

ROLE OF WHOLE GRAINS IN HEALTH AND NUTRITION: EVIDENCE AND RECOMMENDATIONS

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Cereal-based foods are essential components of the human diet

Consuming whole grains improves health and health-outcomes

The most important grains in the human diet

- Grains of the *Gramineae* family
Wheat, oats, barley, rye, triticale,
maize, rice, millet, sorghum, wild rice
- Non-cereal grains
Amaranth, psyllium, quinoa



Whole grains and health outcomes

- Early studies focused on investigating **associations** between whole-grain intake and health outcomes in observational studies
- Few **intervention** studies investigating **mechanisms of action**, but numbers have increased since
 - Cardiovascular diseases [coronary heart disease, ischaemic heart disease, stroke]
 - Cancer [all types, but especially those of the GI tract]
 - Type 2 diabetes

Whole grains and health outcomes

1997

NUTRITION AND CANCER, 27(1), 14-21
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Whole-Grain Consumption and Chronic Disease: Protective Mechanisms

Joanne Slavin, David Jacobs, and Leonard Marquart

1998

NUTRITION AND CANCER, 30(2), 85-96
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REVIEW

Whole-Grain Intake and Cancer: An Expanded Review and Meta-Analysis

David R. Jacobs, Jr., Leonard Marquart, Joanne Slavin, and Lawrence H. Kushi

Accumulating data.....

- Many systematic reviews and meta-analyses all showing the similar beneficial effects
- ‘Umbrella’ reviews of meta-analyses now appearing


McRae, MP (2017) Health benefits of dietary whole grains: an umbrella review of meta-analyses *Journal of Chiropractic Medicine* **16** 10-18

- 21 meta-analyses published between 1980 and 2016

Accumulating data.....

RESEARCH

 OPEN ACCESS



Role of diet in type 2 diabetes incidence: umbrella review of meta-analyses of prospective observational studies

Manuela Neuenschwander,¹ Aurélie Ballon,¹ Katharina S Weber,^{2,3} Teresa Norat,⁵ Dagfinn Aune,^{4,5,6} Lukas Schwingshackl,^{7,8} Sabrina Schlesinger^{1,3}

Cite this as: *BMJ* 2019;365:l2368
<http://dx.doi.org/10.1136/bmj.l2368>

INTERNATIONAL JOURNAL OF FOOD SCIENCES AND NUTRITION
<https://doi.org/10.1080/09637486.2020.1715354>

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RESEARCH ARTICLE



Whole grain consumption and human health: an umbrella review of observational studies

Maria Tieri^a, Francesca Ghelfi^{b,c}, Marilena Vitale^d, Claudia Vetrani^d, Stefano Marventano^e, Alessandra Lafranconi^{f,g}, Justyna Godos^h , Lucilla Titta^a, Angelo Gamberaⁱ, Elena Alonzo^j, Salvatore Sciacca^k, Gabriele Riccardi^d, Silvio Buscemi^l, Daniele Del Rio^{c,m,n}, Sumantra Ray^{c,o,p,q}, Fabio Galvano^r, Eleanor Beck^{s*} and Giuseppe Grosso^{c,r*}

Accumulating data.....

- Increasing numbers of studies included in meta-analyses:
 - Gives added 'strength' to outcome measures
 - Widens population groups/nationalities investigated, making results more generalisable
 - Allows for sub-group analysis of effect of different factors on outcome measures
 - Allows for regression analyses to assess/describe response characteristics

Accumulating data.....

- Increasing number of studies included in meta-analyses:

CRITICAL REVIEWS IN FOOD SCIENCE AND NUTRITION
2023, VOL. 63, NO. 21, 5339–5357
<https://doi.org/10.1080/10408398.2021.2017838>



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REVIEW

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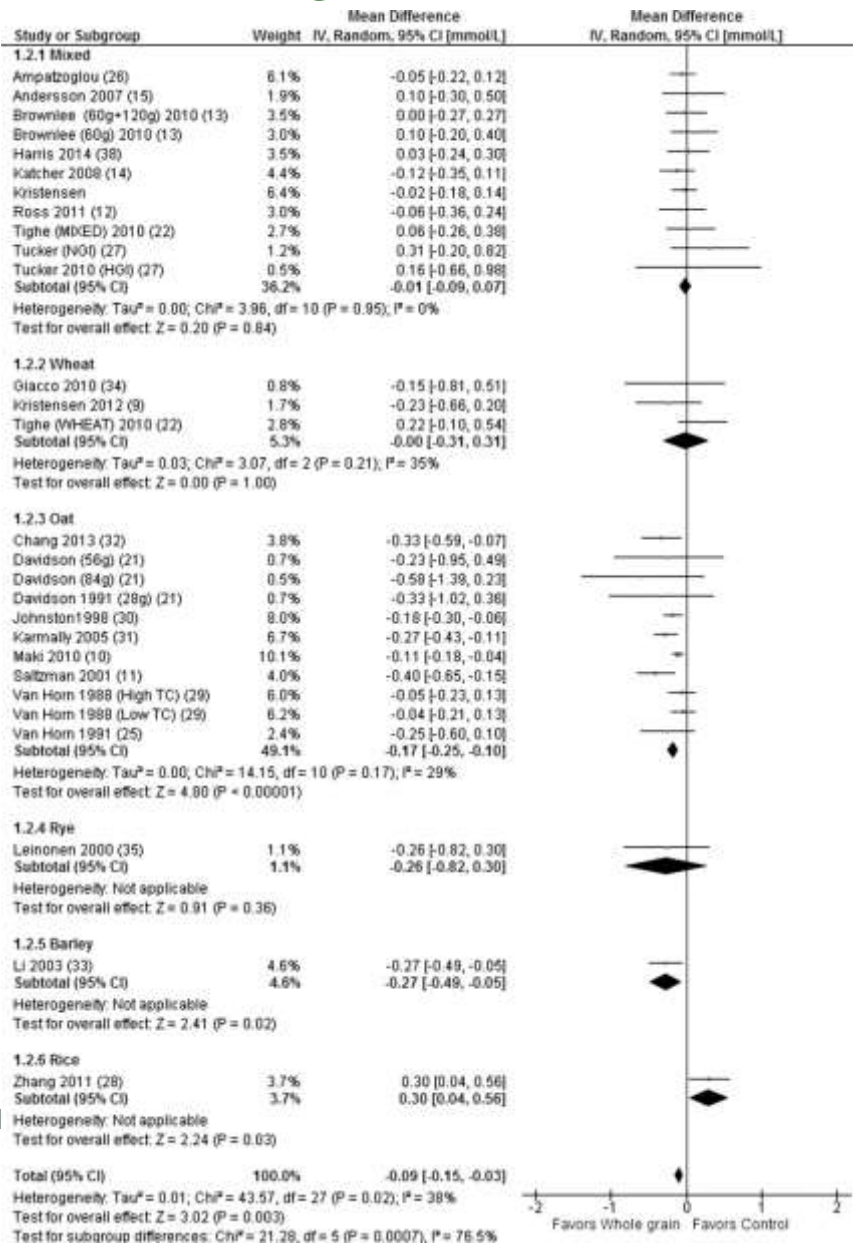


Whole grain intake, compared to refined grain, improves postprandial glycemia and insulinemia: a systematic review and meta-analysis of randomized controlled trials

Lisa M. Sanders^a , Yong Zhu^b, Meredith L. Wilcox^a, Katie Koecher^b and Kevin C. Maki^{a,c}

- **80 eligible RCT studies included in the analysis**

Whole grain lowers LDL cholesterol



Forest plot of the results of the random-effects meta-analysis of change in LDL cholesterol (mmol/L) according to grain type shown as pooled mean differences with 95% CIs.

