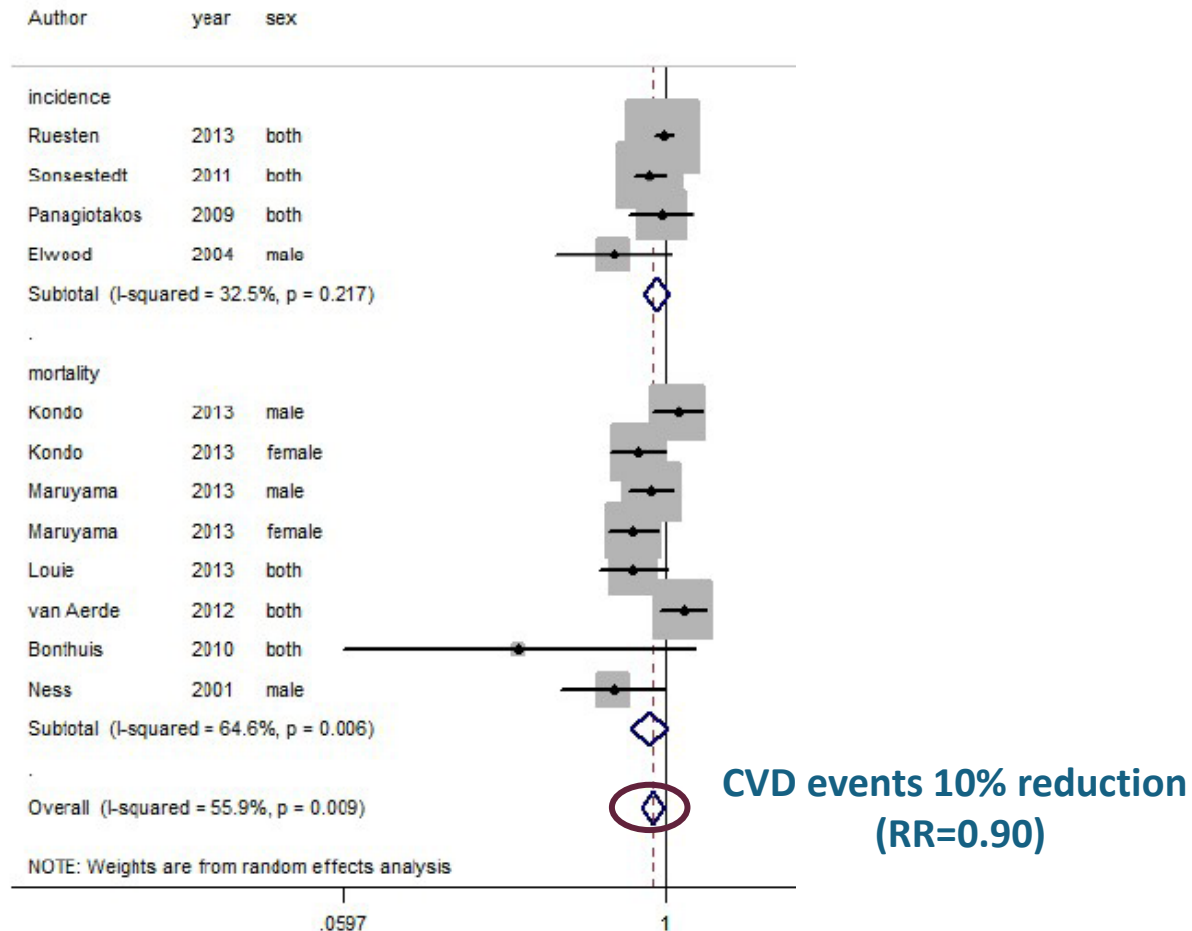
No association: 48,0%

Inconclusive: 10,0%

Increased outcome: 4,3%

Health outcome	Dairy*				Milk				Cheese				Yogurt				Fermented dairy**			
	↓	∅	↑	↔	↓	∅	↑	↔	↓	∅	↑	↔	↓	∅	↑	↔	↓	∅	↑	↔
Cardiovascular outcomes																				
CVD	3	2				1			3	1			1	3			2			
CHD	1	7				5			4	2		1		3		1		1		
Stroke	7	1			2	5		1	6	1		1		2		1	1			
Hypertension/HBP	4	1			2			1		2		1		2		1	1	1		
Cancers																				
Bladder	1	1			2	2		1		3			2	1			2			
Breast	3	2				4	1		1	1			2	2			1			
Colorectal	5				2	2			3	3			3	1		1	1	2		
Corpus uteri		2				2				1										
Esophagus		2				2				1			1				1			
Kidney		1				1														
Leukemia		1																		
Liver		2	1			2	1			2		1	2	1						
Lung		2				1														
Non-Hodgkin lymphoma			1				1			1				1						
Oral	1	1			2				1				1							
Ovarian		1	1			2			1					1						
Pancreatic						1				1				1						
Prostate		1	1			1	1				1			1						
Stomach/gastric		2	1	1		2		1		1				1						
All cancers																	1			
Body composition																				
Weight gain	1	2											1							
Overweight	1	1			1									1						
Obesity	1	1			1									1						
Mortality																				
All-cause mortality		3				4		1		3			2	1			1		1	
CV mortality		1		1		1		1					2							
Others																				
T2DM	6	1			1	3				2	1		6				2			
Joint health	1	1																		
Bone health				3		1		2	1			2	2			1				
Cognitive outcomes		1		1		1		2				1								

