We all demand sustainable foods, but do they always provide sustainable nutrition (and health)?

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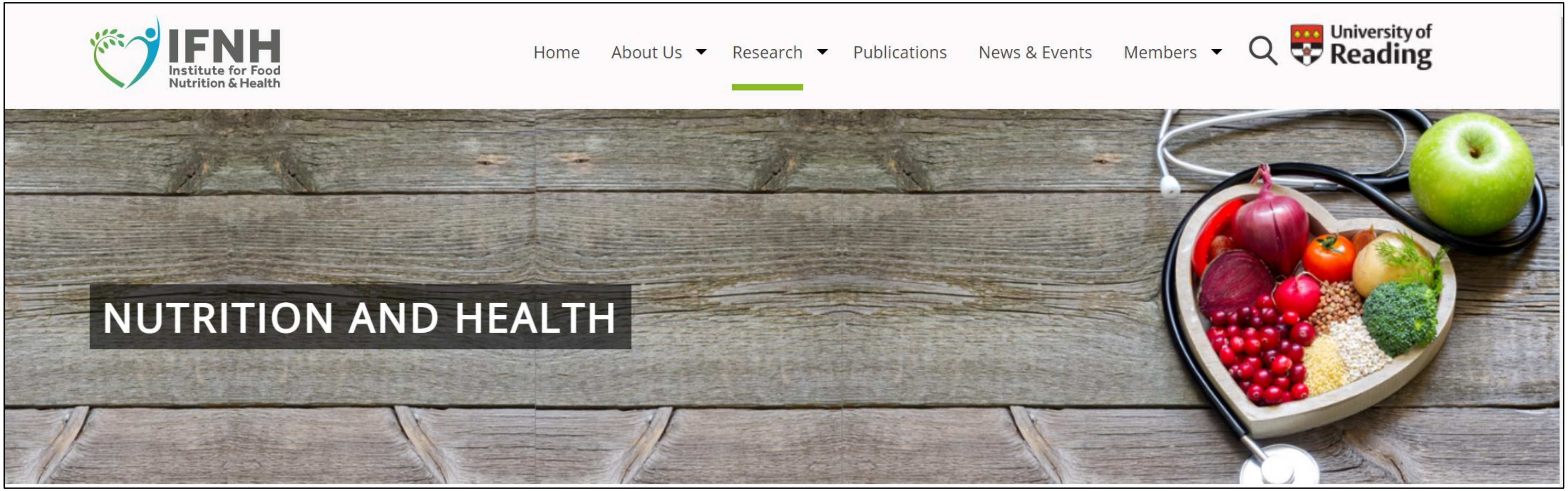
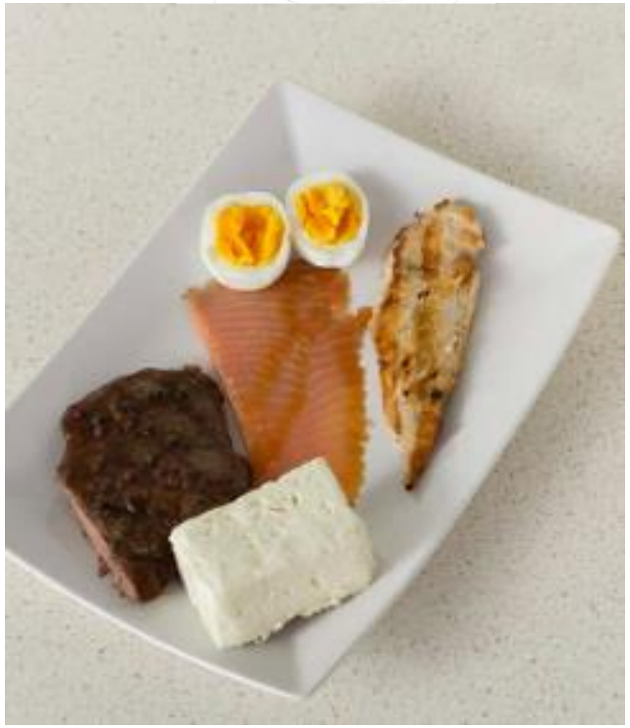


The BCPC Congress

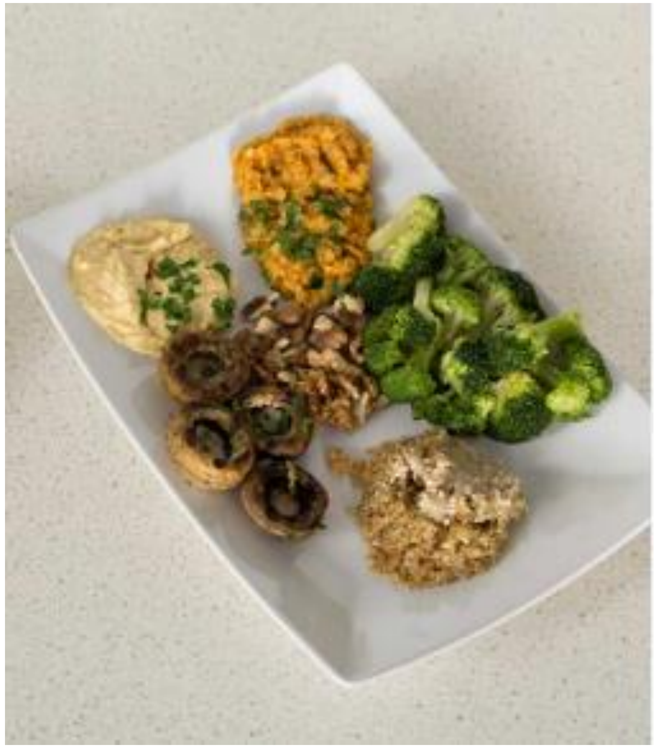
7-8 November, Cedar Court Hotel, Harrogate, UK

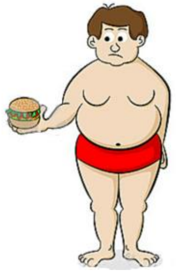
Ian Givens

Institute for Food, Nutrition and Health, University of Reading



Protein transition





What do we know about our starting position?

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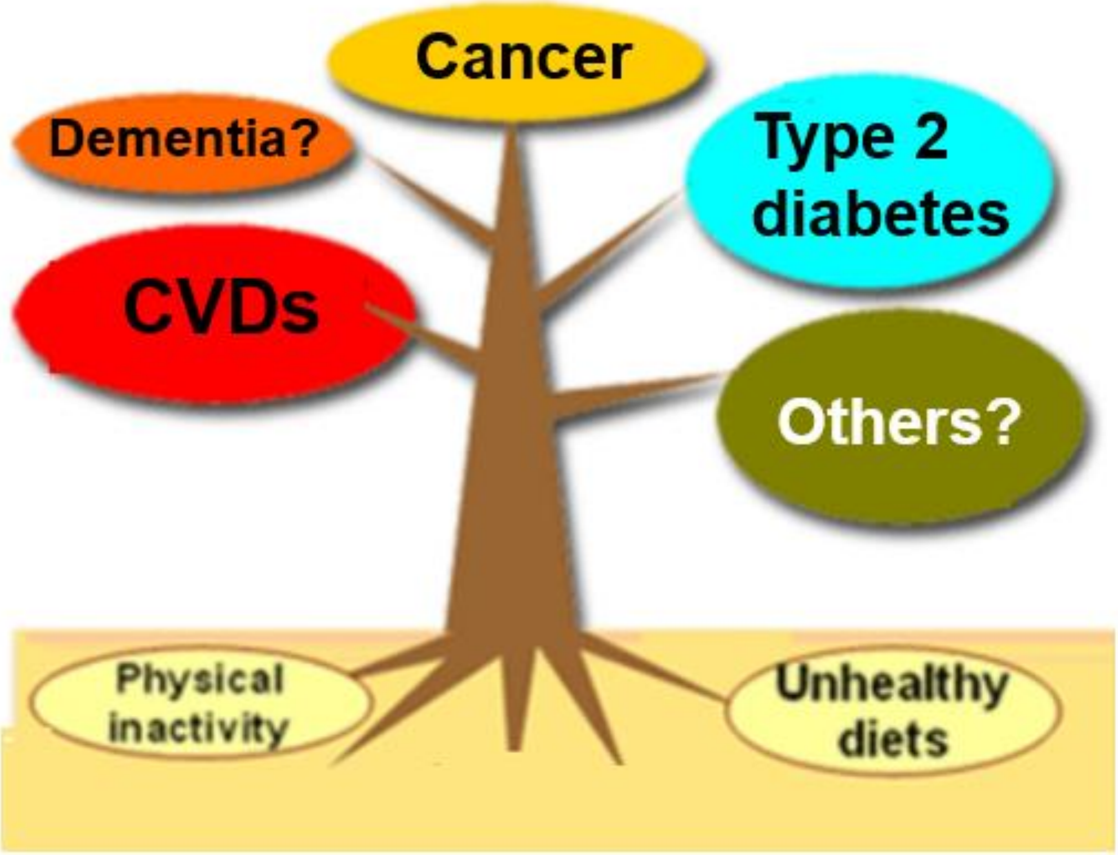
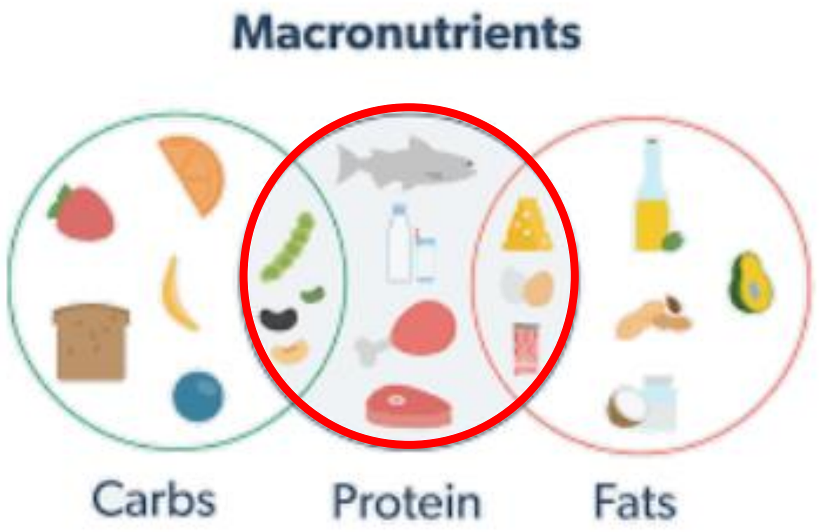
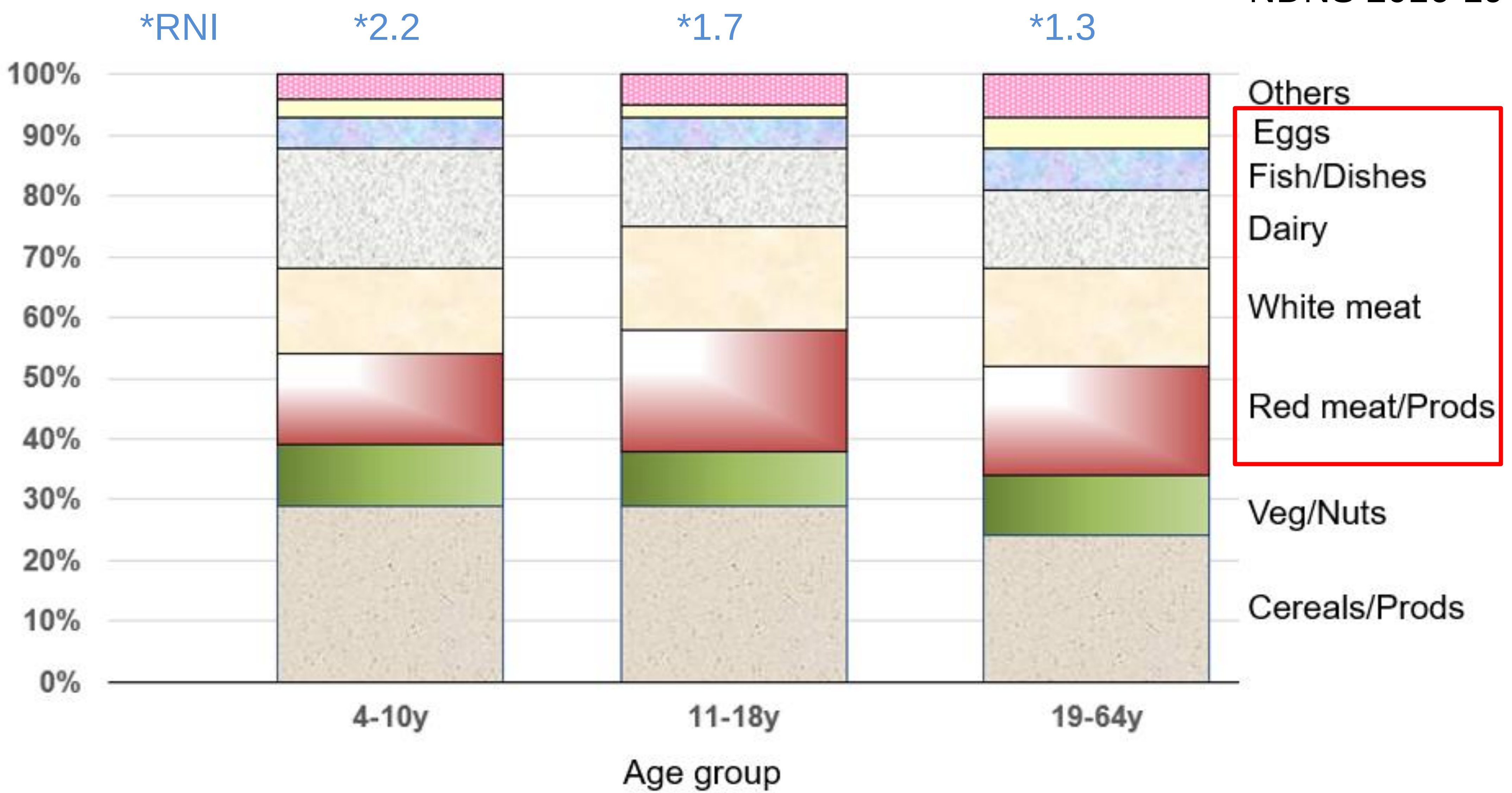




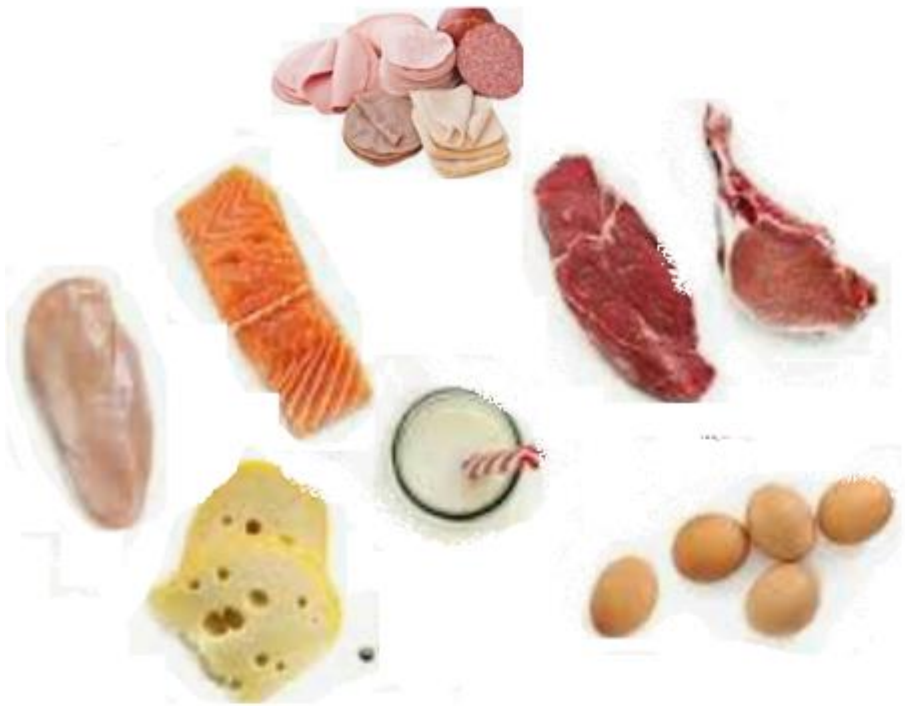
Diet-responsive non-communicable diseases: animal-derived foods