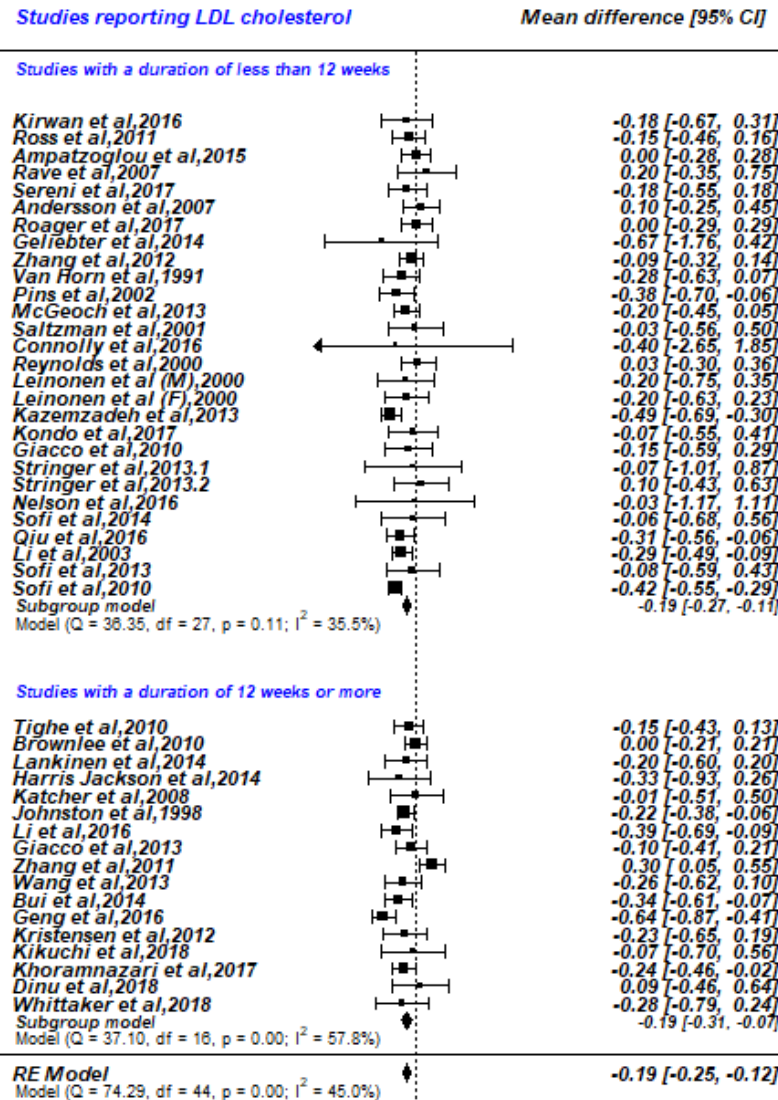
Hollænder *et al.* (2015) *Am J Clin Nutr* 102 556-572