Health benefits: Total dairy intake and CVD risk



Health benefits: Milk fat content and CVD risk



Table I. Association between milk consumption with different fat content and **CHD**

Milk type	Model 1		Model 2		Model 3		Model 4	
	OR (95 % CI)	p value	OR (95 % CI)	p value	OR (95 % CI)	p value	OR (95 % CI)	p value
Skimmed milk	Ref		Ref		Ref		Ref	
Low-fat milk	0.844 (0.605-1.176)	0.31	0.794 (0.567-1.111)	0.18	0.796 (0.553-1.146)	0.22	0.776 (0.538-1.118)	0.17
Reduced-fat milk	0.881 (0.702-1.107)	0.27	0.781 (0.615-0.991)	0.042	0.686 (0.521-0.903)	0.008	0.668 (0.502-0.890)	0.006
Whole milk	0.793 (0.597-1.0523)	0.11	0.685 (0.498-0.942)	0.020	0.601 (0.434-0.833)	0.003	0.582 (0.418-0.810)	0.002
p for trend		0.15		0.026		0.002		0.002

Table II. Association between milk consumption with different fat content and **stroke**

Milk type	Model 1		Model 2		Model 3		Model 4	
	OR (95 % CI)	p value	OR (95 % CI)	p value	OR (95 % CI)	p value	OR (95 % CI)	p value
Skimmed milk	Ref		Ref		Ref		Ref	
Low-fat milk	1.214 (0.784-1.881)	0.38	1.153 (0.748-1.776)	0.51	1.254 (0.819-1.918)	0.29	1.238 (0.813-1.886)	0.31
Reduced-fat milk	1.438 (1.003-2.062)	0.048	1.247 (0.866-1.795)	0.23	1.215 (0.838-1.763)	0.30	1.151 (0.799-1.660)	0.44
Whole milk	1.941 (1.294-2.912)	0.002	1.625 (1.055-2.502)	0.028	1.709 (1.108-2.638)	0.016	1.586 (1.023-2.457)	0.039
p for trend		0.001		0.027		0.022		0.06

- **Contrasting information** between CHD and stroke regarding whole milk compared to skimmed milk:
 - Whole milk linked with reduced prevalence of CHD and increased prevalence of stroke
 - Protective effect on CHD more pronounced in individuals > 65 years of age

CVD = Cardiovascular disease; CHD = Coronary heart disease

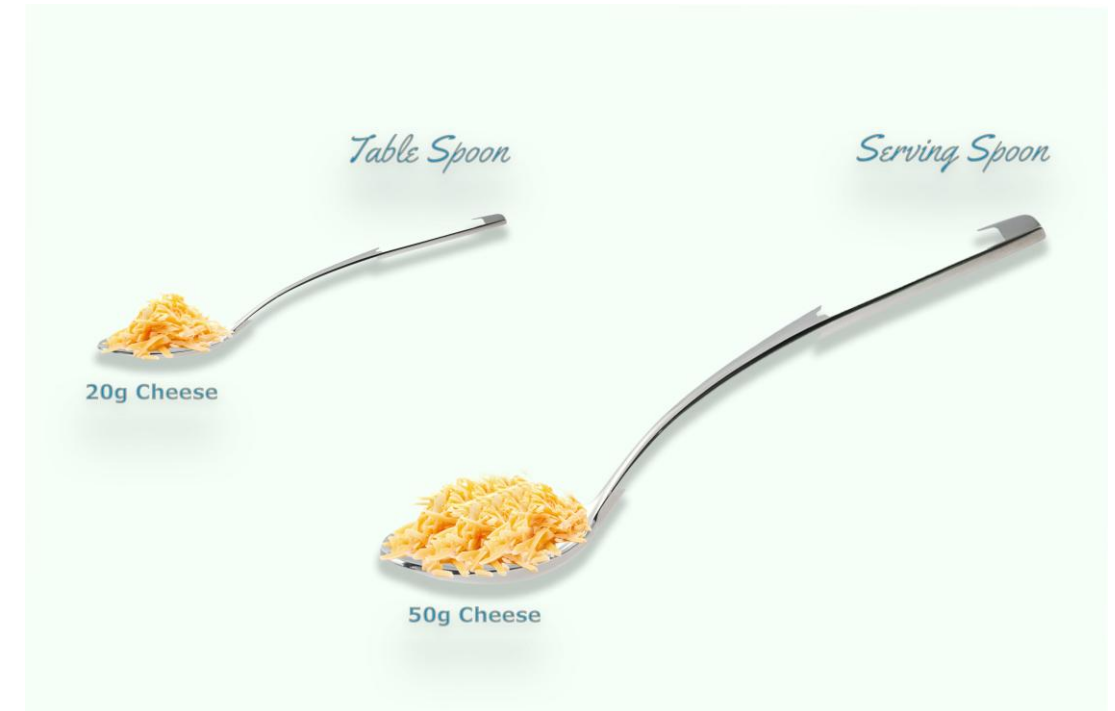
Health benefits: Dose-response of dairy and CVD