Dietary sources of protein in UK diet

NDNS 2016-19



Simplistic protein replacement is too simple

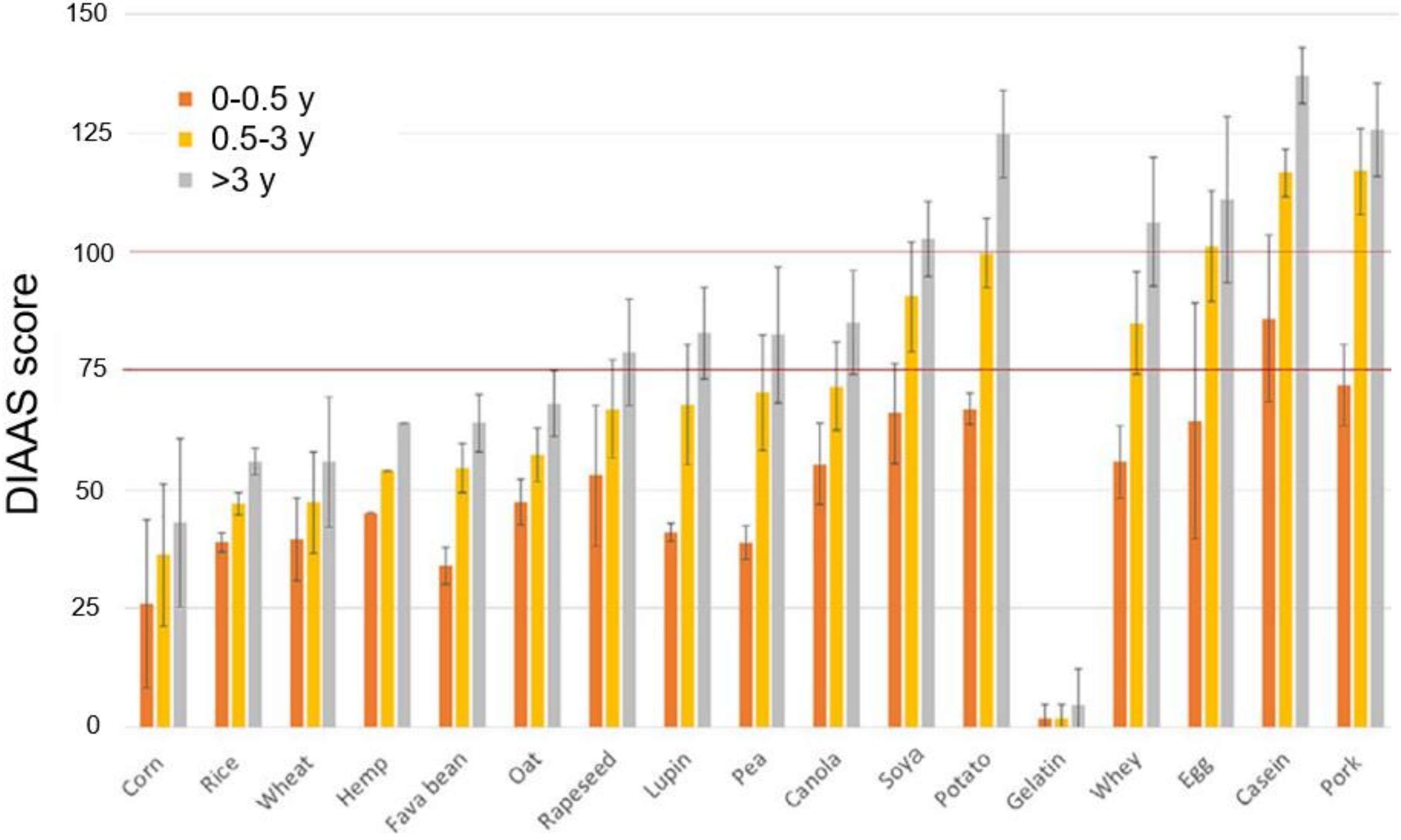


Animal derived foods are highly variable

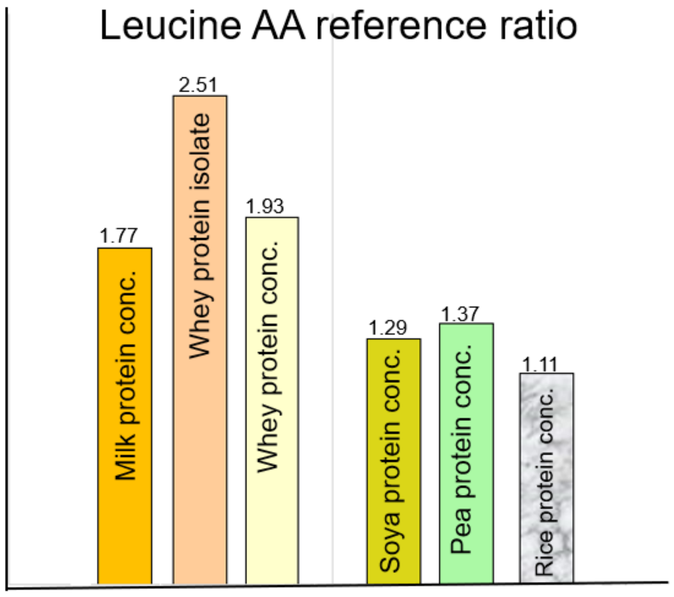
- They have different nutrient profiles
- They have different functionalities
- They have different impacts on health

Simplistic protein replacement is too simple: quality matters

Herreman et al. Food Sci Nutr. 2020;8:5379–5391



Phillips SM (2017) Front Nutr. 4:13.



IFNH Institute for Food, Nutrition & Health

Meta-analyses of associations between meat type and risk of CVDs

Giromini & Givens, 2022

Systematic Review Used	Number of Cohort Studies	Outcome	Comparison Used	Risk Ratio (95% CI [1])
Unprocessed red meat				
Zeraatkar et al. (2019)	3	CVD	Dose–response, per 50 g/day	1.01 (0.99, 1.02)
Kim et al. (2017)	6	Stroke	High vs. low intake	1.11 (1.03, 1.20)
Zeraatkar et al. (2019)	6	Stroke	Dose–response, per 50 g/day	1.01 (1.00, 1.01)
Unprocessed poultry meat				
Kim et al. (2017)	3	Stroke	High vs. low intake	0.87 (0.78, 0.96)
Processed meat				
Zeraatkar et al. (2019)	3	CVD	Dose–response, per 50g/day	1.01 (0.97, 1.05)
Bechthold et al., (2019)	3	IHD	Dose–response, per 50g/day	1.27 (1.09, 1.49)
Kim et al. (2017)	6	Stroke	High vs. low intake	1.17 (1.08, 1.25)
Bechthold et al. (2019)	6	Stroke	Dose–response, per 50g/day	1.17 (1.02, 1.34)
Zeraatkar et al. (2019)	6	Stroke	Dose–response, per 50g/day	1.02 (1.01. 1.04)

[1] CI, Confidence interval.

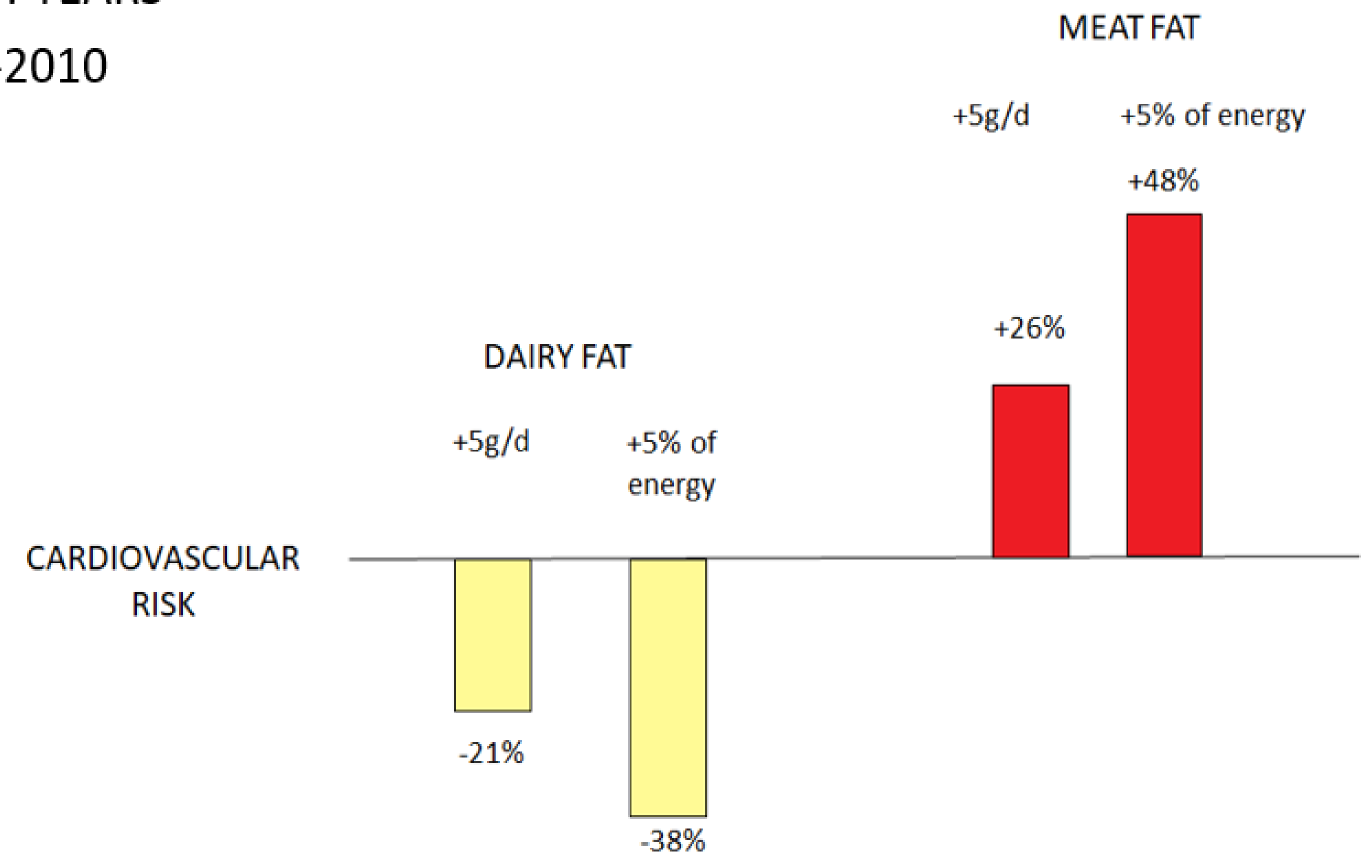
Differences between food sources of SFA and CVD risk

de Oliveira Otto et al.
AJCN 2012, 96, 397-404

MULTI-ETHNIC STUDY OF ATHEROSCLEROSIS

5209 ♀ 45-84 YEARS

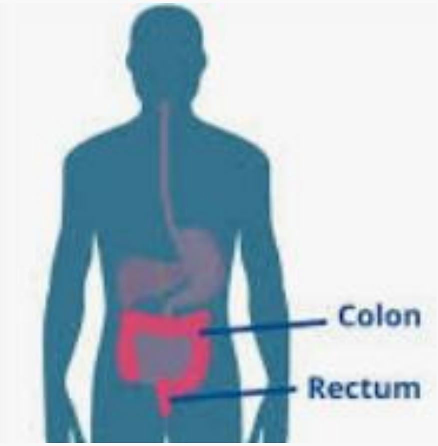
FOLLOW-UP 2000-2010



Association of dairy and meat and risk of colo-rectal cancer

University of Reading

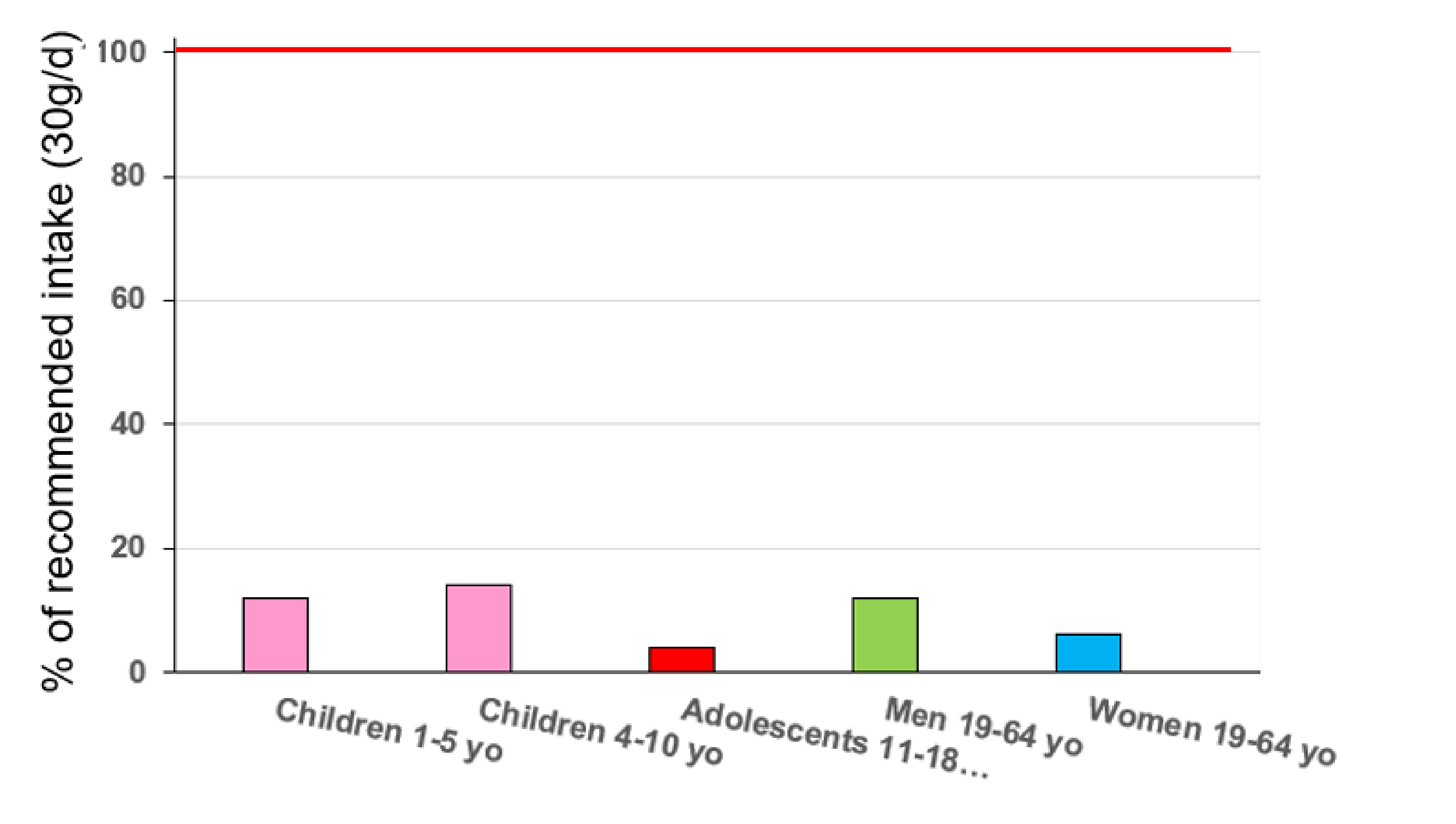
2018
World Cancer Research Fund
American Institute for Cancer Research



WCRF/AICR GRADING		DECREASES RISK		INCREASES RISK	
		Exposure	Cancer site	Exposure	Cancer site
STRONG EVIDENCE	Convincing			Processed meat[1]	Colorectum 2017
	Probable	Dairy products	Colorectum 2017[2]	Red meat[3] Cantonese-style salted fish[4]	Colorectum 2017 Nasopharynx 2017