Whole grain lowers LDL cholesterol

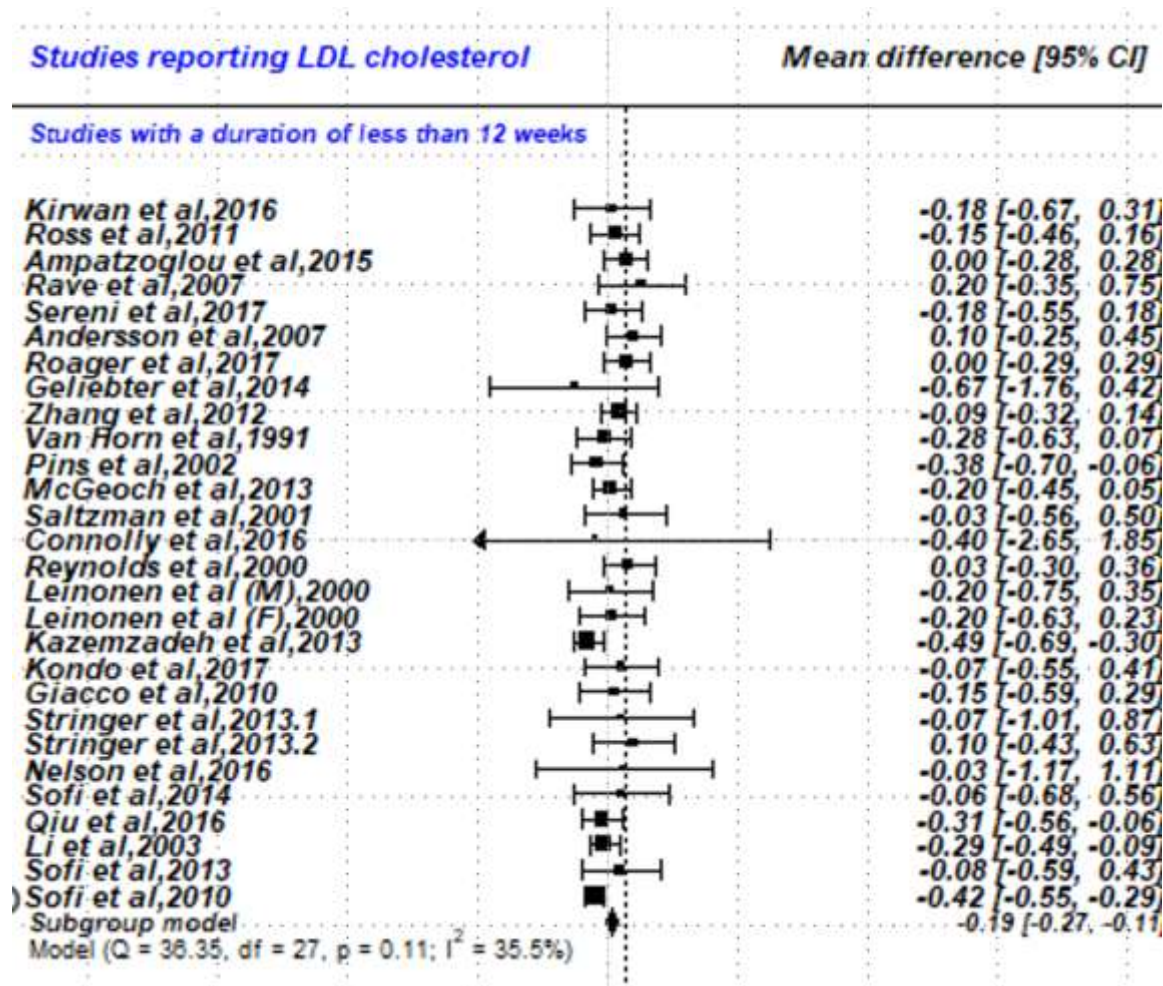
Intervention studies

- 43 eligible RCT studies included in the analysis

Iqbal & Seal (unpublished)



Whole grain lowers LDL cholesterol



Iqbal & Seal (unpublished)

Whole grains and more diverse health outcomes

- ↓ Dementia and Alzheimer's disease
 - Wang *et al.* (2023) *Psych Clin Neuro* **77** 172
- ↓ Hospitalisation with kidney disease
 - Shan *et al.* (2023) *Food Funct* **14** 3863
- ↓ Non-Alcoholic Fatty Liver disease
 - Wu *et al.* (2022) *Clin Nutr* **41** 1483
- ↓ Risk of knee osteoarthritis
 - Liu *et al.* (2023) *Rheumatol* **62** 1834

Words of caution.....

- Avoid duplication of data from large studies (use only the most up to date publications)
- Avoid over-interpretation (ensure that the results are plausible)
- Consider confounding factors

ASSOCIATIONS \neq CAUSALITY

Not all results show benefit of whole grains

RESEARCH

 OPEN ACCESS

 Check for updates

Associations of cereal grains intake with cardiovascular disease and mortality across 21 countries in Prospective Urban and Rural Epidemiology study: prospective cohort study

Sumathi Swaminathan,¹ Mahshid Dehghan,² John Michael Raj,³ Tinku Thomas,³ Sumathy Rangarajan,² David Jenkins,⁴ Prem Mony,¹ Viswanathan Mohan,⁵ Scott A Lear,⁶ Alvaro Avezum,⁷ Patricio Lopez-Jaramillo,⁸ Annika Rosengren,^{9,10} Fernando Lanas,¹¹ Khalid F AlHabib,¹² Antonio Dans,¹³ Mirac Vural Keskinler,¹⁴ Thandi Puoane,¹⁵ Biju Soman,^{16,17} Li Wei,¹⁸ Katarzyna Zatonska,¹⁹ Rafael Diaz,²⁰ Noorhassim Ismail,²¹ Jephath Chifamba,²² Roya Kelishadi,²³ Afzalhussein Yusufali,²⁴ Rasha Khatib,^{25,26} Liu Xiaoyun,¹⁸ Hu Bo,¹⁸ Romaina Iqbal,²⁷ Rita Yusuf,²⁸ Karen Yeates,^{29,30} Koon Teo,² Salim Yusuf²

Cite this as: *BMJ* 2021;372:m4948

<http://dx.doi.org/10.1136/bmj.m4948>

Why are there inconsistencies and heterogeneity in results?

- **Varying definitions of whole grain used in diet analysis**
 - Difficult to confirm 'validity' of food composition, no standard tables of whole grain content of foods, some studies include 'added bran'
- **Mixed interventions**
 - Different grains, whole grain as part of healthy diet patterns, mixed with other foods
- **Compliance difficult to ascertain**
 - Biomarkers of intake not always measured
 - Compliance may not be recorded

Why are there inconsistencies and heterogeneity in results?

- **Population groups differ between studies**
 - ‘Healthy’, ‘disease’ or ‘at risk’ populations
 - Limited data outside North America and Europe so cultural differences in (habitual) diet between regions are not accounted for
 - Weight loss studies included
- **Duration of studies**
 - 2 weeks to 6 months vs longer exposure in observational data

Benefits of consuming whole grains

- **Improves nutrient profile of the diet**
 - Increases dietary fibre intake
 - Increases micronutrient intake
 - Lowers energy density of the diet
- **Beneficial health effects**
 - Reduces risk of chronic diseases
 - Improves lipid profile
 - Reduces markers of inflammation
 - Lower BMI and weight gain

Should increased whole-grain intake be recommended?

YES!

- Health benefits of consuming whole grain are clear
- Key for delivery of additional dietary fibre to meet dietary recommendations
- Should be encouraged as part of a drive towards a more plant-based diet

So how much whole grain should we
consume?



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



GBD 2017 Diet Collaborators*

Summary

Lancet 2019; 393: 1958–72

Published Online

April 3, 2019

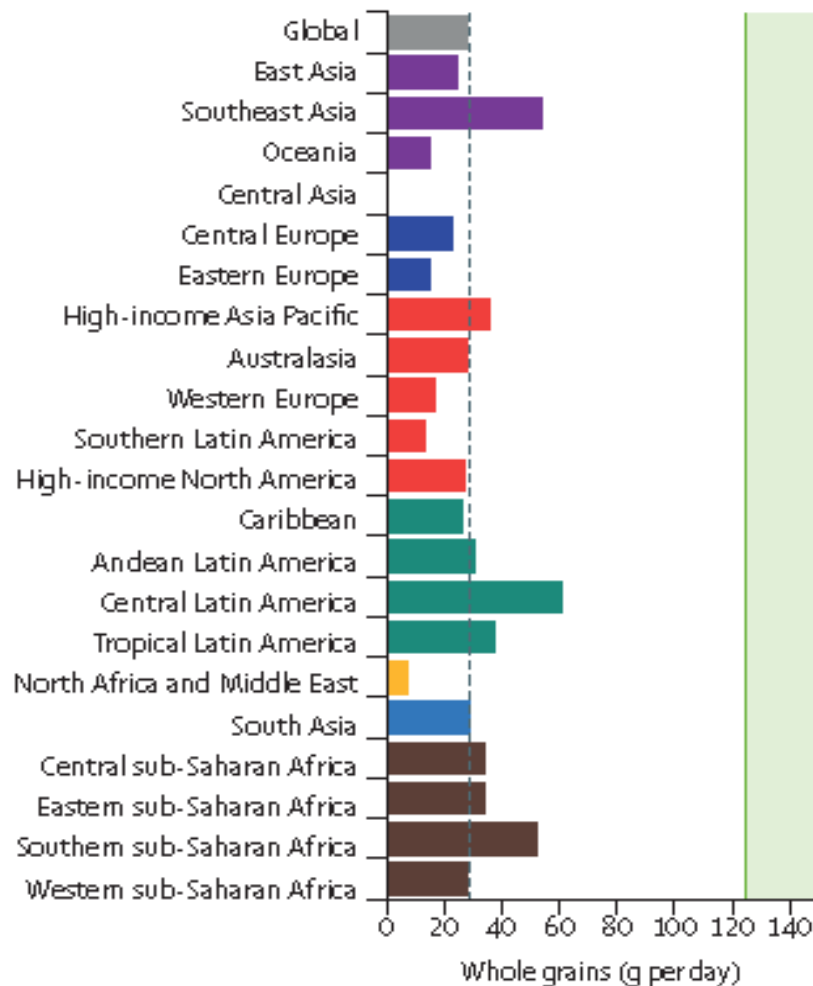
[http://dx.doi.org/10.1016/](http://dx.doi.org/10.1016/S0140-6736(19)30041-8)