Review

Consumption of Dairy Foods and Cardiovascular Disease: A Systematic Review

Annalisa Giosuè ^{1,†} , Ilaria Calabrese ^{1,†} , Marilena Vitale ¹ , Gabriele Riccardi ¹ and Olga Vaccaro ^{2,*} 

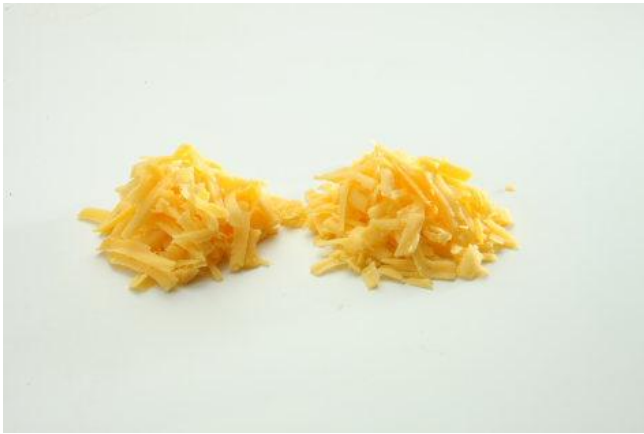
Cheese	
Portion size	Risk reduction
10 g per day	2%
20 g per day	4%
50 g per day	10-14%



CVD = Cardiovascular disease

Health benefits: Dose-response of dairy and CVD

- For **healthy individuals with a normal serum cholesterol** level:
 - Total dairy intake (full-fat or low-fat products): up to 200g per day
 - Milk intake: up to 200ml per day
 - Yoghurt intake: $\pm$ 200g per day
 - Cheese consumption: up to 50g per day



Health benefits: Diabetes Mellitus

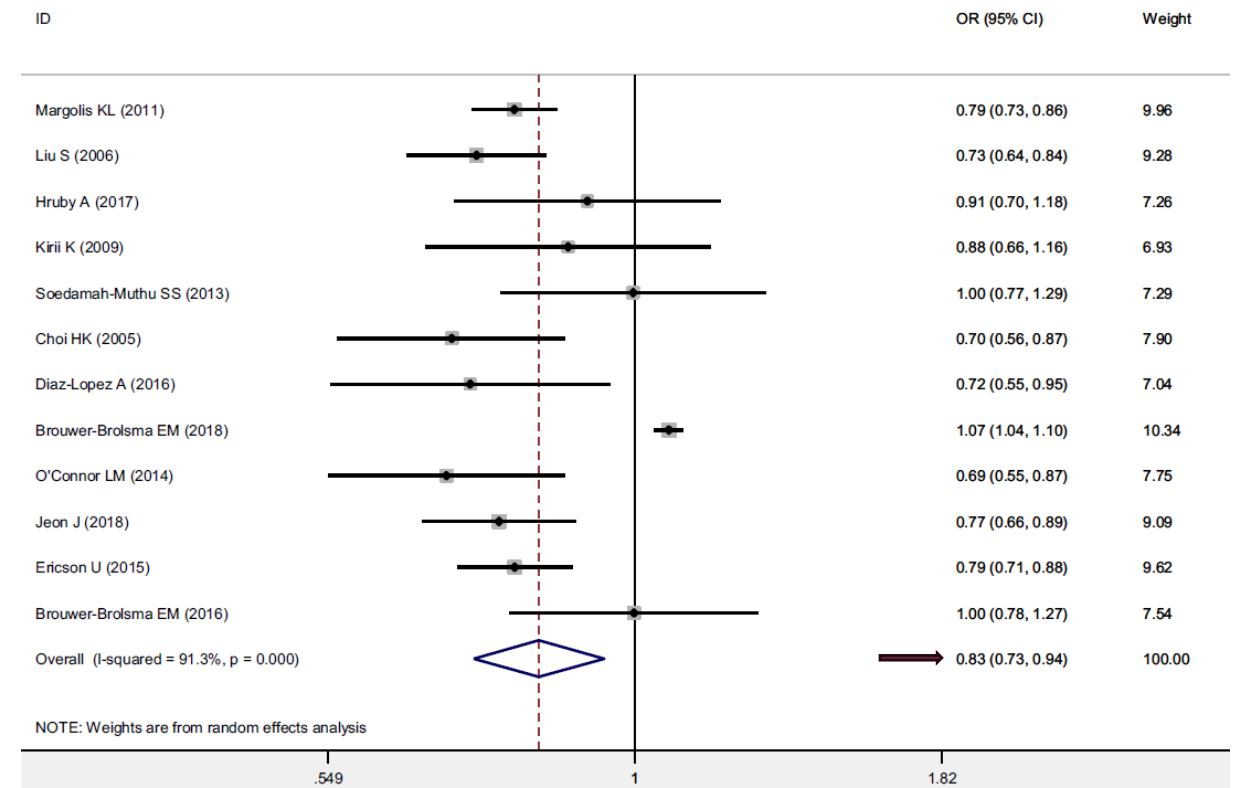
Effect of fermented dairy foods on Diabetes Mellitus risk.