Mean dietary fibre (AOAC) intake in UK

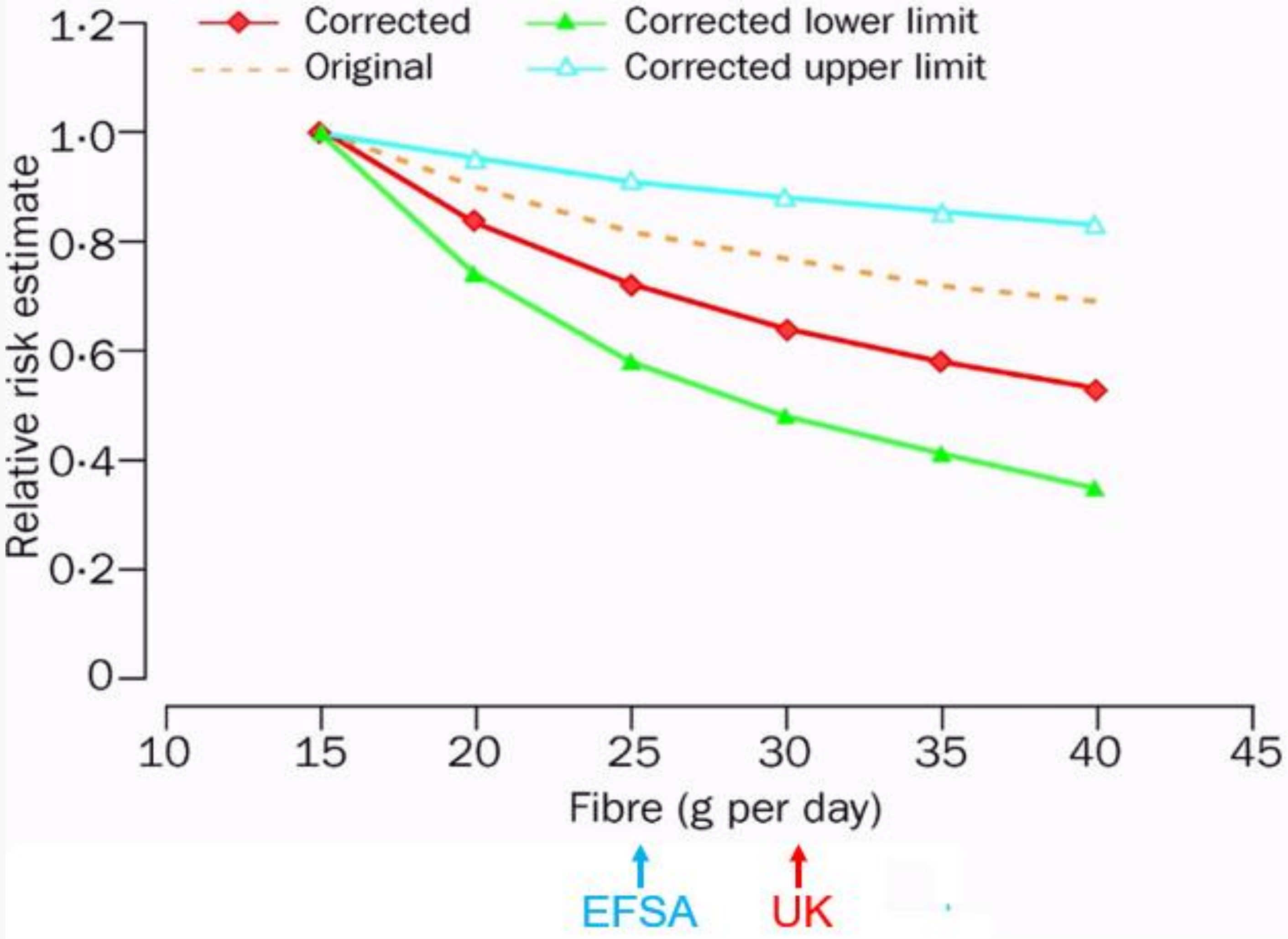
NDNS Years 9-11



Dietary fibre and risk of colorectal cancer

University of Reading

Bingham SA *et al.* (2003) *Lancet* **361**, 1496-1501

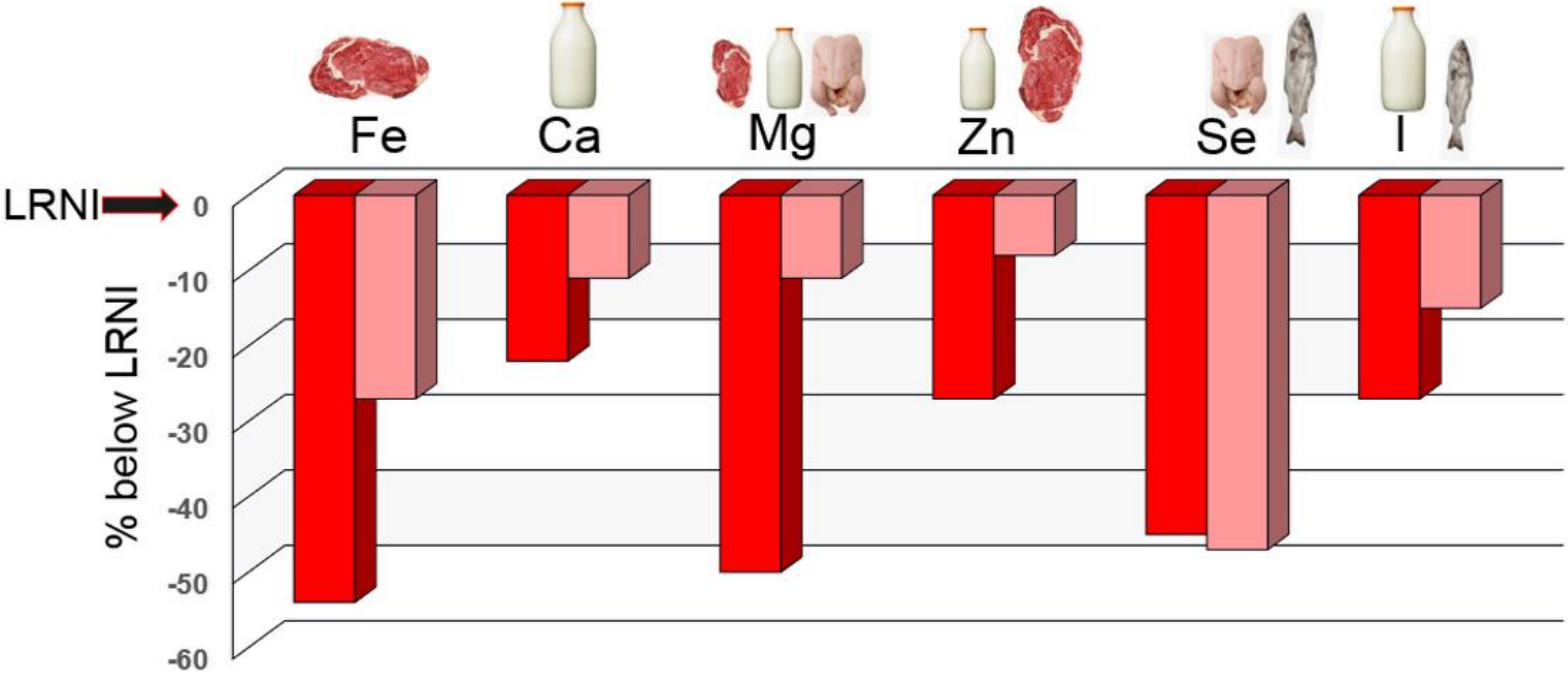


epic
European Prospective Investigation of Cancer

Key micronutrients from animal-derived foods

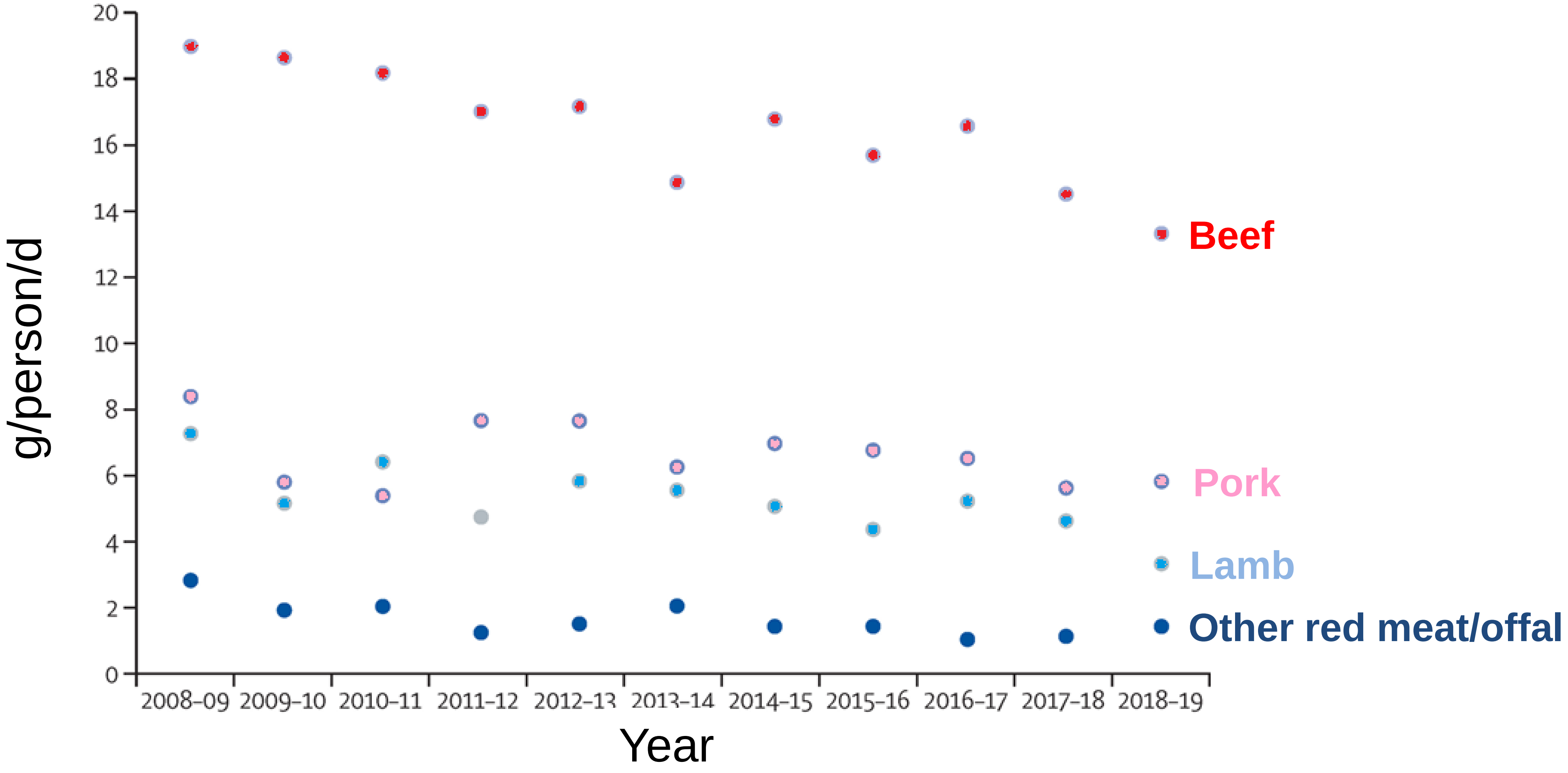
Sub-optimal micronutrient intake of UK female adolescents and adults

National Diet and Nutrition Survey
Rolling programme Years 9 to 11
(2016/2017 to 2018/2019)