[S0140-6736\(19\)30041-8](http://dx.doi.org/10.1016/S0140-6736(19)30041-8)

Background Suboptimal diet is an important preventable risk factor for non-communicable diseases (NCDs); however, its impact on the burden of NCDs has not been systematically evaluated. This study aimed to evaluate the consumption of major foods and nutrients across 195 countries and to quantify the impact of their suboptimal intake on NCD mortality and morbidity.

“3 (of 11) million deaths and 80 (of 255) million disability-adjusted life-years were attributable to low dietary whole grain intake; alongside high salt intake and low fruit intake as leading dietary risk factors”

Global Burden of Disease Study



- Optimal whole grain intake set at 125 g/day (optimal range 100-150 g/day) based on meta-analysis of dietary relative risks

Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems



Walter Willett, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, David Tilman, Fabrice DeClerck, Amanda Wood, Malin Jonell, Michael Clark, Line J Gordon, Jessica Fanzo, Corinna Hawkes, Rami Zurayk, Juan A Rivera, Wim De Vries, Lindiwe Majele Sibanda, Ashkan Afshin, Abhishek Chaudhary, Mario Herrero, Rina Agustina, Francesco Branca, Anna Lartey, Shenggen Fan, Beatrice Crona, Elizabeth Fox, Victoria Bignet, Max Troell, Therese Lindahl, Sudhvir Singh, Sarah E Cornell, K Srinath Reddy, Sunita Narain, Sania Nishtar, Christopher J L Murray

“Healthy diets have an appropriate caloric intake and consist of a diversity of plant-based foods, low amounts of animal source foods, unsaturated rather than saturated fats, and small amounts of refined grains, highly processed foods, and added sugars”.

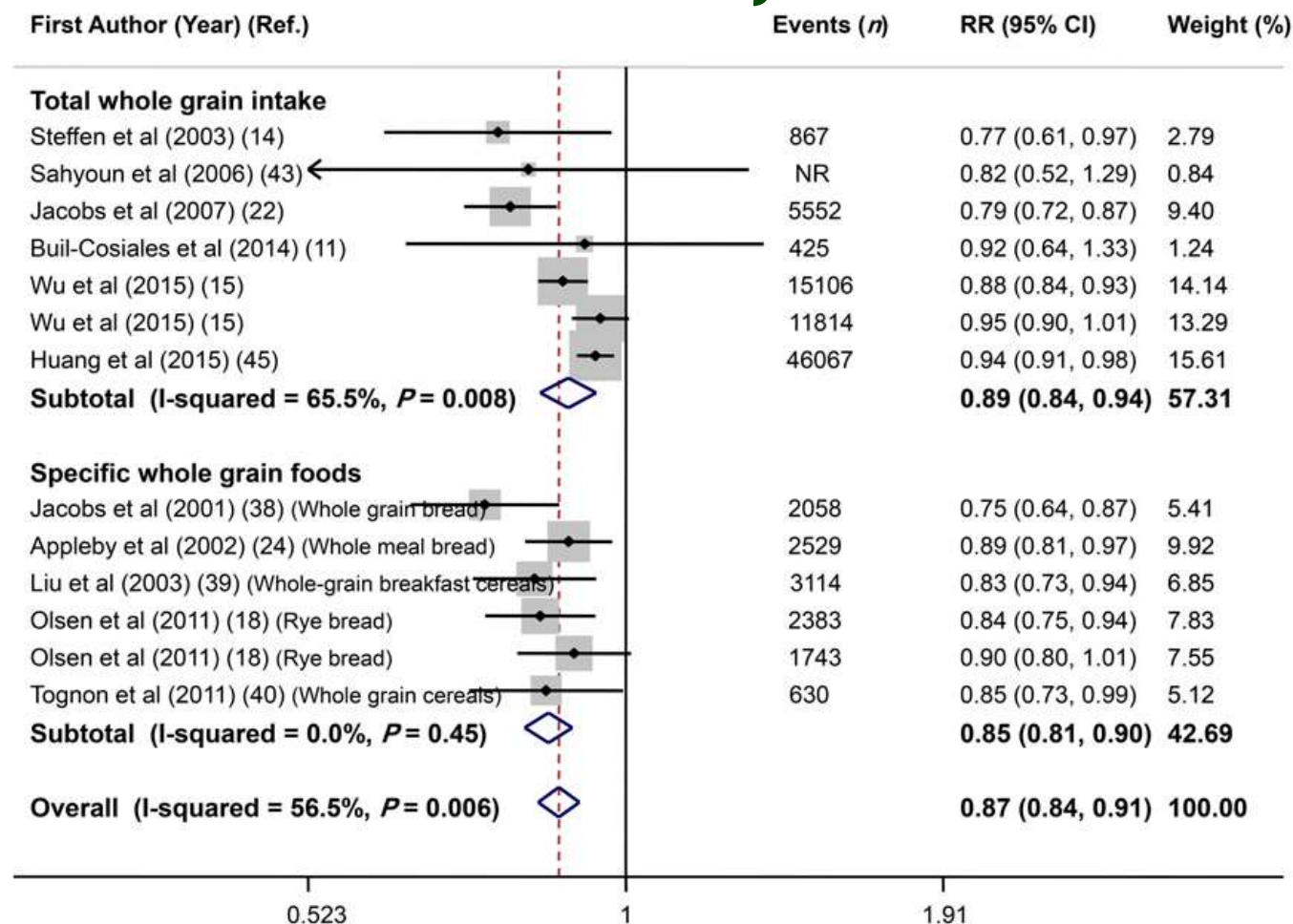
	Macronutrient intake (possible range), g/day	Caloric intake, kcal/day
Whole grains*		
Rice, wheat, corn, and other†	232 (total gains 0-60% of energy)	811
Tubers or starchy vegetables		
Potatoes and cassava	50 (0-100)	39
Vegetables		
All vegetables	300 (200-600)	--
Dark green vegetables	100	23
Red and orange vegetables	100	30
Other vegetables	100	25
Fruits		
All fruit	200 (100-300)	126
Dairy foods		
Whole milk or derivative equivalents (eg, cheese)	250 (0-500)	153
Protein sources‡		
Beef and lamb	7 (0-14)	15
Pork	7 (0-14)	15
Chicken and other poultry	29 (0-58)	62
Eggs	13 (0-25)	19
Fish§	28 (0-100)	40
Legumes		
Dry beans, lentils, and peas*	50 (0-100)	172
Soy foods	25 (0-50)	112
Peanuts	25 (0-75)	142
Tree nuts	25	149
Added fats		
Palm oil	6.8 (0-6.8)	60
Unsaturated oils¶	40 (20-80)	354
Dairy fats (included in milk)	0	0
Lard or tallow	5 (0-5)	36
Added sugars		
All sweeteners	31 (0-31)	120