- All fermented foods decreased risk by 8% (OR 0,92; 0.86-0.99)
- Yoghurt decreased risk by 17% (OR 0,83; 0.73-0.94)

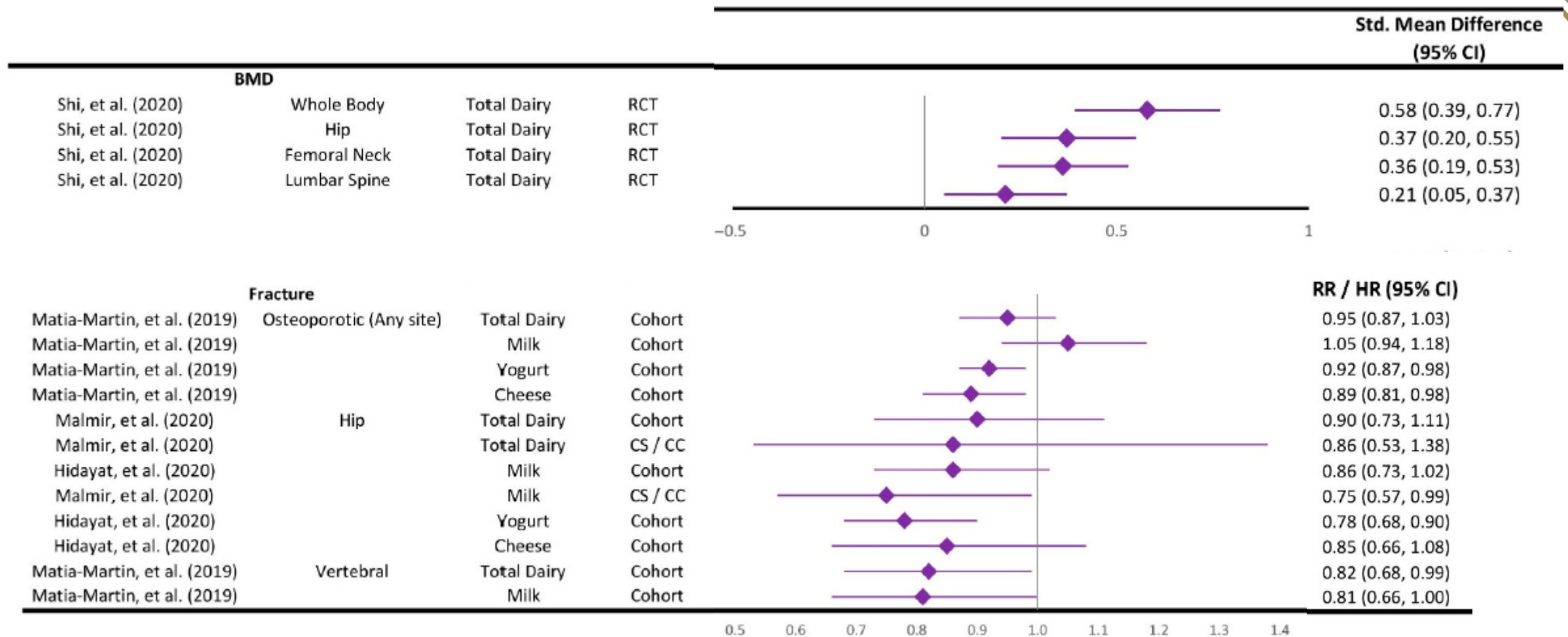
Dose-response effect noted

Yogurt

	n *	Cases/controls	OR (95% CI)	p Value †
Higher dose	12	15,183/385,446	0.828 (0.729–0.941) ‡	<0.001
Lower dose	13	19,478/472,377	0.927 (0.691–1.244)	<0.001