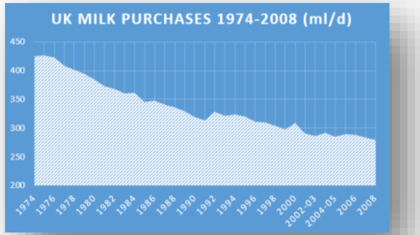


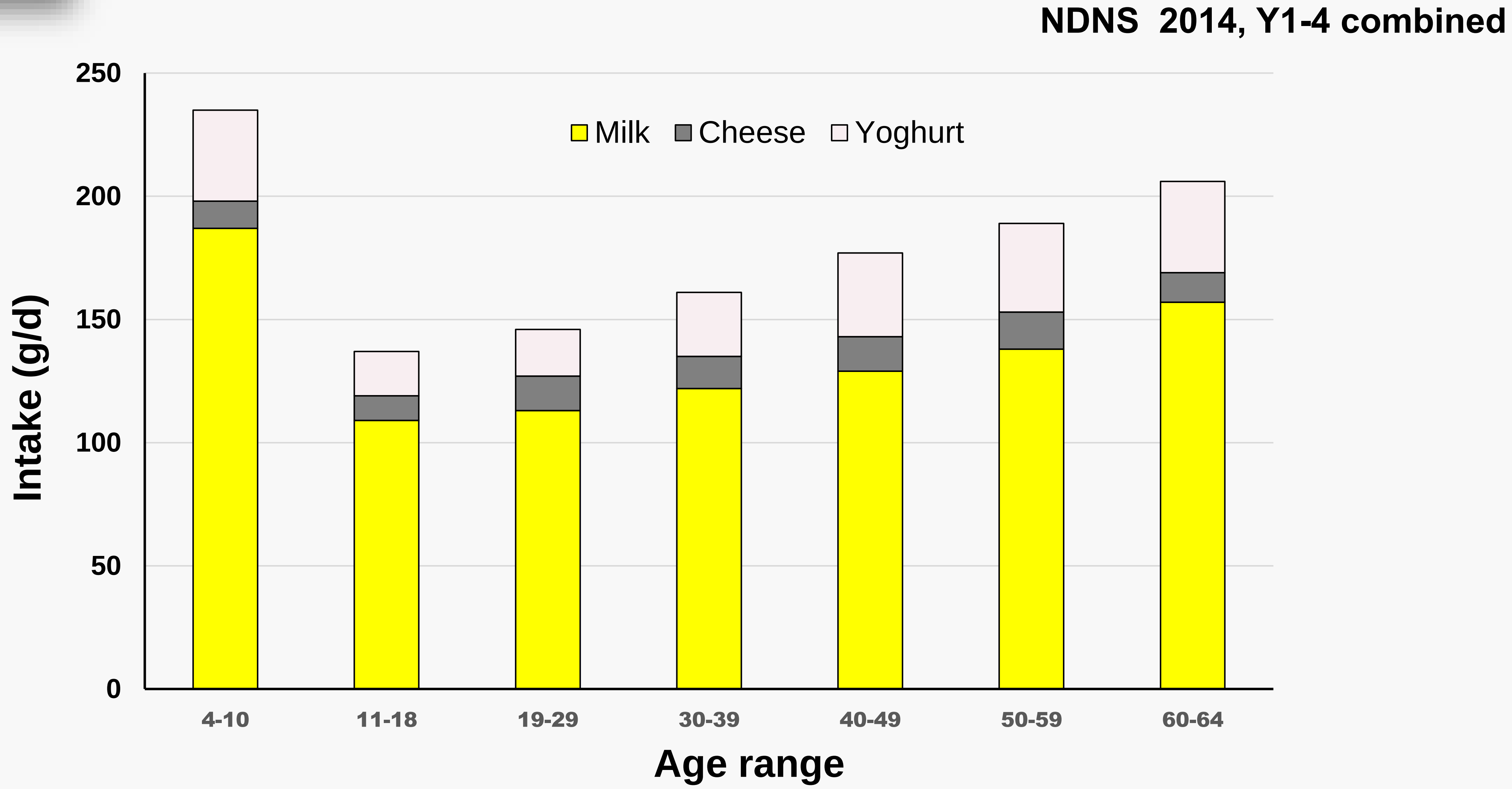
Meat consumption trends in UK

Stewart et al., 2021



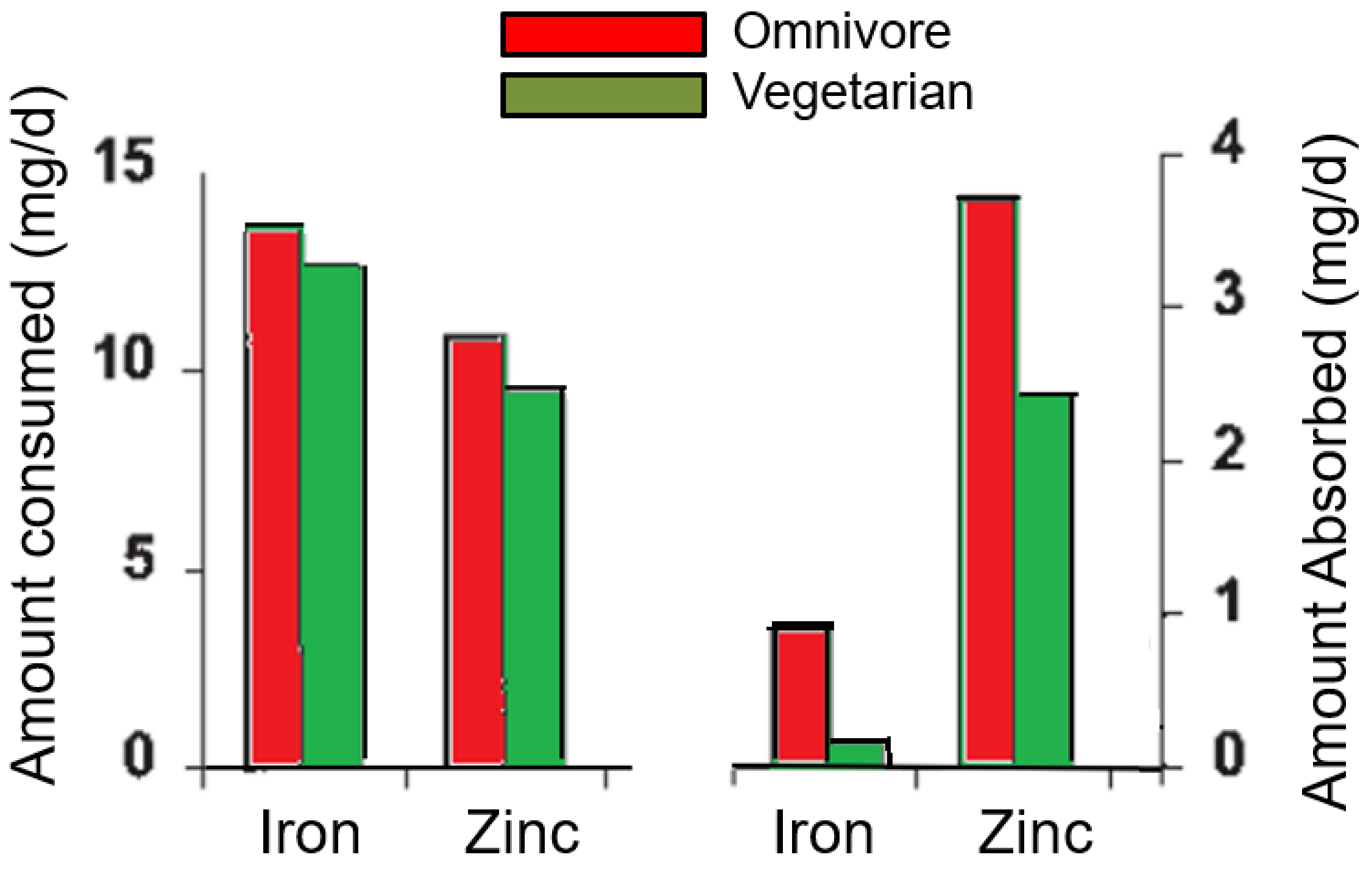
Dairy food intake in UK females





Micronutrient bioavailability in omnivorous and vegetarian diets

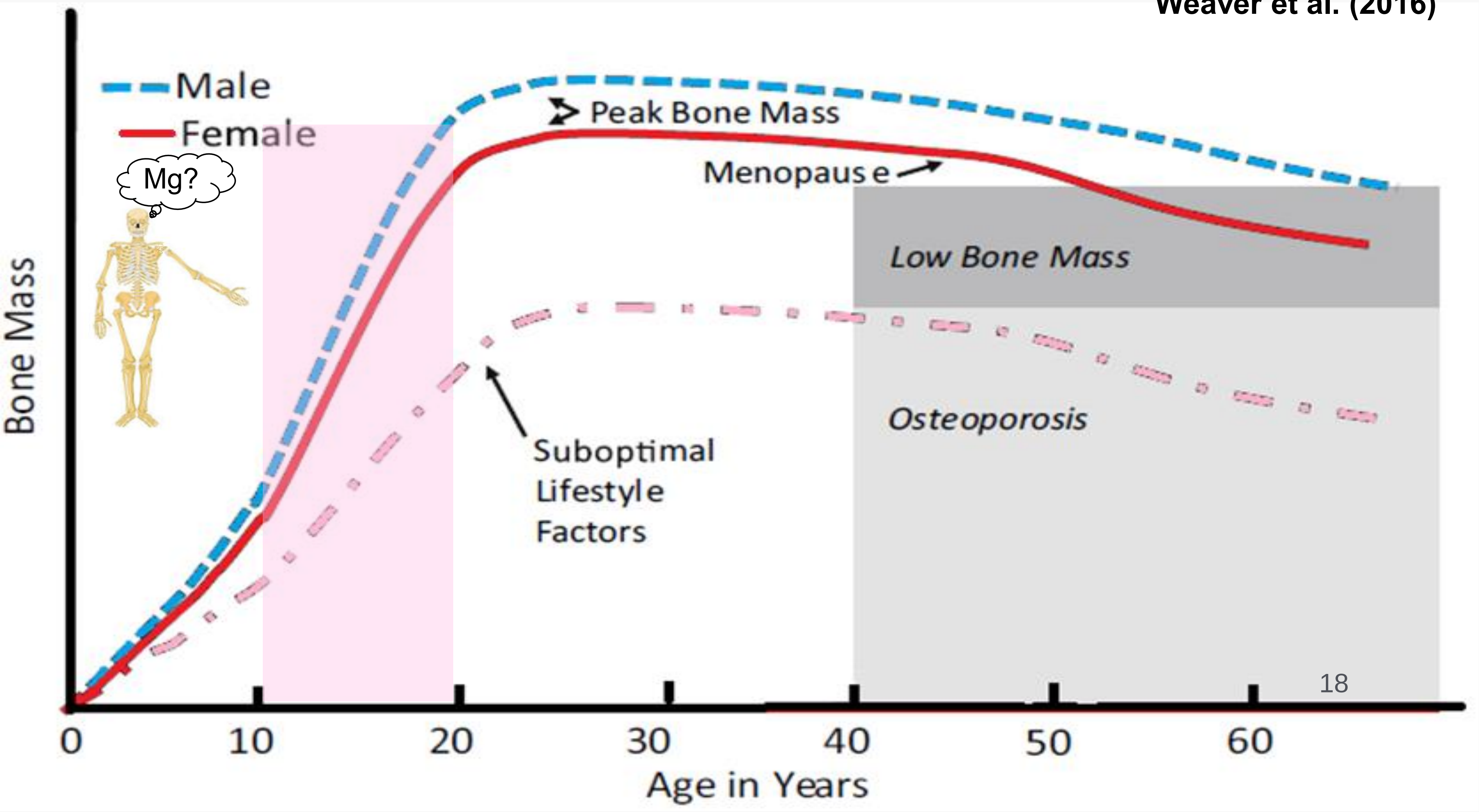
Hunt, 2003, *AJCN* 78:633S-639S



Bone mass changes with age

University of Reading

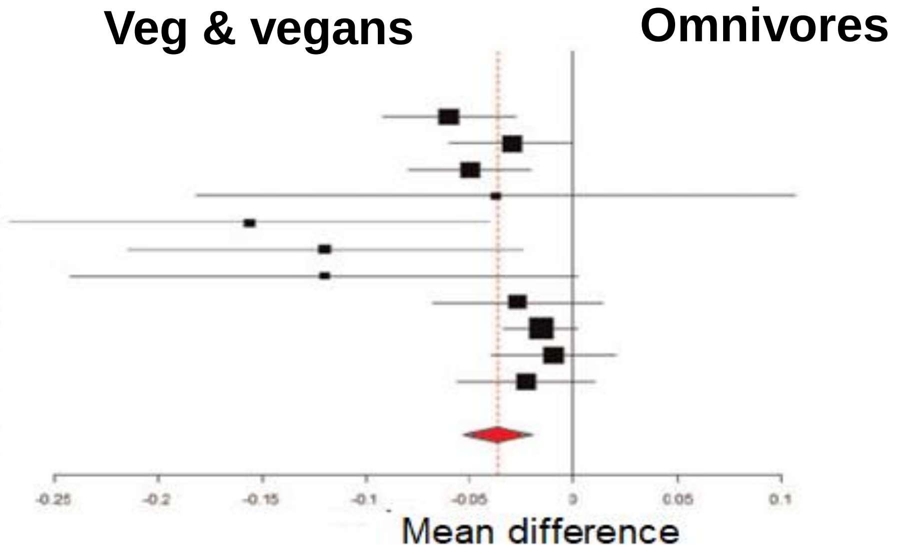
Weaver et al. (2016)



Meta-analysis of the effects of vegetarian and vegan diets on BMD at the femoral neck

Isabel Iguacel , María L. Miguel-Berges
Alejandro Gómez-Bruton, Luis A. Moreno,
and Cristina Julián 2019
Nutrition Reviews® Vol. 77(1):1–18

Reference	Estimate (95%CI)
Chiu et al (1997)[26](vegan women)	−0.060 (−0.092, −0.028)
Lau et al (1998)[28](vegan women)	−0.030 (−0.060, −0.000)
Lau et al (1998)[28](vegetarian women)	−0.050 (−0.079, −0.021)
Outila et al (2000)[29](vegetarian women)	−0.038 (−0.182, 0.106)
Outila et al (2000)[29](vegan women)	−0.156 (−0.271, −0.041)
Fontana et al (2005)[31](vegan women)	−0.120 (−0.215, −0.025)
Fontana et al (2005)[31](vegan men)	−0.120 (−0.242, 0.002)
Kim et al (2007)[32](vegetarian women)	−0.027 (−0.068, 0.014)
Wang et al (2008)[33](vegetarian men)	−0.016 (−0.034, 0.002)
Ho-Pham et al (2009)[34](vegan women)	−0.010 (−0.040, 0.020)
Krivosikova et al (2009)[35](vegetarian women)	−0.023 (−0.056, 0.010)
Overall (I^2 =48.92 % , P=0.034)	**−0.037 (−0.054, −0.020)**



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Lau et al (1998)[28](vegetarian women)	−0.050 (−0.079, −0.021)
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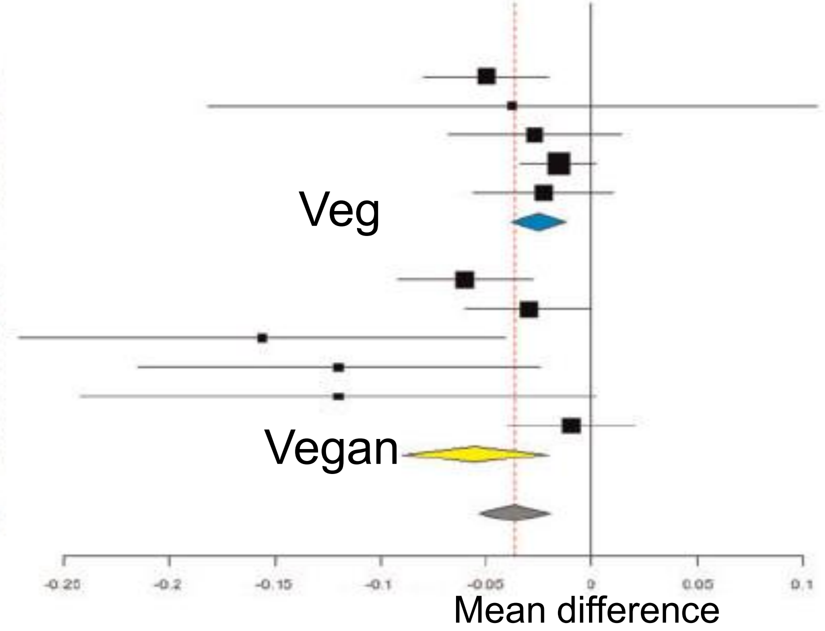
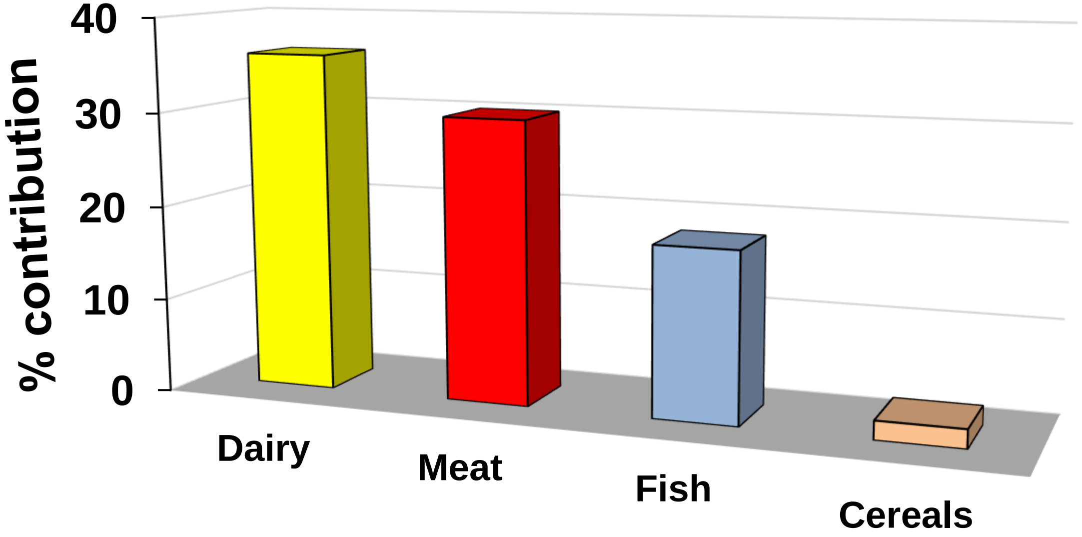
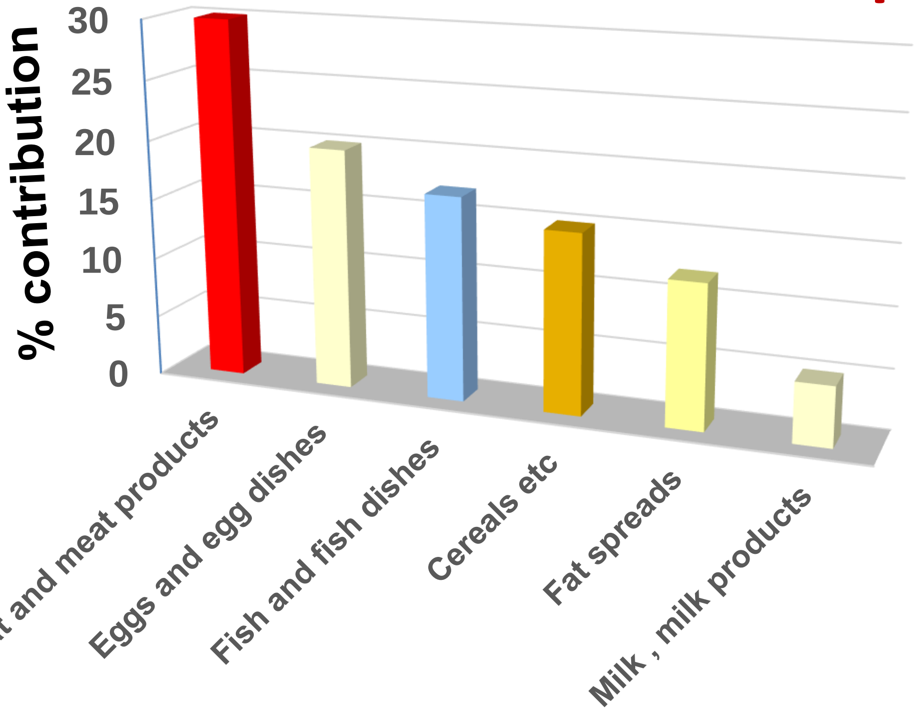
Wang et al (2008)[33](vegetarian men)	−0.016 (−0.034, 0.002)
Krivosikova et al (2009)[35](vegetarian women)	−0.023 (−0.056, 0.010)
Subgroup Vegetarian (I^2 =0 % , P=0.424)	**−0.025 (−0.038, −0.012)**
Chiu et al (1997)[26](vegan women)	−0.060 (−0.092, −0.028)
Lau et al (1998)[28](vegan women)	−0.030 (−0.060, −0.000)
Outila et al (2000)[29](vegan women)	−0.156 (−0.271, −0.041)
Fontana et al (2005)[31](vegan women)	−0.120 (−0.215, −0.025)
Fontana et al (2005)[31](vegan men)	−0.120 (−0.242, 0.002)
Ho-Pham et al (2009)[34](vegan women)	−0.010 (−0.040, 0.020)
Subgroup Vegan (I^2 =64.41 % , P=0.015)	**−0.055 (−0.090, −0.021)**
Overall (I^2 =48.92 % , P=0.034)	**−0.037 (−0.054, −0.020)**





Micronutrients that plants cannot supply!



Dietary supply very low

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What do we know about our starting position?

Quite a lot

What we know about our starting position

- Meat/products are the greatest protein source in UK diets, but protein is often overconsumed.
- Protein quality is important, animal products >plant
- More health risks with processed meat than red but both > milk/dairy/white meat
- Dietary fibre intake is abysmally low.
- Intake of key micronutrients typically provided by red meat and dairy are very low in adolescent females and those of childbearing age. Risk of bone weakness and issues during pregnancy etc.
- A transition away from red meat consumption started a long time ago.
- Further transition from animal-derived foods will require a new source of vitamin B12 and vitamin D supplementation is needed now but further reduced red meat consumption will exacerbate

What changes are needed from nutrition/health position?