	Macronutrient intake (possible range), g/day	Caloric intake, kcal/day
Whole grains*		
Rice, wheat, corn, and other†	232 (total gains 0-60% of energy)	811

Proposed sustainable, healthy diet assumes that all grains are consumed as whole grains

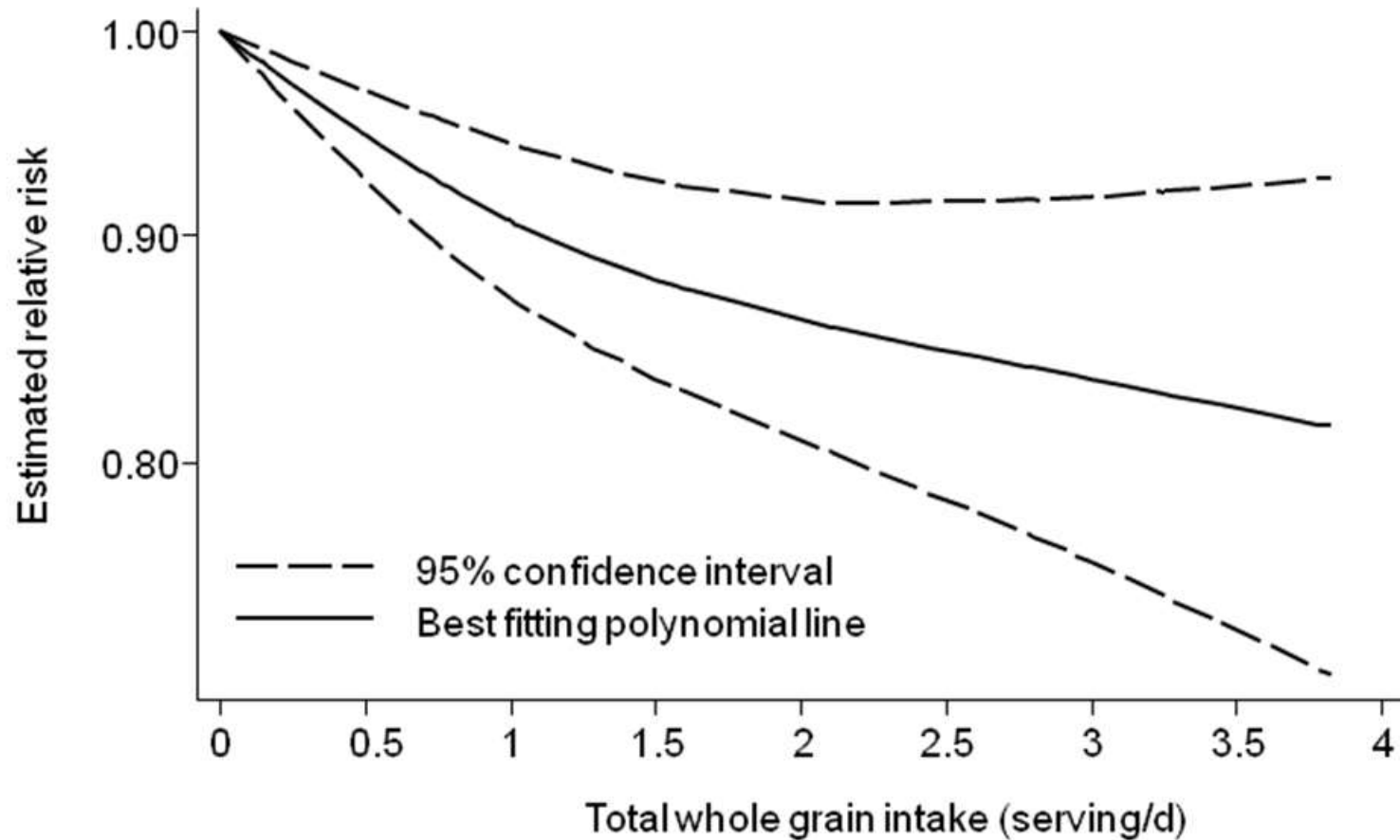
Willett *et al.* (2019) *The Lancet* **393**, 447-492.