Health benefits: Bone health / Osteoporosis

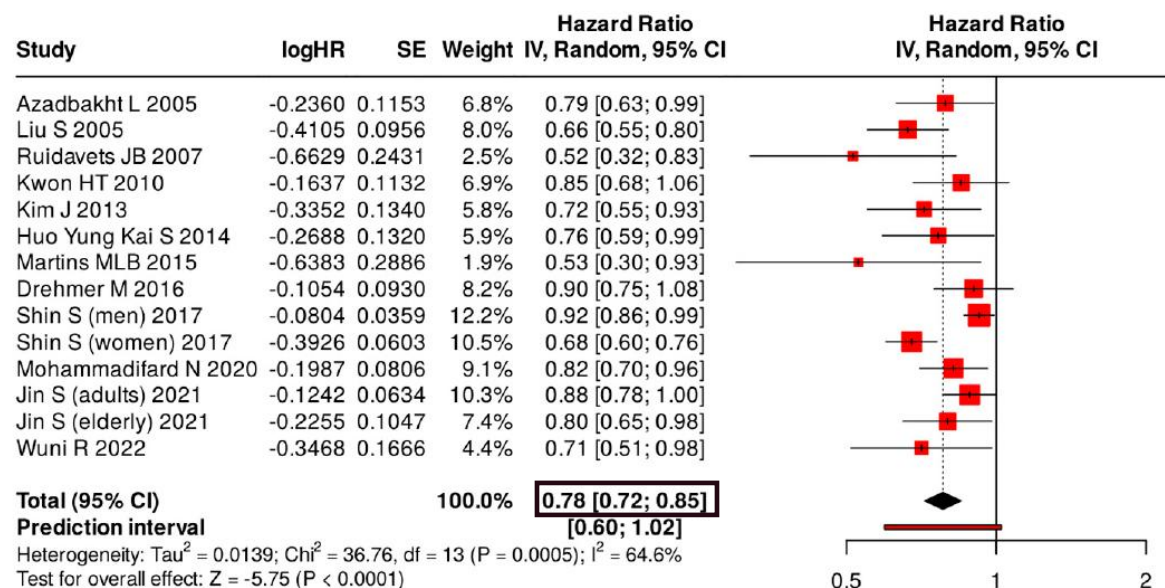


BMD = bone mineral density

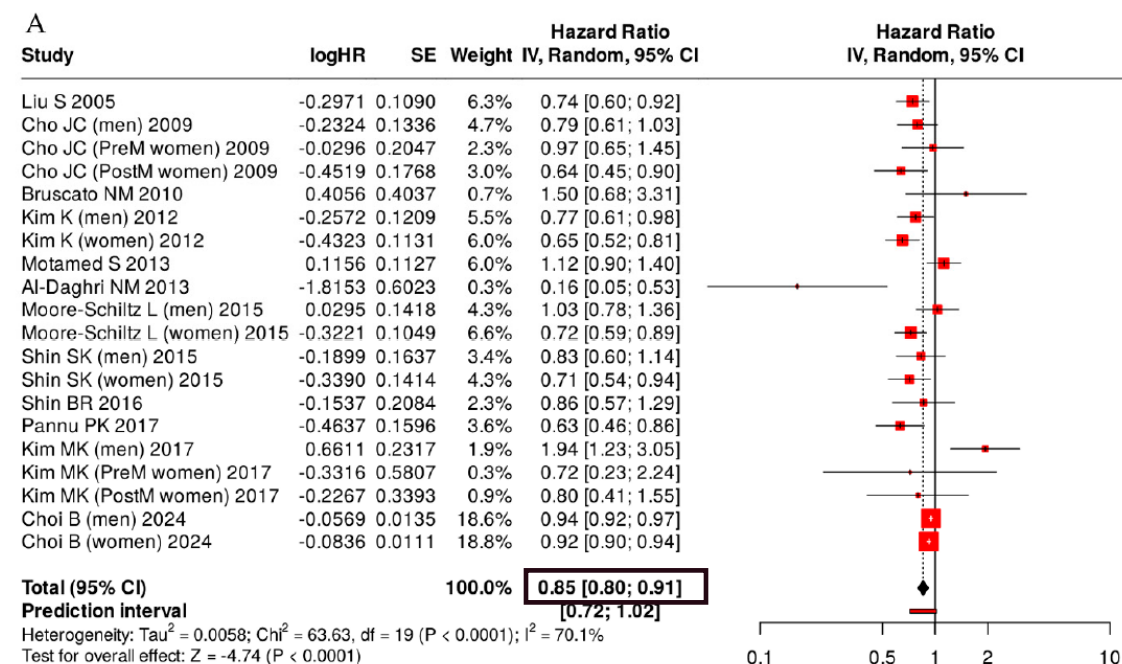
Health benefits: Metabolic syndrome

Effect of dietary calcium or dairy product intake on Metabolic Syndrome risk.