- Consumption of processed meat should reduce substantially and red to some extent, some loss of protein not a problem for most.
- No requirement to reduce milk/dairy intake but challenged by environment.
- A greater intake of plant foods needed to increase dietary fibre if for nothing else.
- Must be a country-wide initiative to protect female adolescents and women OCBA. Bioavailability of nutrients e.g. Ca and Fe much lower in plant foods.
- A greater intake of plant-foods has risks, bone weakness, and sub-optimal iodine, vitamin B12 and vitamin D status

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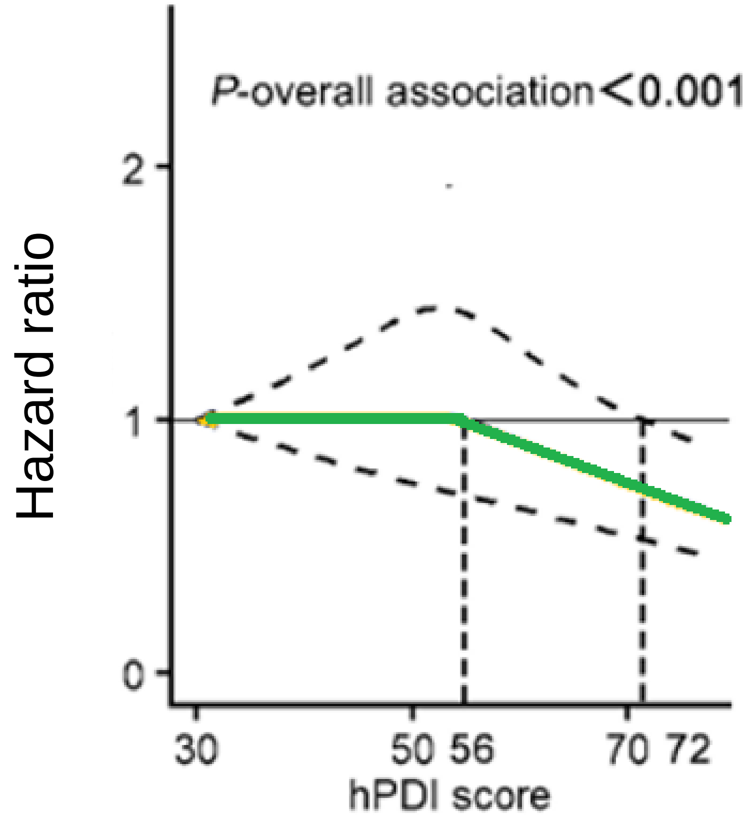
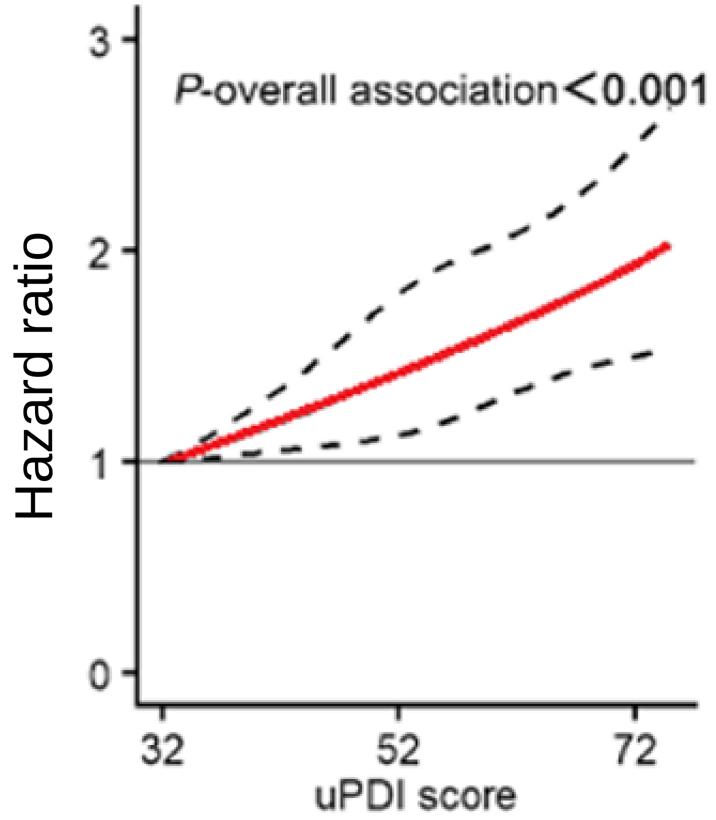
But are plant-based diets always healthier?

Plant-based dietary indices (PDI) and mortality risk

Li et al., 2022 EJN 61:387-398

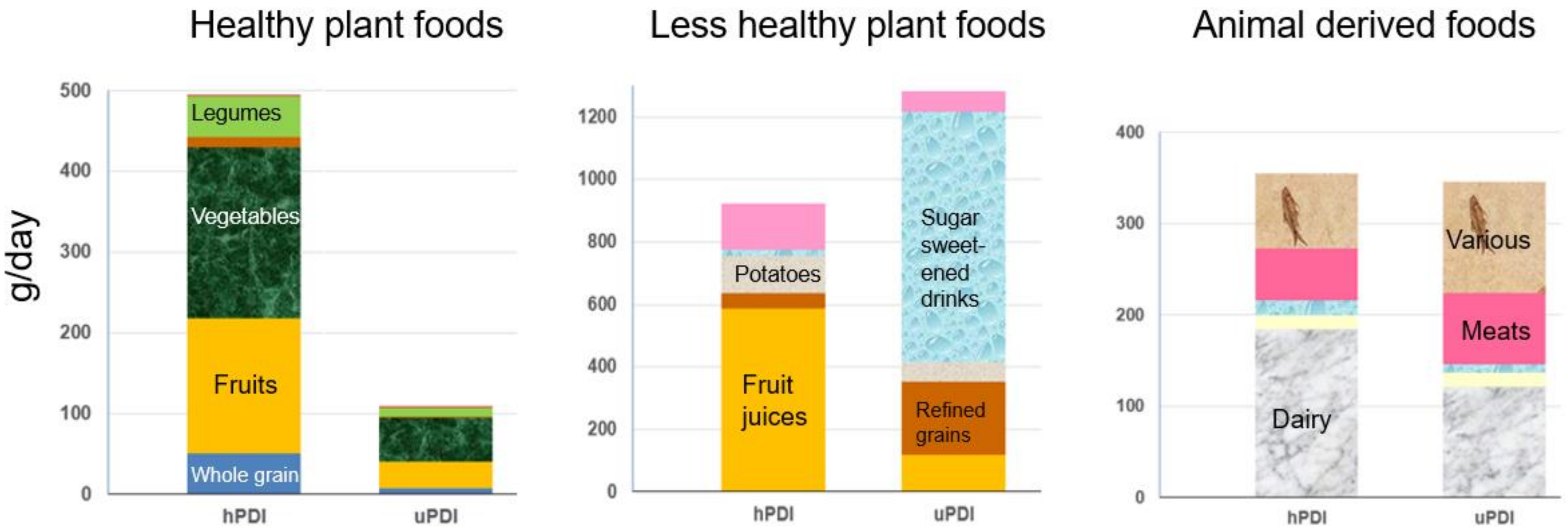


Healthy PDI index



UnhealthyPDI index

Plant-based dietary indices (PDI) and mortality risk

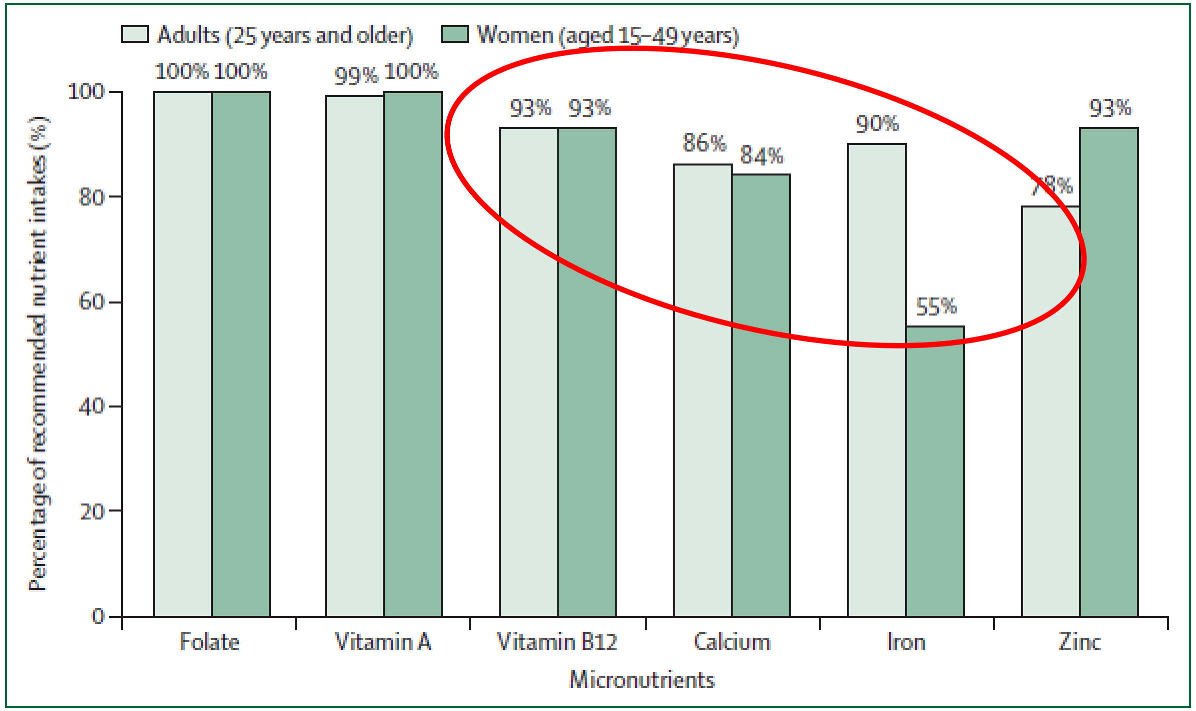


EAT-Lancet diet

Estimated micronutrient shortfalls of the EAT–*Lancet* planetary health diet

Ty Beal, Flaminia Ortenzi, Jessica Fanzo

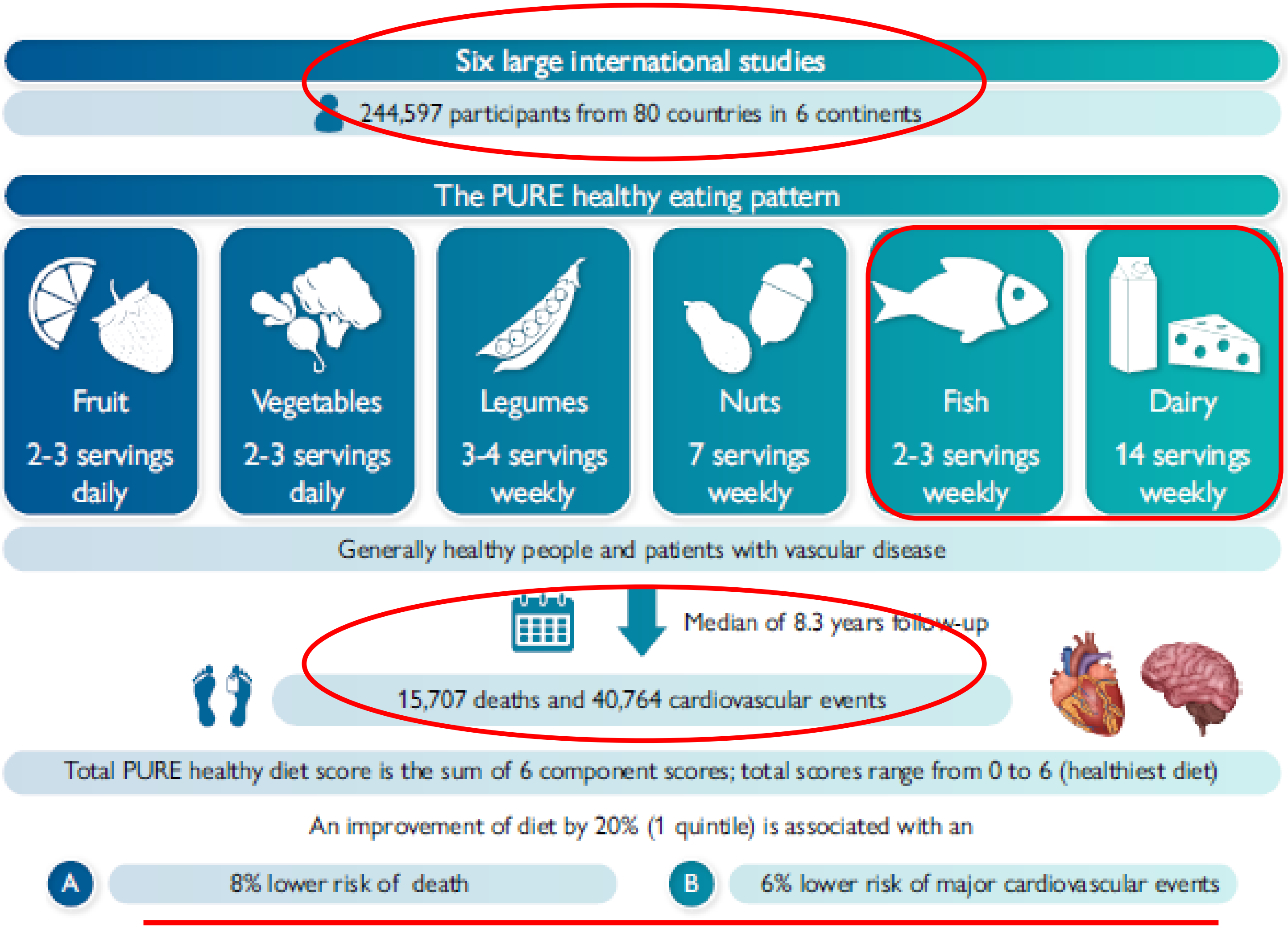
Lancet Planet Health **2023; 7: e233–37**



Food Planet Health	8.6 MJ/day (2053 kcal)	Macronutrient intake grams per day (possible range)
Whole grains	Rice, wheat, corn and other	232
Tubers or starchy vegetables	Potatoes and cassava	50 (0–100)
Vegetables	All vegetables	300 (200–600)
Fruits	All fruits	200 (100–300)
Dairy foods	Whole milk or equivalents	250 (0–500)
Protein sources	Beef, lamb and pork	14 (0–28)
	Chicken and other poultry	29 (0–58)
	Eggs	13 (0–25)
	Fish	28 (0–100)
	Legumes	75 (0–100)
	Nuts	50 (0–75)
Added fats	Unsaturated oils	40 (20–80)
	Saturated oils	11.8 (0-11.8)
Added sugars	All sugars	31 (0–31)

Dietary pattern and CVD and mortality in 80 countries

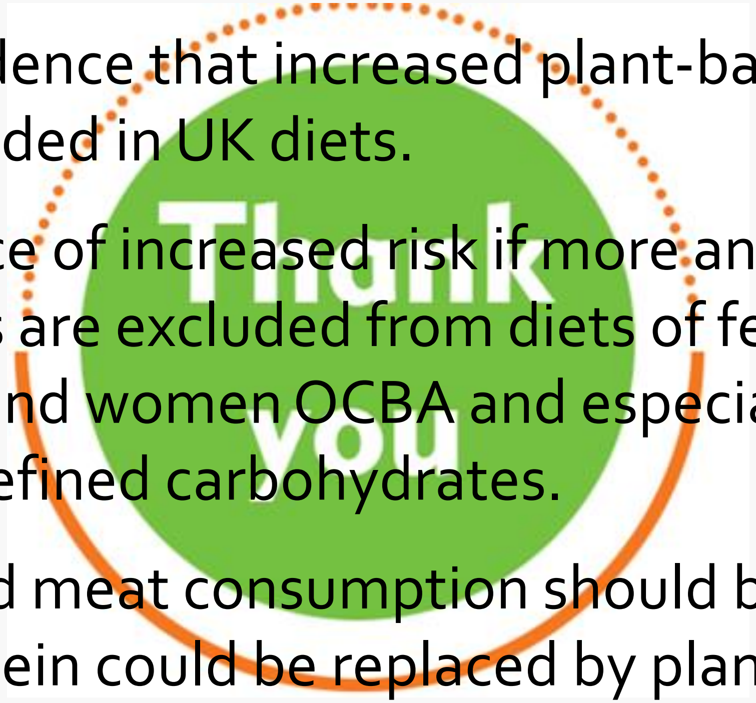
Mente et al., 2023 Eur. Heart J. 44:2560