WG intake and all-cause mortality



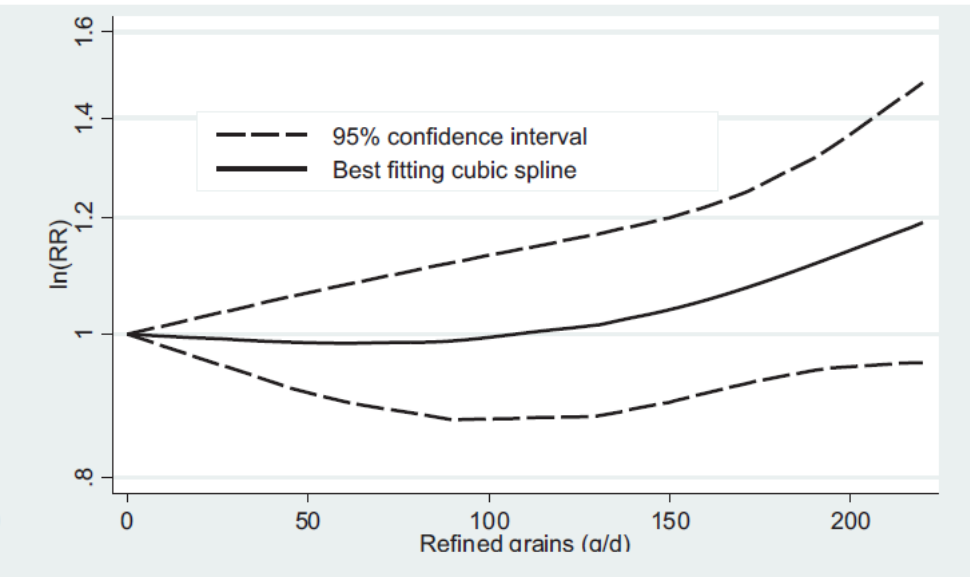
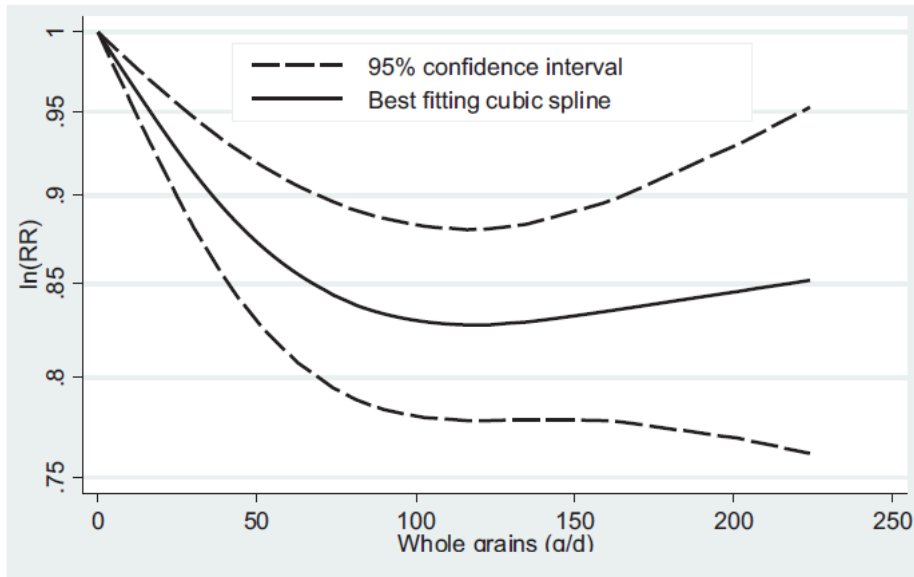
Benisi-Kohansal *et al.* (2016) *Advances in Nutrition* 7 1052-1065

WG intake and all-cause mortality



Benisi-Kohansal *et al.* (2016) *Advances in Nutrition* 7 1052-1065

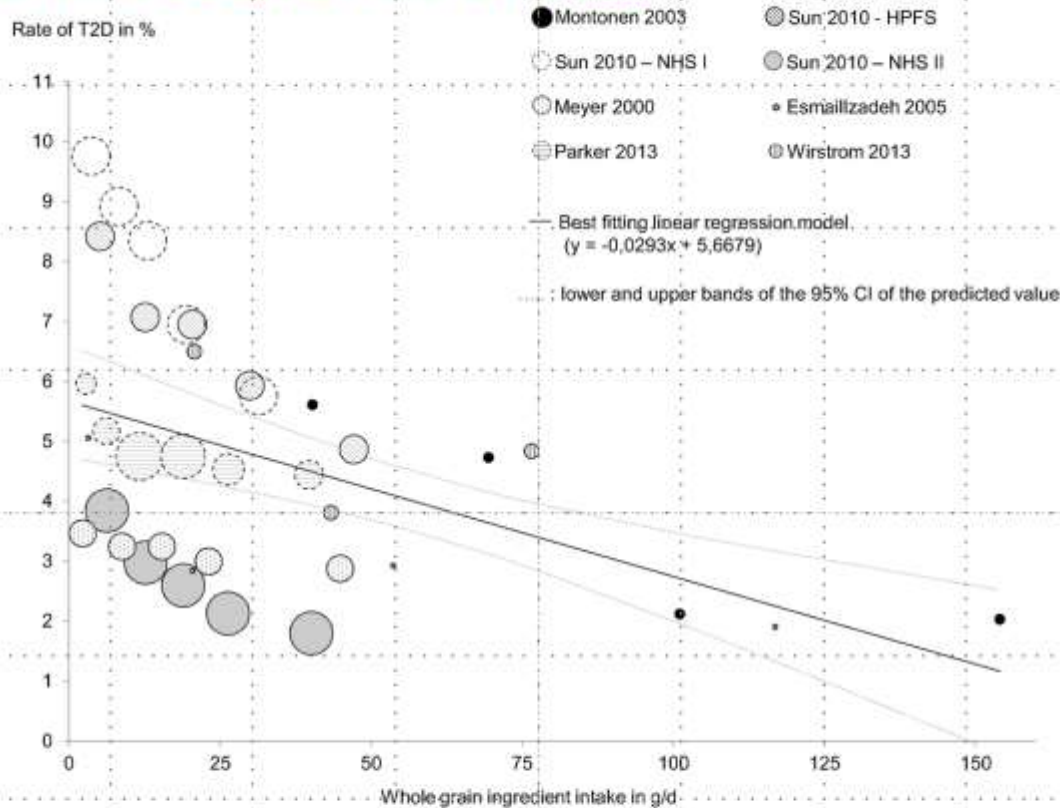
Whole grain vs Refined grain and CHD



30g servings/d	0	1	2	3	4	5	6	Total	P
Whole grain	1.00	0.91	0.86	0.83	0.83	0.83	0.83	0.95	0.007
Refined grain	1.00	0.99	0.99	1.07	1.01	1.04	1.10	1.01	0.31