Dairy product consumption



Calcium consumption

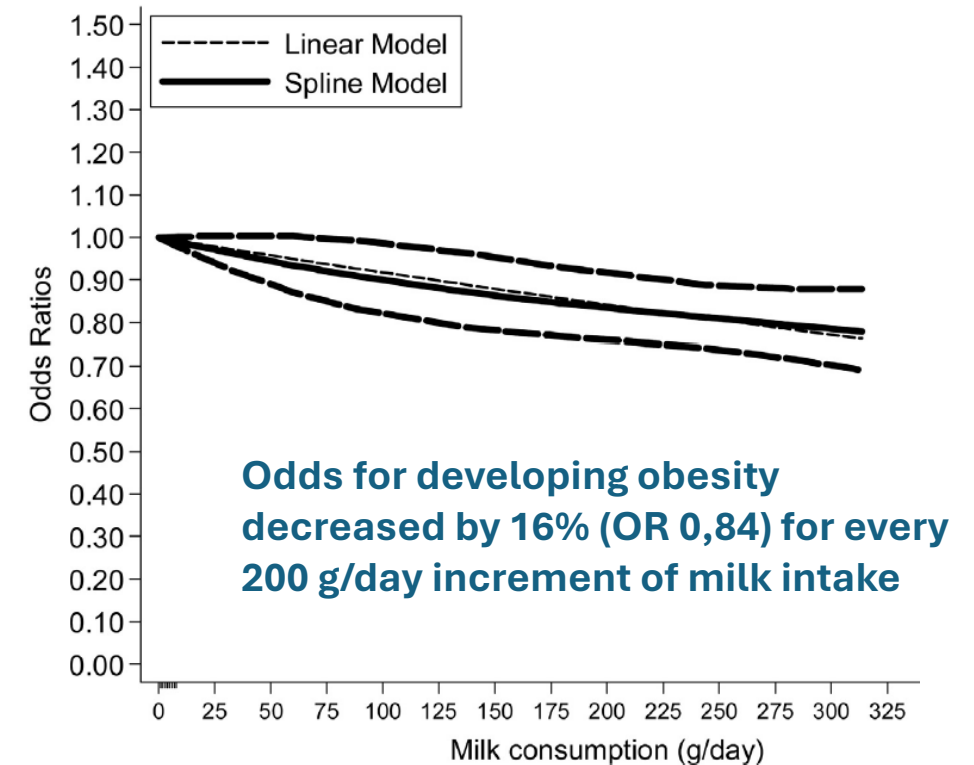
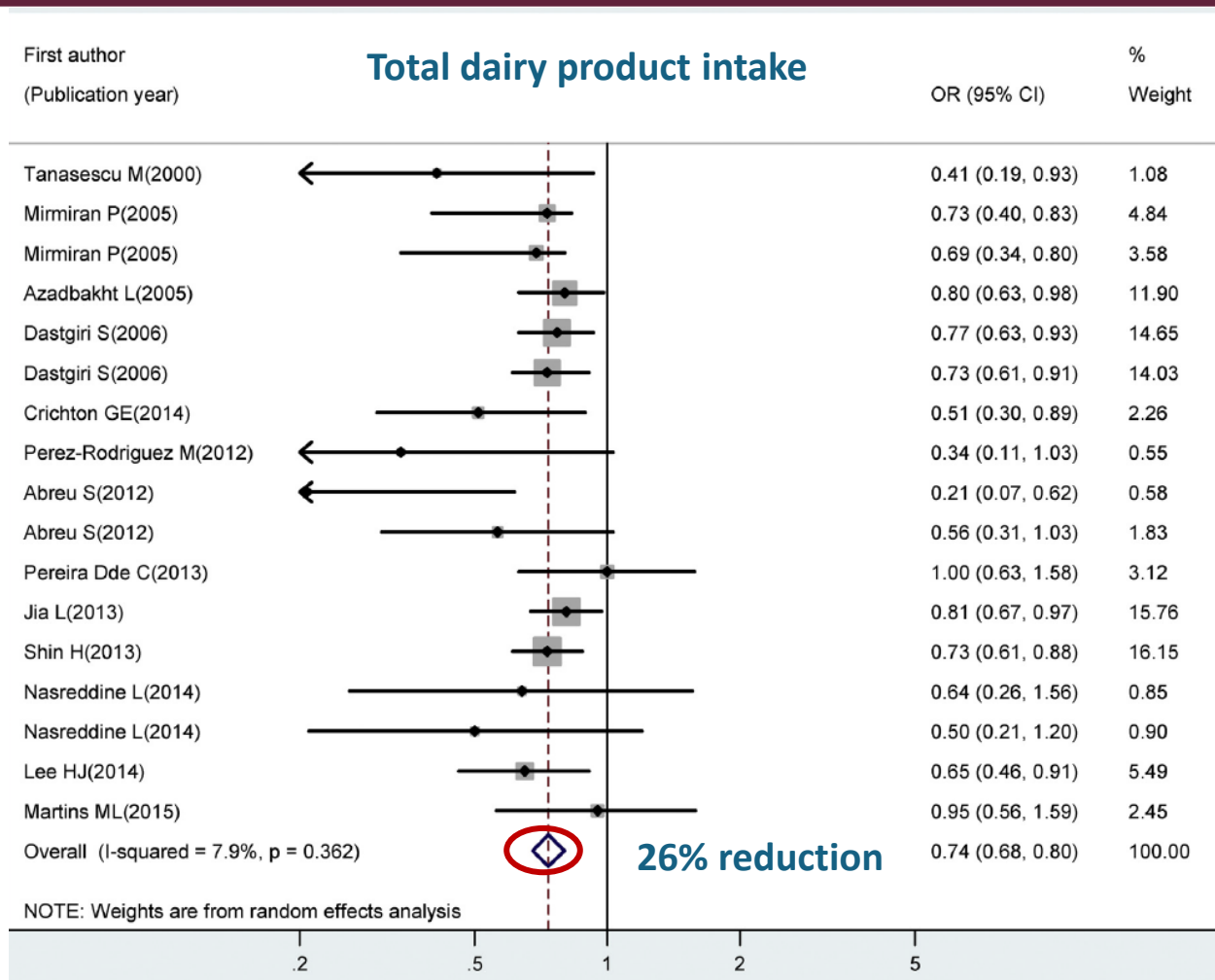


Dose-response analysis:

Each 100 mg/day increment in dietary calcium intake, associated with a 2% lower odds of metabolic syndrome.

Greatest reduction at ± 500 mg/day

Health benefits: Obesity



OR = odds ratio

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Global Review of Dairy Recommendations in Food-Based Dietary Guidelines

*Kevin B. Comerford^{1*}, Gregory D. Miller², Amy C. Boileau²,
Stephanie N. Masiello Schuette², Janice C. Giddens² and Katie A. Brown²*

Food-Based Dietary Guidelines



Nutrient/Health-based Dairy messaging in FBDG

Nutrient-based

“Milk provides key nutrients such as calcium and vitamin D”

“Milk and dairy foods are an important source of iodine”

“Change from whole milk to reduced fat, from reduced fat to low fat and from low fat to fat-free or non-fat or skimmed milk.”

“Prefer milk and dairy products with low fat and salt content.”