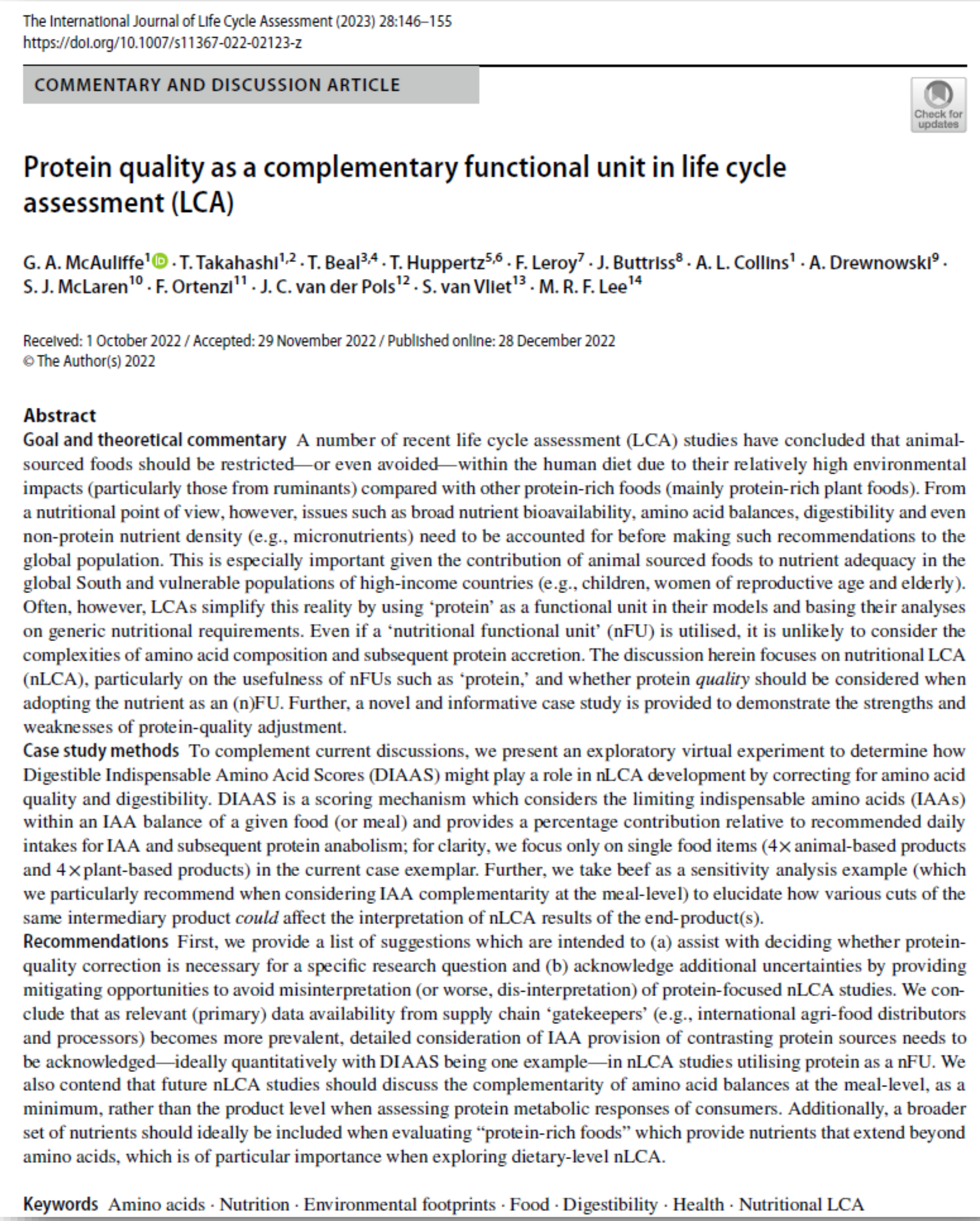


- **Moderate amounts of wholegrains and unprocessed meat can be part of a healthy diet**
- A higher PURE Healthy Diet Score which includes fruits, vegetables, nuts, legumes, fish, and dairy was associated with lower mortality and cardiovascular disease risk.
- This was consistent in individuals with or without vascular disease, and in all world regions, especially in countries with lower income

A few final thoughts

- All plant-based diets are not healthy and do not provide sustainable nutrition. They need careful planning like all diets.
- But good evidence that increased plant-based foods are needed in UK diets.
- Good evidence of increased risk if more animal derived foods are excluded from diets of female adolescents and women OCBA and especially if replaced by refined carbohydrates.
- But processed meat consumption should be reduced, protein could be replaced by plants.
- Are all plant-based foods more environmentally friendly and sustainable than animal-based?
- Comparison should consider nutrition and health.





The International Journal of Life Cycle Assessment (2023) 28:146–155
https://doi.org/10.1007/s11367-022-02123-z

COMMENTARY AND DISCUSSION ARTICLE

Check for updates

Protein quality as a complementary functional unit in life cycle assessment (LCA)

G. A. McAuliffe[1] · T. Takahashi[1,2] · T. Beal[3,4] · T. Huppertz[5,6] · F. Leroy[7] · J. Buttriss[8] · A. L. Collins[1] · A. Drewnowski[9] · S. J. McLaren[10] · F. Ortenzi[11] · J. C. van der Pols[12] · S. van Vliet[13] · M. R. F. Lee[14]

Received: 1 October 2022 / Accepted: 29 November 2022 / Published online: 28 December 2022

Abstract

Goal and theoretical commentary A number of recent life cycle assessment (LCA) studies have concluded that animal-sourced foods should be restricted—or even avoided—within the human diet due to their relatively high environmental impacts (particularly those from ruminants) compared with other protein-rich foods (mainly protein-rich plant foods). From a nutritional point of view, however, issues such as broad nutrient bioavailability, amino acid balances, digestibility and even non-protein nutrient density (e.g., micronutrients) need to be accounted for before making such recommendations to the global population. This is especially important given the contribution of animal sourced foods to nutrient adequacy in the global South and vulnerable populations of high-income countries (e.g., children, women of reproductive age and elderly). Often, however, LCAs simplify this reality by using 'protein' as a functional unit in their models and basing their analyses on generic nutritional requirements. Even if a 'nutritional functional unit' (nFU) is utilised, it is unlikely to consider the complexities of amino acid composition and subsequent protein accretion. The discussion herein focuses on nutritional LCA (nLCA), particularly on the usefulness of nFUs such as 'protein,' and whether protein *quality* should be considered when adopting the nutrient as an (n)FU. Further, a novel and informative case study is provided to demonstrate the strengths and weaknesses of protein-quality adjustment.

Case study methods To complement current discussions, we present an exploratory virtual experiment to determine how Digestible Indispensable Amino Acid Scores (DIAAS) might play a role in nLCA development by correcting for amino acid quality and digestibility. DIAAS is a scoring mechanism which considers the limiting indispensable amino acids (IAAs) within an IAA balance of a given food (or meal) and provides a percentage contribution relative to recommended daily intakes for IAA and subsequent protein anabolism; for clarity, we focus only on single food items (4 × animal-based products and 4 × plant-based products) in the current case exemplar. Further, we take beef as a sensitivity analysis example (which we particularly recommend when considering IAA complementarity at the meal-level) to elucidate how various cuts of the same intermediary product *could* affect the interpretation of nLCA results of the end-product(s).

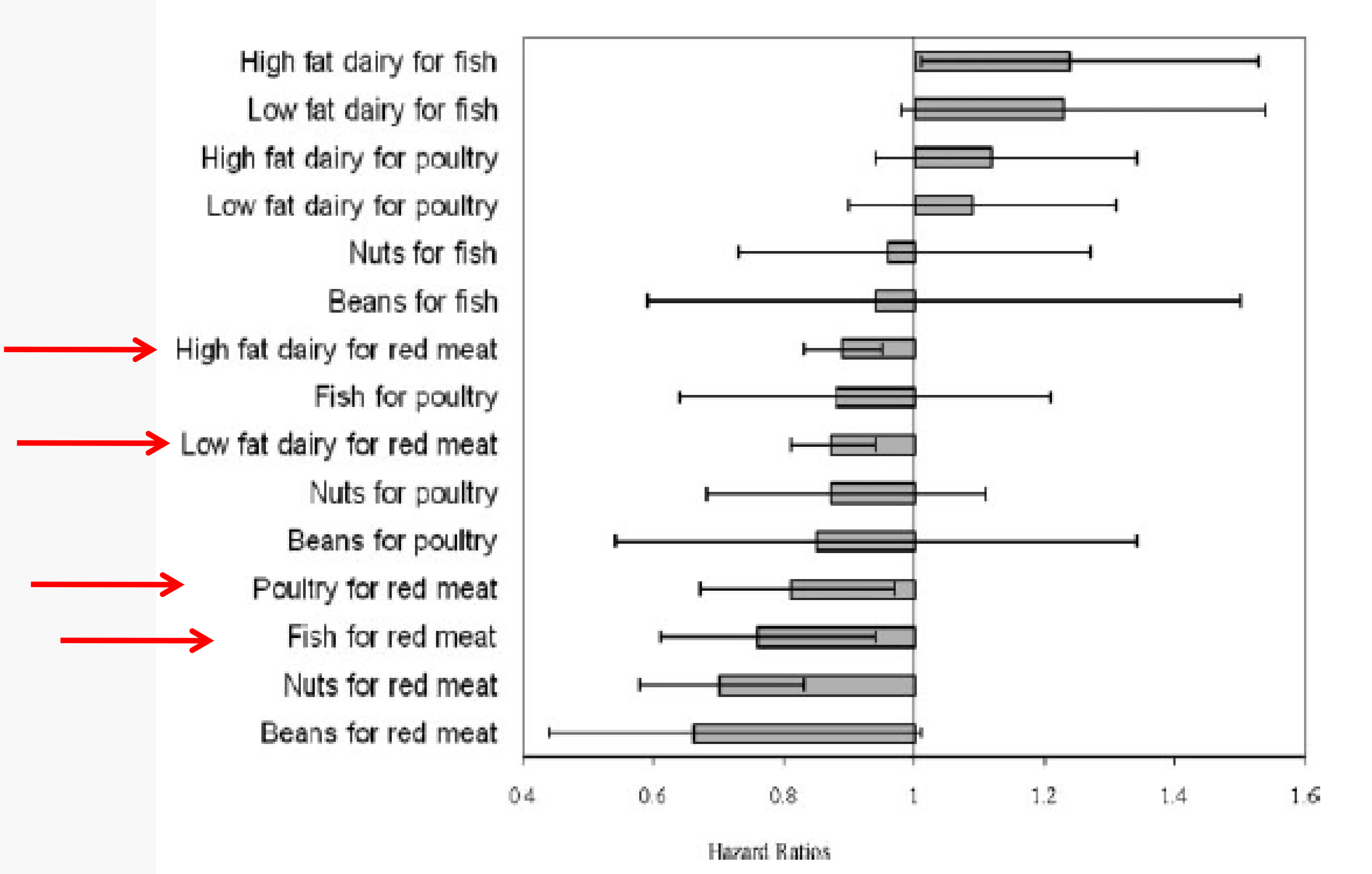
Recommendations First, we provide a list of suggestions which are intended to (a) assist with deciding whether protein-quality correction is necessary for a specific research question and (b) acknowledge additional uncertainties by providing mitigating opportunities to avoid misinterpretation (or worse, dis-interpretation) of protein-focused nLCA studies. We conclude that as relevant (primary) data availability from supply chain 'gatekeepers' (e.g., international agri-food distributors and processors) becomes more prevalent, detailed consideration of IAA provision of contrasting protein sources needs to be acknowledged—ideally quantitatively with DIAAS being one example—in nLCA studies utilising protein as a nFU. We also contend that future nLCA studies should discuss the complementarity of amino acid balances at the meal-level, as a minimum, rather than the product level when assessing protein metabolic responses of consumers. Additionally, a broader set of nutrients should ideally be included when evaluating "protein-rich foods" which provide nutrients that extend beyond amino acids, which is of particular importance when exploring dietary-level nLCA.

Keywords Amino acids · Nutrition · Environmental footprints · Food · Digestibility · Health · Nutritional LCA

SPARE SLIDES POSSIBLY FOR DISCUSSION

Relative risks for CHD with replacement of protein source

Bernstein et al., 2010



Change % in micronutrient concentrations in fruit, vegetables & nuts since agricultural intensification

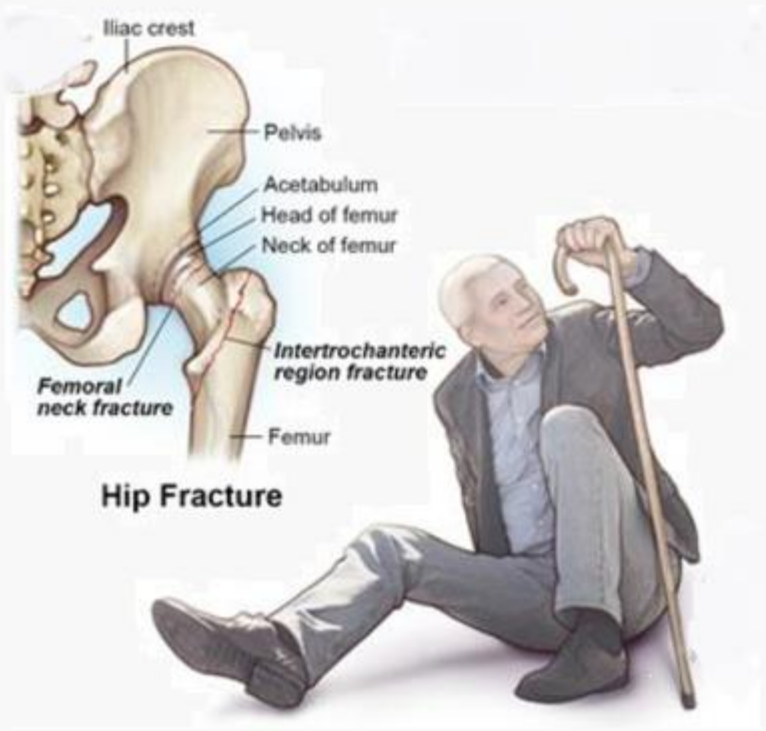
University of Reading

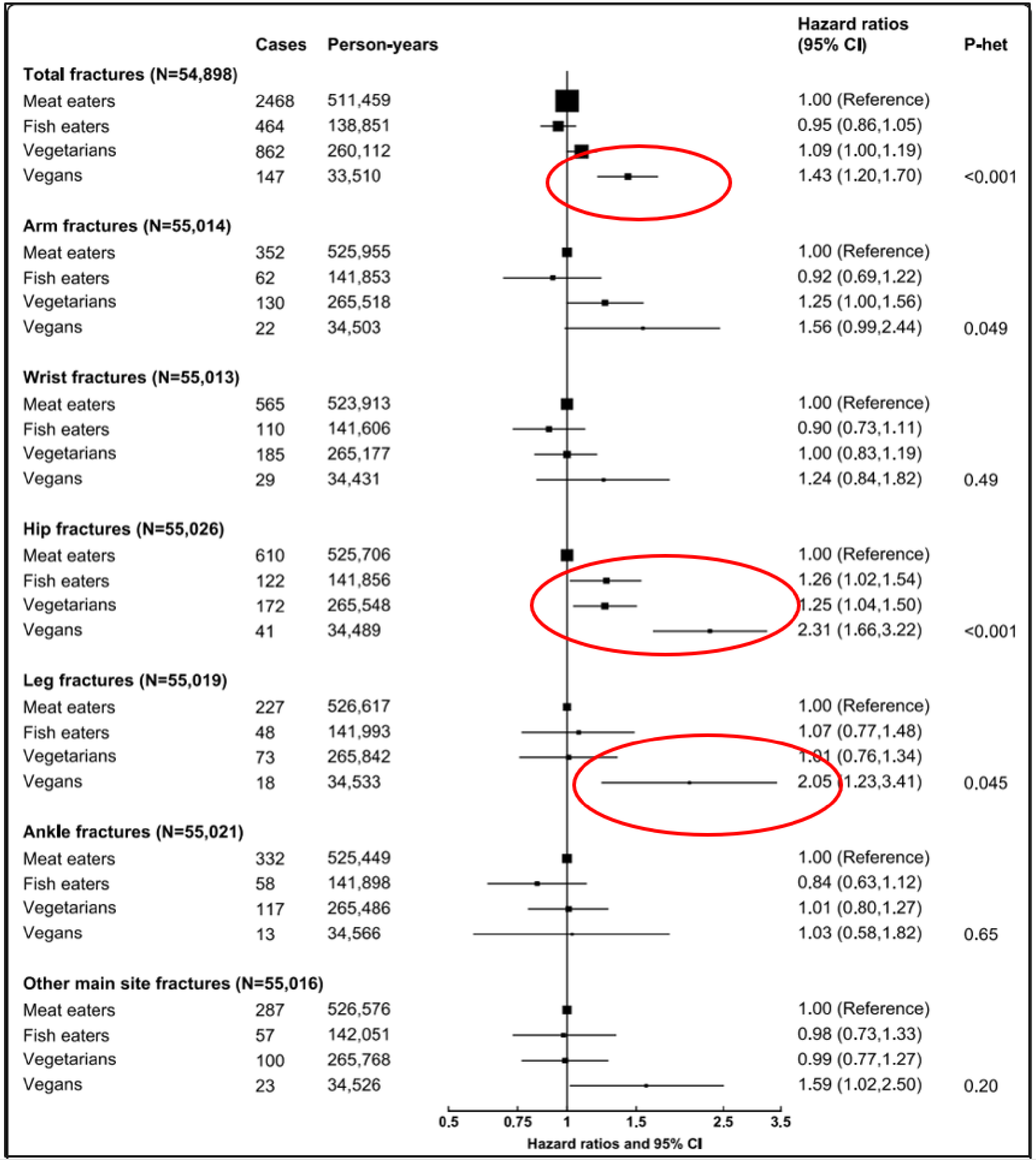
Hasanaliyeva et al.,2023

Country [Ref] Products	Time Periods Compared	Ca	Mg	Cu	Fe	K	P
		Mineral Nutrients Assessed					
UK [10]							
Vegetables	1960s–1990s	−19 *	−45 *	−81 ***	−22 T	−14 T	−6 NS
Fruit	1960s–1990s	0 NS	−11 *	−36 **	−32 **	−20 ***	−1 NS
UK [11]							
Fruit and Vegetables	1940s–1990s	−6 *	−13 ***	−60 **	−23 NS	−6 NS	+10 NS
	1990s–2010s	+3.2 NS	+18 **	+29 *	−35 **	+2 NS	−8 NS
	1940s–2010s	−3 T	−10 **	−49 *	−50 **	−5 NS	+1 NS
UK [13]							
Vegetables	1930s–1980s	−13 T	−21 *	−132 ***	−18 T	−6 NS	+8 NS
Fruits	1930s–1980s	+4 NS	−1 NS	−41 **	−16 *	−11 *	+3 NS
Nuts	1930s–1980s	+9 NS	+6 NS	+8 *	+5 NS	−4 NS	−10 NS
USA [13]							
Vegetables	1930s–2004	−46 ***	+1 NS	−51 ***	−120 ***	−3 NS	−4 NS
Fruits	1930s–2004	−49 T	ND	−44 **	−126 ***	−14 *	−1 NS
Nuts	1930s–2004	ND	ND	+2 NS	−16 NS	ND	ND

*, significant ($p < 0.05$); **, significant ($p < 0.01$); ***, significant ($p < 0.001$); NS, not significant; ND, not determined; T, trend ($0.01 > p > 0.05$).