Bechthold *et al* (2019) *Crit Rev Food Sci Nutr* 59, 1071-1090

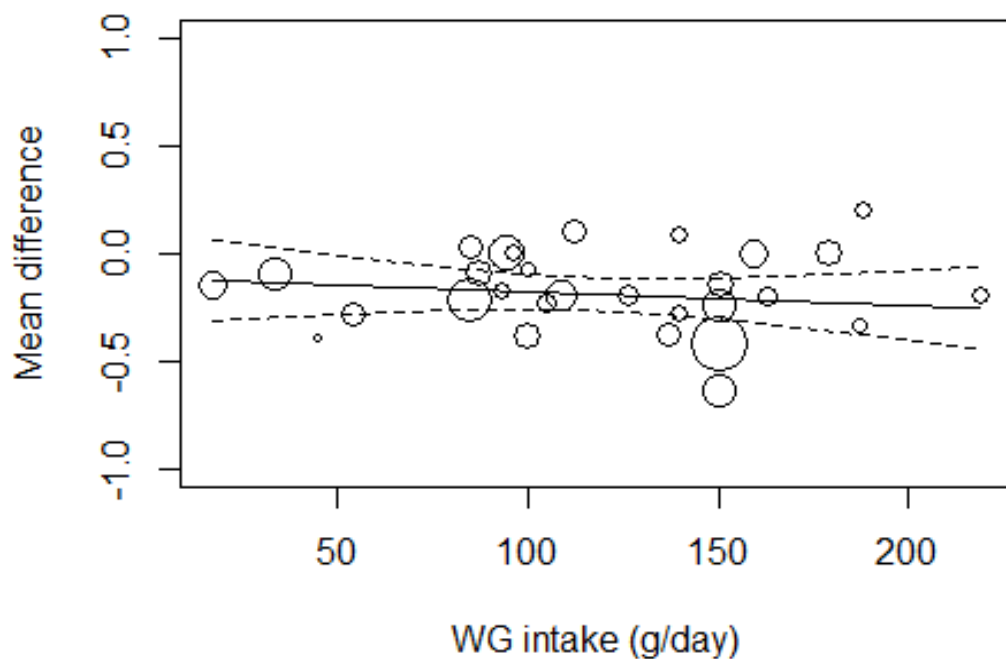
WG intake and occurrence of T2D



Meta-regression analysis between whole grain intake and occurrence of T2D

Chanson-Rolle *et al.* (2015) PLoS ONE 10 (6) e0131377

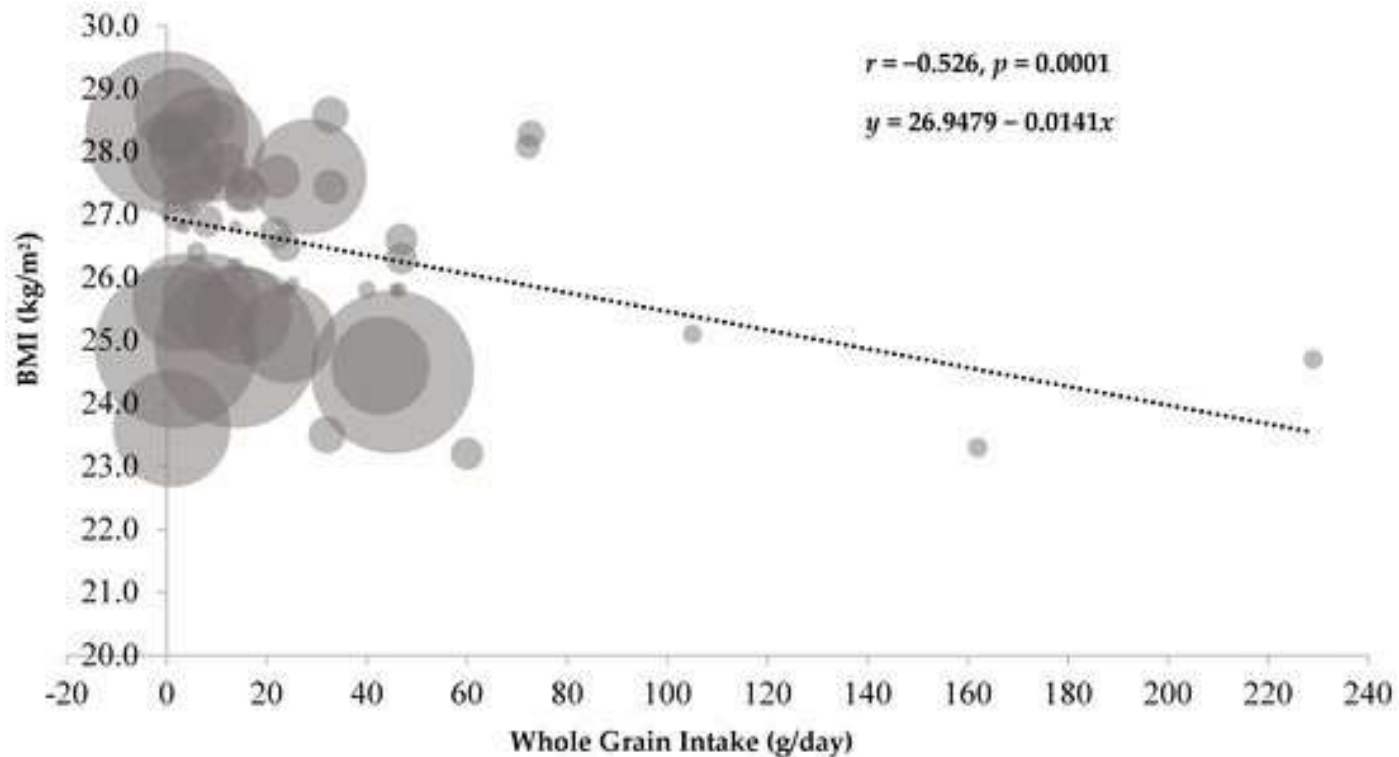
Whole grain intake and LDL cholesterol



Meta-regression
analysis of 27
intervention
studies of less than
12 weeks duration

Iqbal & Seal (unpublished)