Health-based

“Without dairy for breakfast, it’s difficult to reach the three servings we need per day to maintain bone health.”

“Abundant use of skimmed and low - fat dairy products is connected to lower hypertension, stroke and risk of type 2 diabetes”

“Prefer yogurt with probiotics because it improves the bacterial flora”

Dairy across healthy dietary patterns



DASH

Fruits, vegetables, whole grains and low-fat dairy



Fruits Vegetables Whole grains Milk Yoghurt

Dairy: core component

2–3 servings/day (low-fat or fat-free)

Nordic

Whole foods from land and sea



Berries Whole grains Fish Milk Yoghurt/Skyr

Dairy: regular component

~350–500 g/day (often low-fat/fermented)

Mediterranean

Plant-rich, olive oil, fish and fermented dairy



Vegetables Olive oil Legumes Fish Cheese/Yoghurt

Dairy: moderate component

Often yoghurt and cheese

Planetary / plant-forward

Mostly plant foods, with limited dairy



Vegetables Legumes Whole grains Nuts Milk/Cheese

Dairy: smaller, optional component

~250 g/day (≈ 1 serving)

DASH

Dairy as a core component



- 2–3 servings/day
- Emphasis on low-fat or fat-free dairy
- Fruits, vegetables, whole grains, lean proteins, nuts
- Associated with lower blood pressure and cardiometabolic health

Nordic

Regular inclusion of dairy



- ~350–500 g/day milk and dairy (e.g. 2–3 servings)
- Often low-fat and fermented dairy (e.g. yoghurt, skyr)
- Whole grains, berries, fish, vegetables
- Associated with cardiometabolic health and overall diet quality

Mediterranean

Moderate amounts, traditionally yoghurt and cheese



- Moderate amounts of dairy
- Yoghurt and cheese more common than milk
- Olive oil, vegetables, legumes, fish, whole grains, nuts
- Associated with lower risk of CVD, type 2 diabetes and mortality