Facture risks associated with four dietary patterns in the prospective EPIC-Oxford study **Tong et al. (2020)**

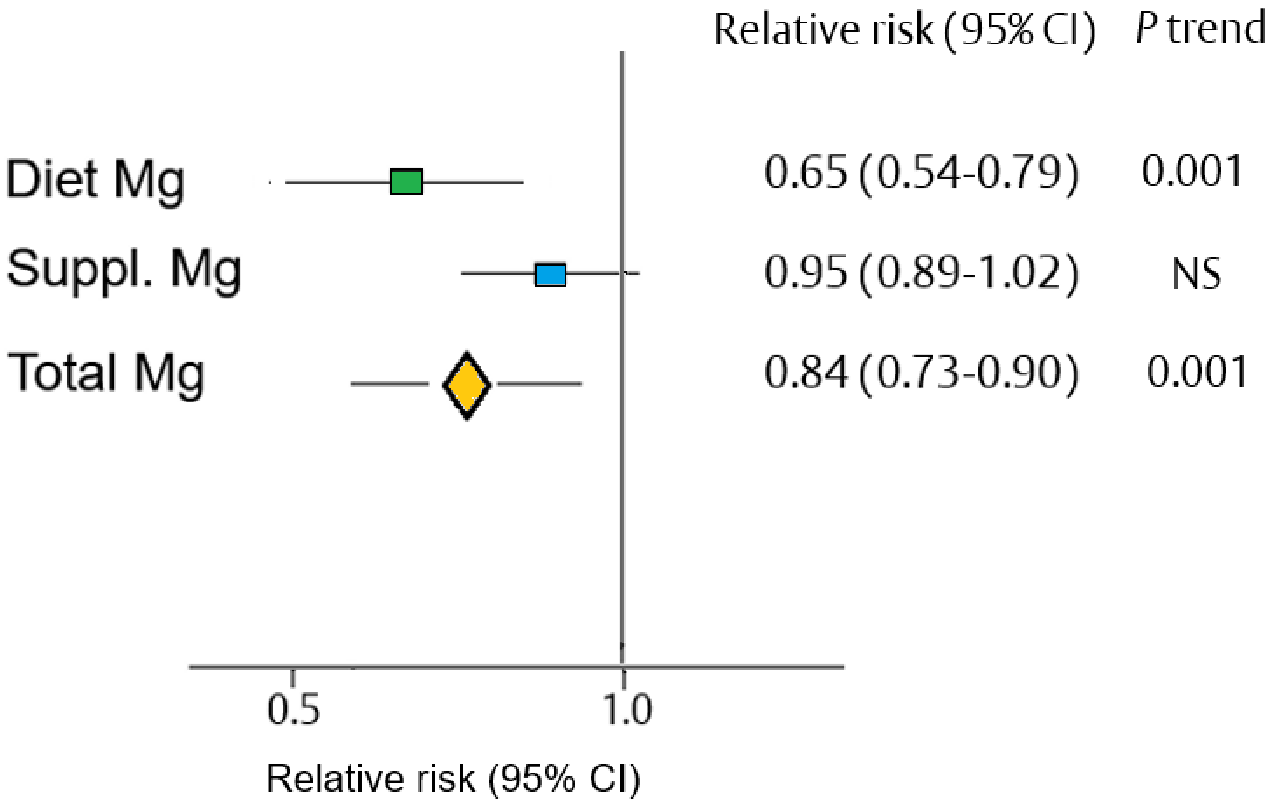




	Cases	Person-years	Hazard ratios (95% CI)	P-het
Total fractures (N=54,898)				
Meat eaters	2468	511,459	1.00 (Reference)	
Fish eaters	464	138,851	0.95 (0.86,1.05)	
Vegetarians	862	260,112	1.09 (1.00,1.19)	
Vegans	147	33,510	1.43 (1.20,1.70)	<0.001
Arm fractures (N=55,014)				
Meat eaters	352	525,955	1.00 (Reference)	
Fish eaters	62	141,853	0.92 (0.69,1.22)	
Vegetarians	130	265,518	1.25 (1.00,1.56)	
Vegans	22	34,503	1.56 (0.99,2.44)	0.049
Wrist fractures (N=55,013)				
Meat eaters	565	523,913	1.00 (Reference)	
Fish eaters	110	141,606	0.90 (0.73,1.11)	
Vegetarians	185	265,177	1.00 (0.83,1.19)	
Vegans	29	34,431	1.24 (0.84,1.82)	0.49
Hip fractures (N=55,026)				
Meat eaters	610	525,706	1.00 (Reference)	
Fish eaters	122	141,856	1.26 (1.02,1.54)	
Vegetarians	172	265,548	1.25 (1.04,1.50)	
Vegans	41	34,489	2.31 (1.66,3.22)	<0.001
Leg fractures (N=55,019)				
Meat eaters	227	526,617	1.00 (Reference)	
Fish eaters	48	141,993	1.07 (0.77,1.48)	
Vegetarians	73	265,842	1.01 (0.76,1.34)	
Vegans	18	34,533	2.05 (1.23,3.41)	0.045
Ankle fractures (N=55,021)				
Meat eaters	332	525,449	1.00 (Reference)	
Fish eaters	58	141,898	0.84 (0.63,1.12)	
Vegetarians	117	265,486	1.01 (0.80,1.27)	
Vegans	13	34,566	1.03 (0.58,1.82)	0.65
Other main site fractures (N=55,016)				
Meat eaters	287	526,576	1.00 (Reference)	
Fish eaters	57	142,051	0.98 (0.73,1.33)	
Vegetarians	100	265,768	0.99 (0.77,1.27)	
Vegans	23	34,526	1.59 (1.02,2.50)	0.20

Magnesium intake and risk of frailty in older women

Struijk et al., 2023 Curr. Dev. Nutr. 7 Supp 1

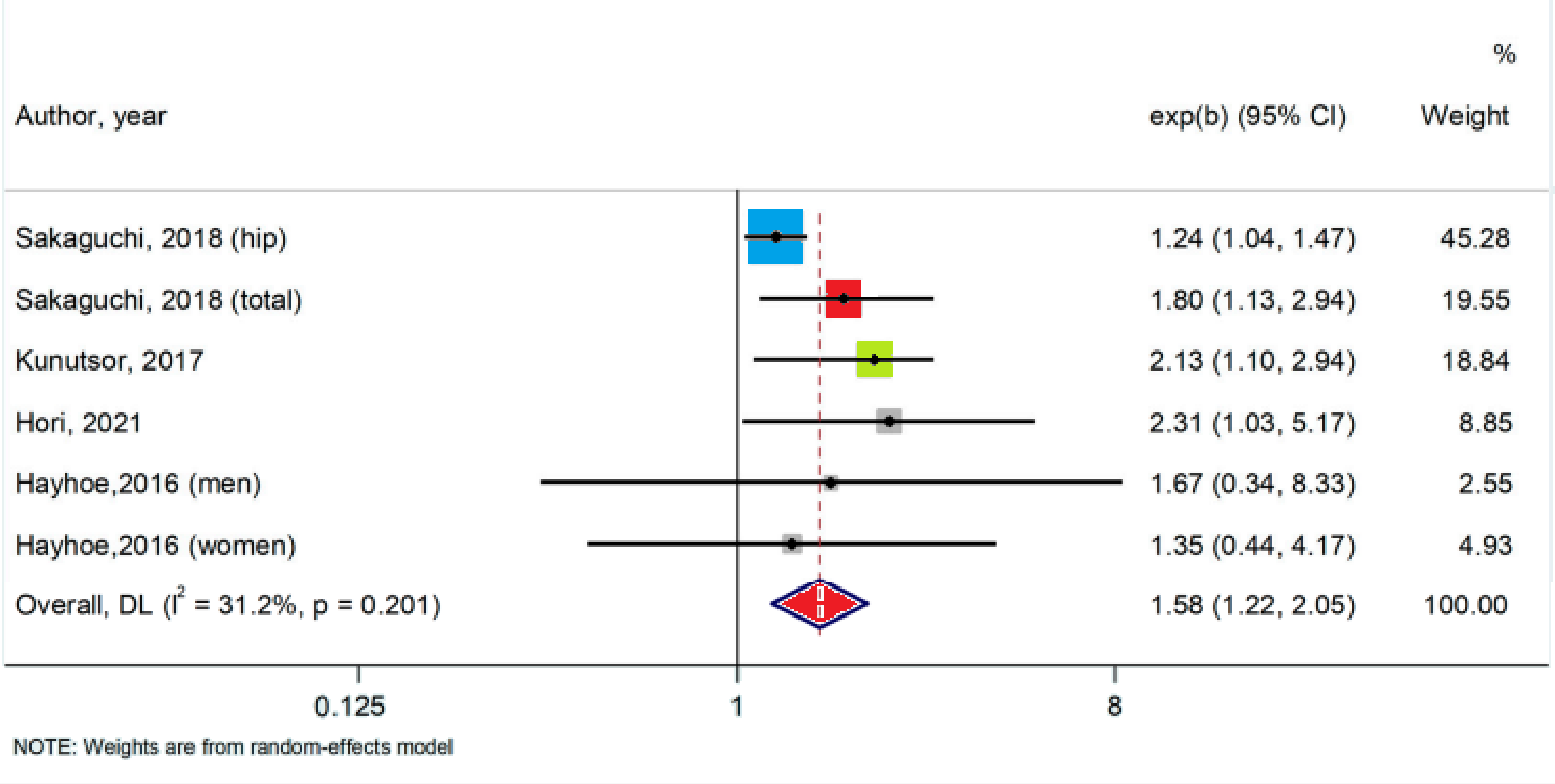


- 81,524 women aged ≥ 60 y from Nurses' Health Study
- Median follow-up 16 y
- Frailty = at least 3 FRAIL scale criteria

Association between low serum Mg and incident fractures

University of Reading

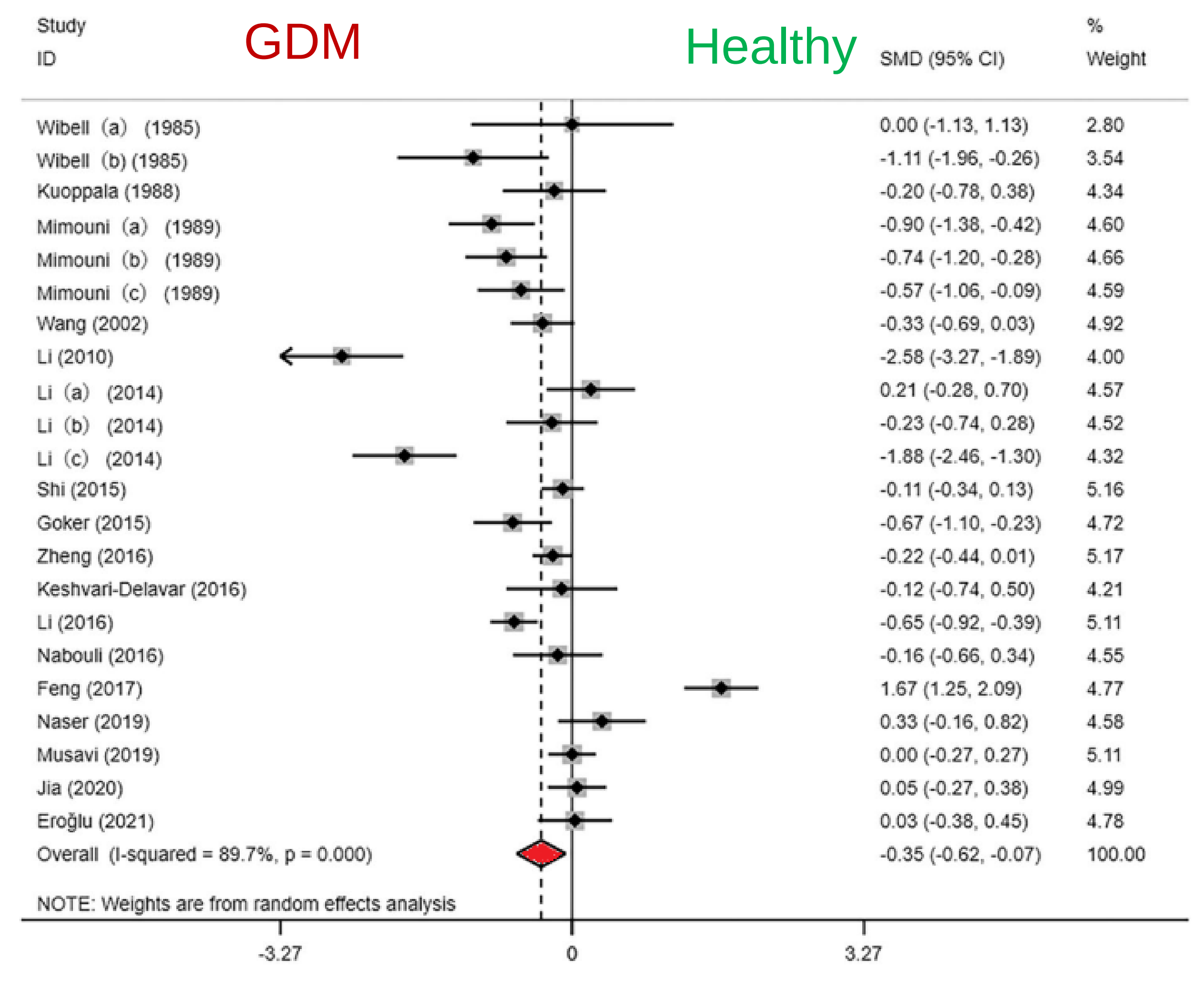
Dominguez et al., 2023
Nutrients 15, 1304