WG Intake and Body Mass Index

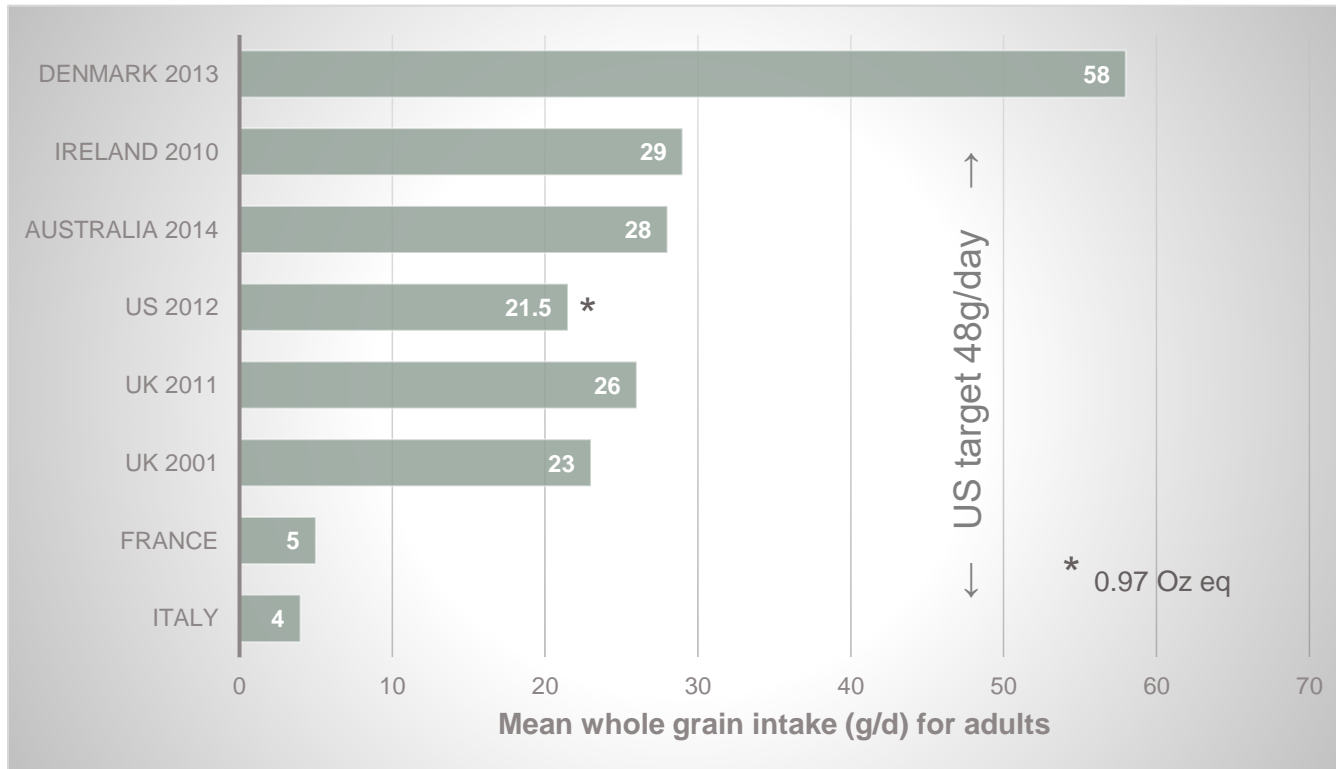


Maki *et al* (2019) *Nutrients* 11(8), 1839

However....

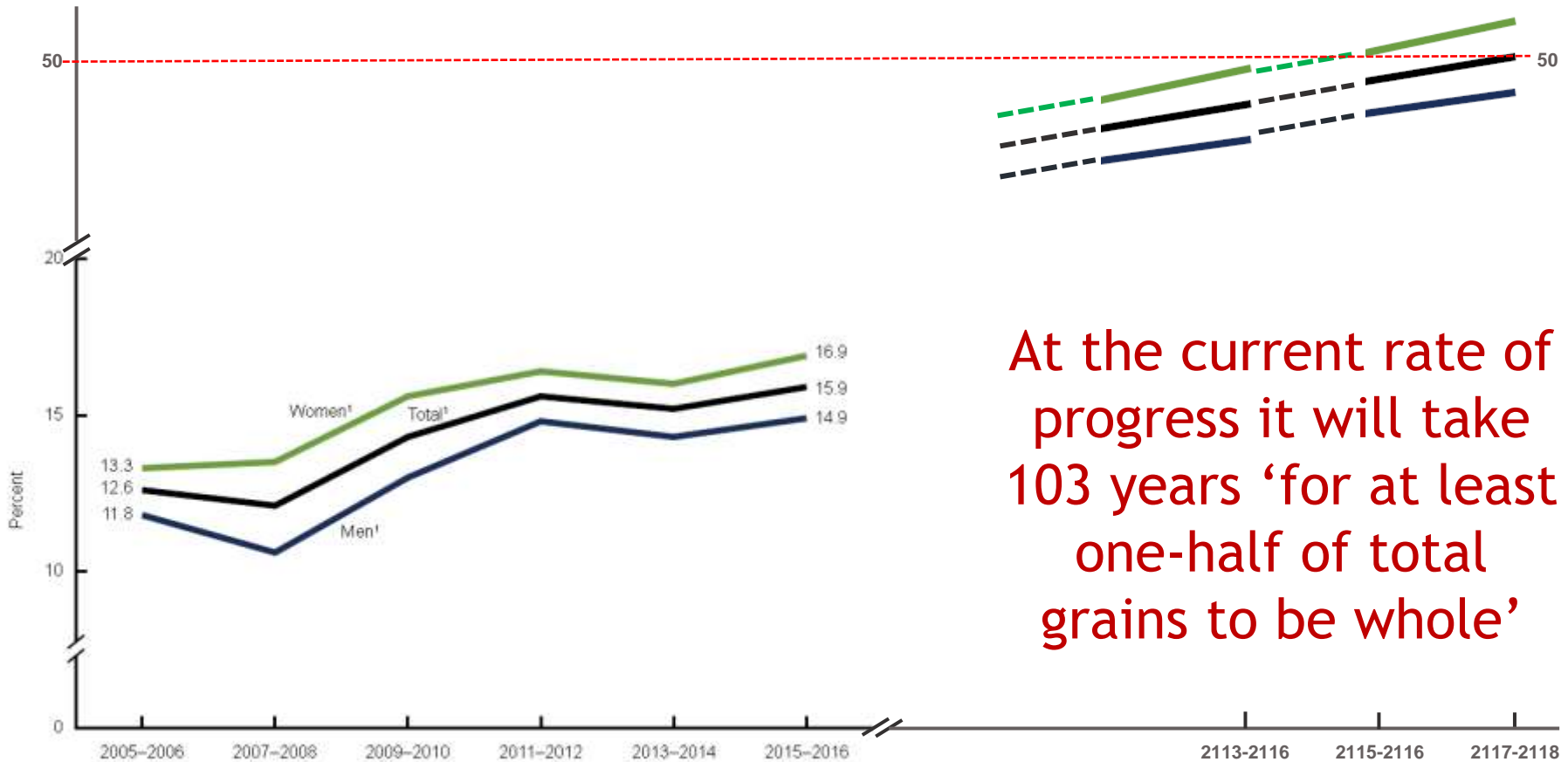
Whole-grain intake is well below target levels and is only increasing slowly

Whole-grain consumption



Mann, Pearce & Seal (2017) *Proc Nutr Soc* 76 369-377

Increasing whole-grain intake.....



At the current rate of progress it will take 103 years 'for at least one-half of total grains to be whole'

Increasing whole grain intake.....

- Requires a concerted effort between health agencies, industry and academics
- Better inform public on benefits of whole-grain consumption, where whole grains can be found, and how much is present in different cereal foods
- Better labelling of whole-grain foods, and definitions of whole grain and whole-grain foods
- Incorporate whole grains in a mixed diet based on greater consumption of plant-based foods improve diet sustainability

Summary

- The relationship between whole grain intake and health outcomes is consistent, but the dose-response is less clear
- Optimal ranges for whole grain intake appear to be around 100-125 g whole grain per day
- The strongest impact appears to be moving from 'no' or 'low' intake to this level of intake
- Higher levels of intake appear not to be justified and may be a barrier to change

Summary

- Increased whole grain intake can have a positive impact on diet quality, especially fiber intake

BUT:

- May need to consider the impact of contaminants (e.g. mycotoxins and pesticides) in whole grain flours
- Whole grain flours may require fortification in countries where this is not routine
- Reduced mineral availability may be a problem

Thank you for your attention