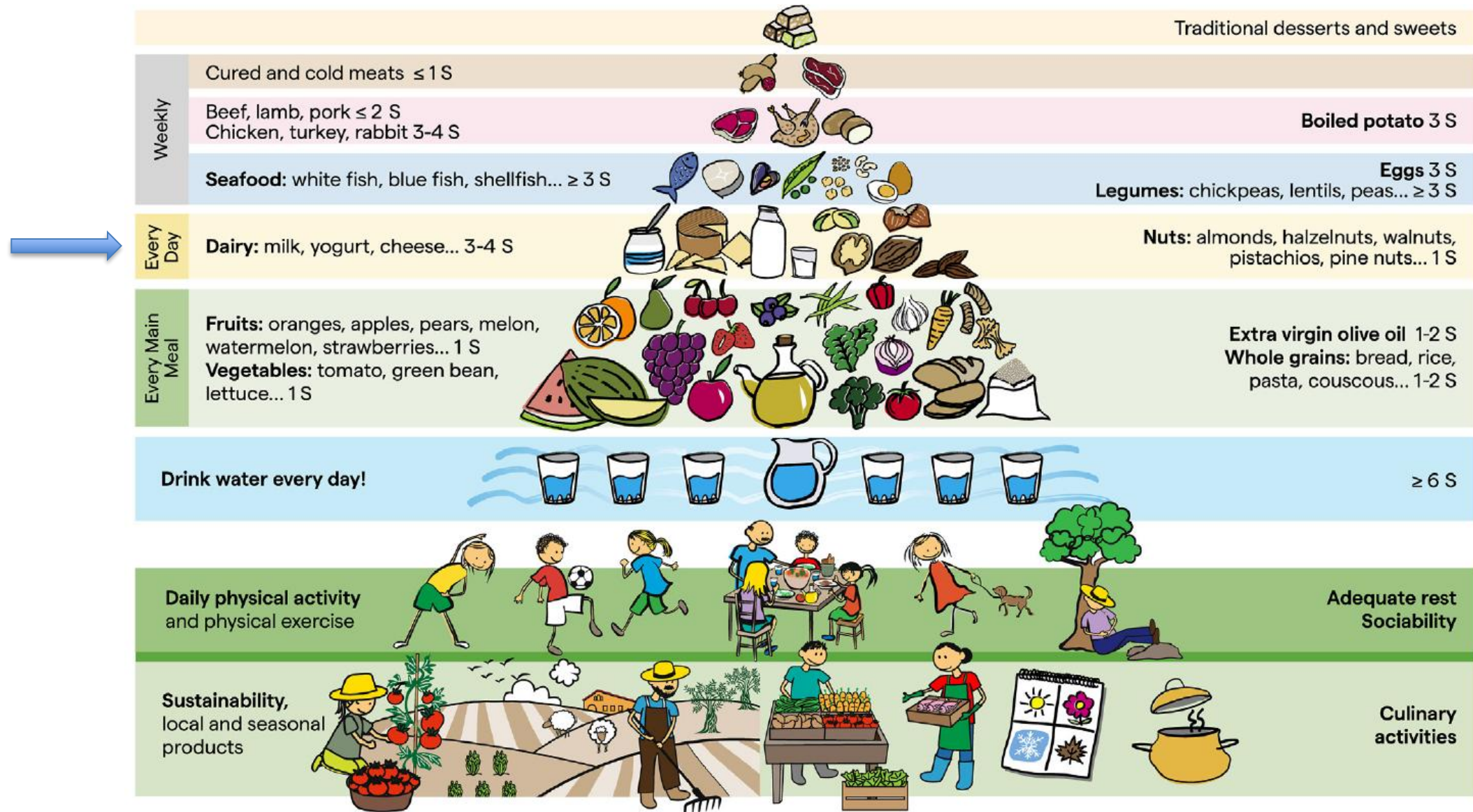
Planetary / plant-forward

Smaller, optional dairy component



- ~250 g/day (≈ 1 serving) in the reference planetary diet (optional)
- Emphasis on plant foods: vegetables, legumes, whole grains, nuts, fruits
- Can include modest amounts of dairy
- Supports both human health and environmental sustainability

A New Mediterranean Lifestyle Pyramid for Children and Youth: A Critical Lifestyle Tool for Preventing Obesity and Associated Cardiometabolic Diseases in a Sustainable Context



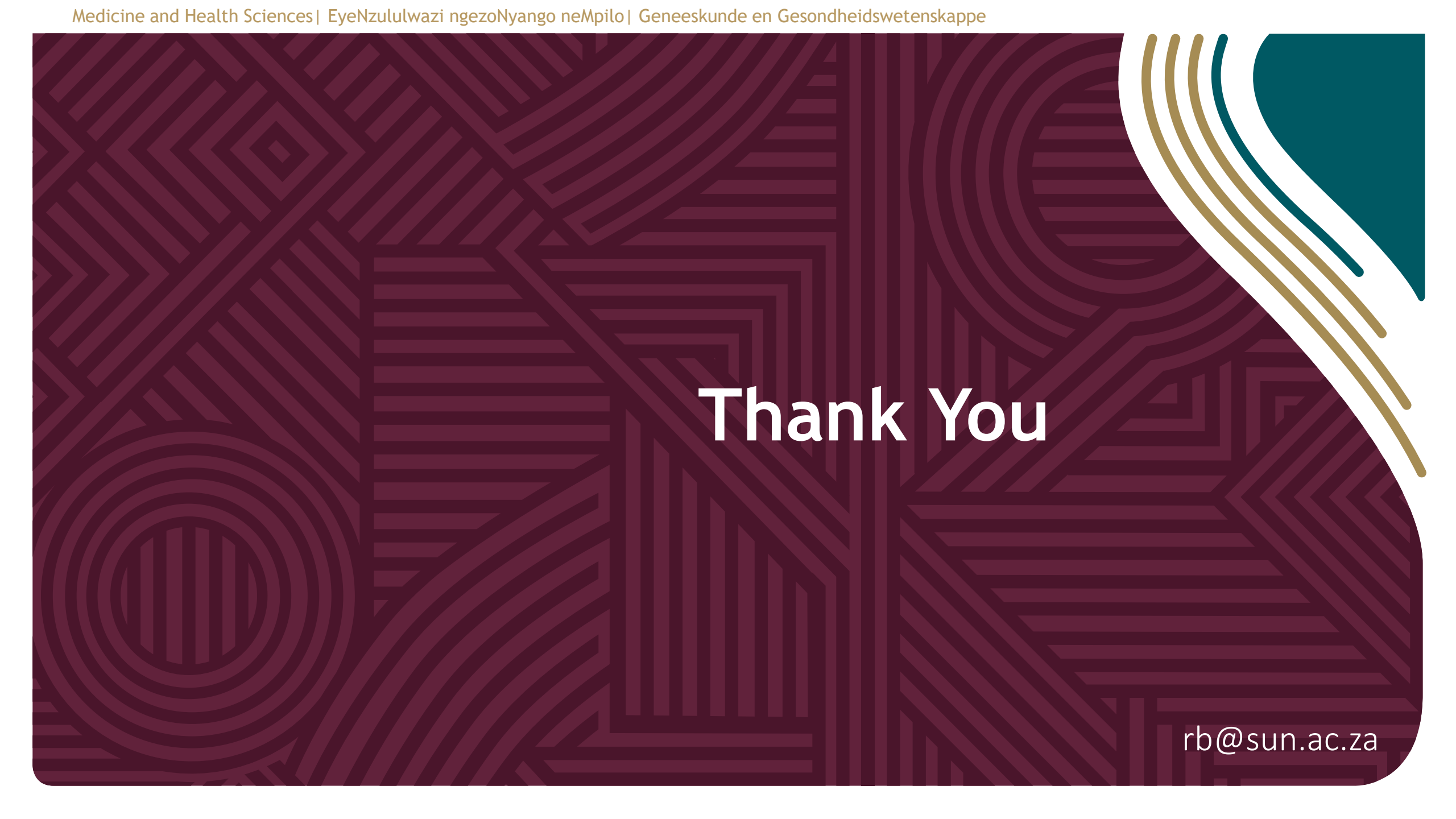
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Practical implications

- Dairy matrix is unique and associated with positive health outcomes.
- Current evidence demonstrates that dairy foods should be considered within the context of the whole food matrix and overall dietary patterns.
 - Full-fat versus low-fat debate
- Evidence-based recommendations should reflect the totality of available scientific evidence rather than focusing on individual nutrients alone.





Thank You

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