Association between serum Mg level in Gestational Diabetes Mellitus

University of Reading

Ren et al., 2023

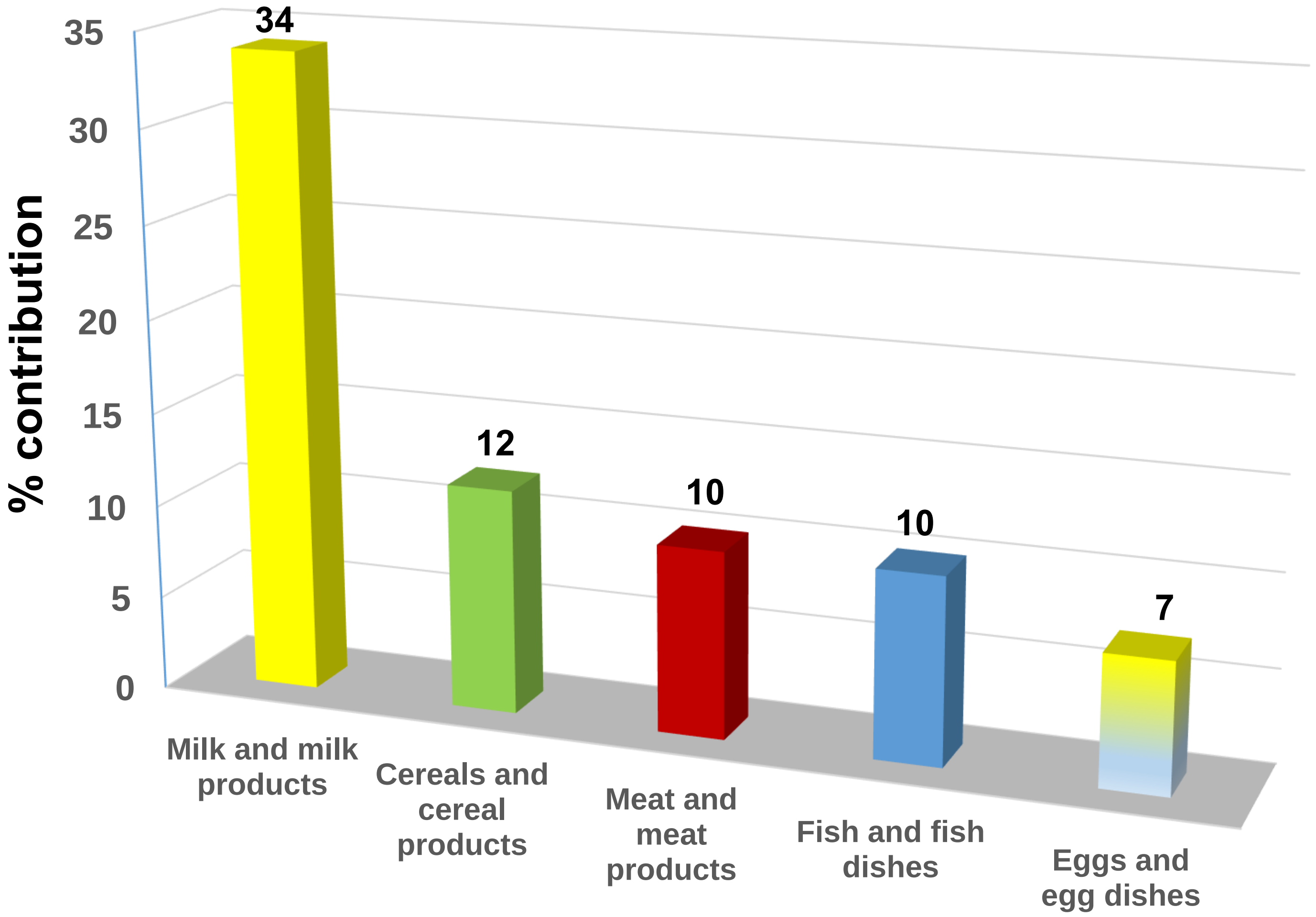


Why is iodine important in pregnancy?

Start of foetal thyroxine production

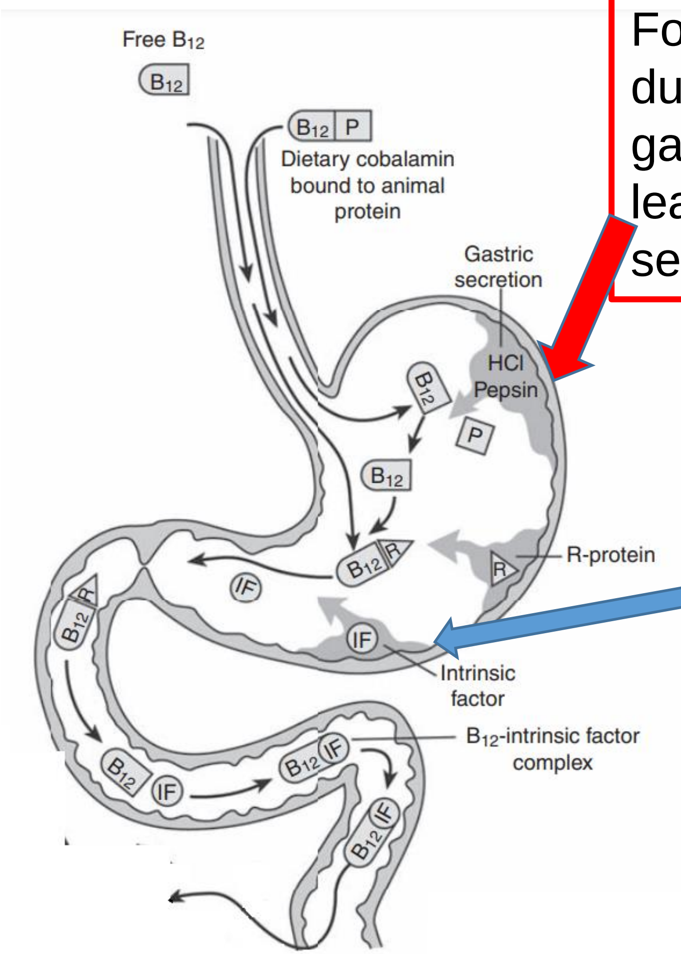
Contribution of foods to iodine intake by UK females (19-64 years)

National Diet and Nutrition Survey 2008/9-2015/16



RNI iodine during pregnancy & lactation
= 140 μg/day (UK)
= 250 μg/day (WHO)

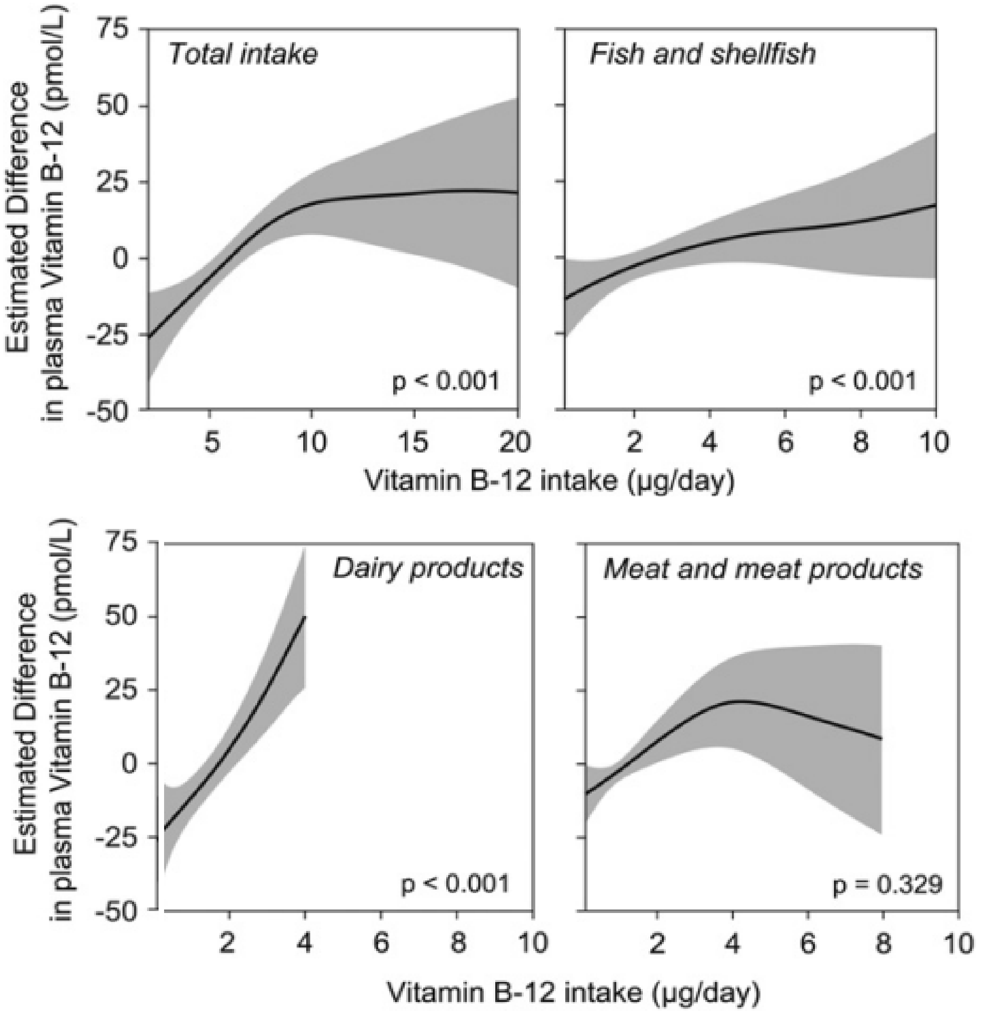
Reduced vitamin B_{12} absorption by the elderly



Food-bound malabsorption due to reduced by atrophic gastritis & PPI therapy leading to less gastric acid secretion

Reduced IF associated with pernicious anaemia

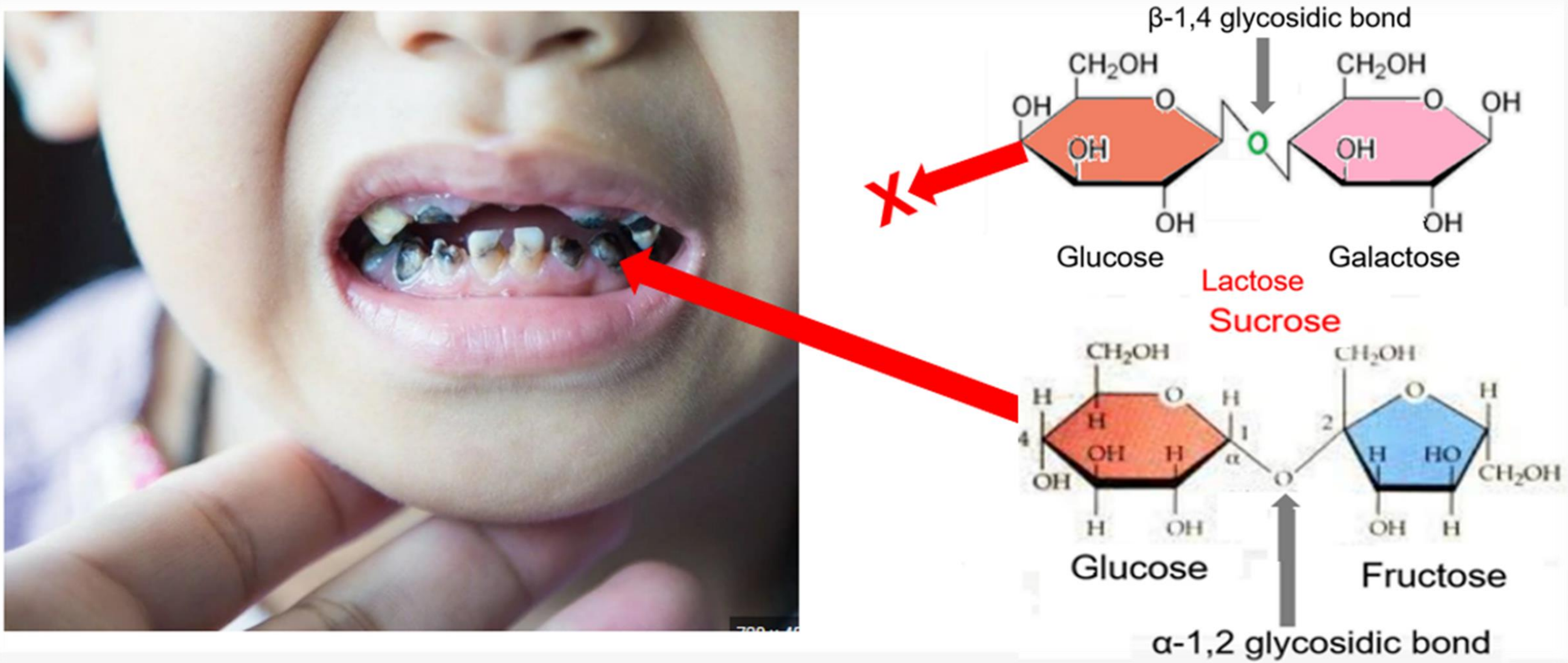
Hughes, et al Annals of Clinical Biochemistry 50(4) 315–329 2013



Am J Clin Nutr 2009;89:1078–87.

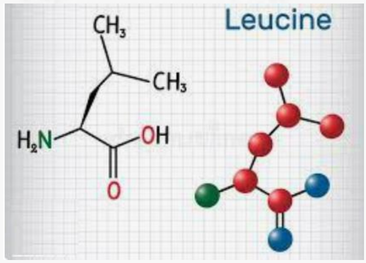
Vogiatzoglou, et al

Tooth decay and the β-link



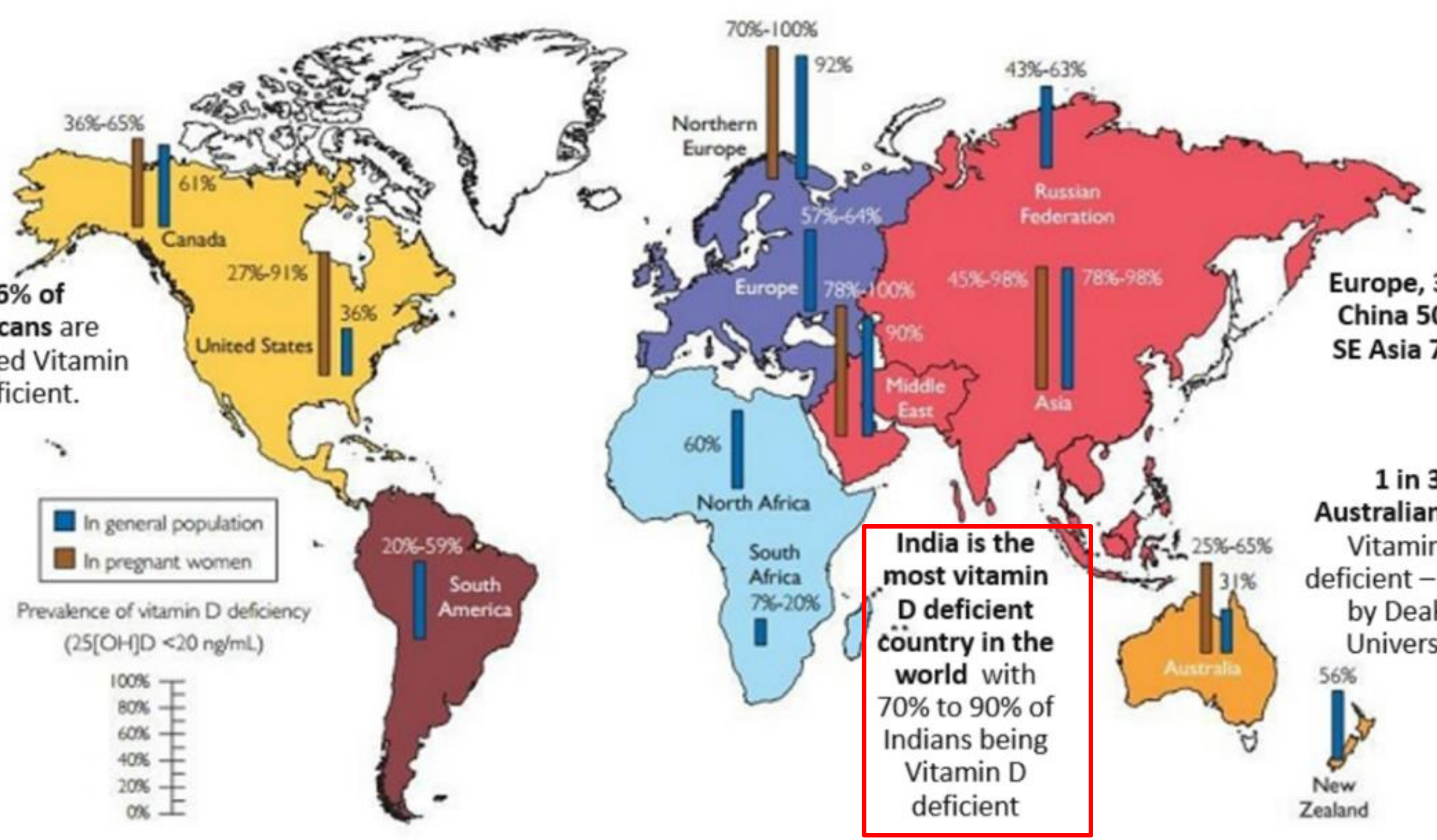
Reducing muscle loss in the elderly

University of Reading



Global rates of vitamin D deficiency

University of Reading



41.6% of Americans are considered Vitamin D deficient.

Europe, 30% China 50%, SE Asia 70%

1 in 3 Australians are Vitamin D deficient – Study by Deakin University

India is the most vitamin D deficient country in the world with 70% to 90% of Indians being Vitamin D deficient

NCB IPrevalence and correlates of vitamin D deficiency in US adults. International Osteoporosis Foundation: Vitamin D Status in Europe. China: Wolters-Kluwer journal Medicine Lips P. Worldwide status of vitamin D nutrition. J Steroid Biochem Mol Biol. 2010; 121:297-300. Holick MF. Vitamin D: importance in the prevention of cancers, type 1 diabetes, heart