Evidence of effects of animal source foods on growth, development and other health outcomes

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Program in International and Community Nutrition

Outline for today's presentation

- Children
  - Growth
  - Anemia and micronutrient status
  - Child development
- Pregnancy
  - Birth weight
  - Child growth & BMI
  - Child development
- Adult
  - Chronic disease (CVD, cancer)
- Summary

Child growth & stunting

Guatemalan children raised in a low income community in Guatemala

Guatemalan children raised in Florida

Image source: ABC News, 2010

Types and amounts of complementary foods and beverages consumed and growth, size, and body composition: a systematic review

Laural K English,[1] Julie E Obbagy,[2] Yat Ping Wong,[2] Nancy F Butte,[3] Kathryn G Dewey,[4] Mary Kay Fox,[5] Frank R Greer,[6] Nancy F Krebs,[7] Kelley S Scanlon,[2] and Eve E Stoody[2]

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ABSTRACT

Background: Systematic reviews (SRs) were conducted by the Nutrition Evidence Systematic Review (NESR) team for the USDA's and the Department of Health and Human Services' Pregnancy and Birth to 24 Months Project.

Objectives: The aim was to describe the SRs examining the relationship between types and amounts of complementary foods and beverages (CFBs) and growth, size, and body-composition outcomes.

Methods: The NESR team collaborated with subject matter experts to conduct this SR. The literature was searched and screened using predetermined criteria. For each included study, data were extracted and risk of bias was assessed. The evidence was qualitatively synthesized to develop a conclusion statement, and the strength of evidence was graded.

Results: This SR includes 49 articles that examined type, amount, or both of CFBs consumed and growth, size, and body-composition outcomes. Moderate evidence suggests that consuming either different amounts of meat, meat instead of iron-fortified cereal, or types of CFBs with different fats or fatty acids does not favorably or unfavorably influence growth, size, or body composition. In relation to overweight/obesity, insufficient evidence is available with regard to the intake of meat or CFBs with different fats or fatty acids. Limited evidence suggests that type and amount of fortified infant cereal does not favorably or unfavorably influence growth, size, body composition, or overweight/obesity. Limited evidence suggests that sugar-sweetened beverage consumption during the complementary feeding period is associated with increased obesity risk in childhood but is not associated with other measures of growth, size, or body composition. Limited evidence showed a positive association between juice intake and infant weight-for-length and child body mass index *z* scores. Insufficient evidence is available on other CFBs or dietary patterns in relation to outcomes.

Conclusions: Although several conclusions were drawn, additional research is needed that includes randomized controlled trials, examines a wider range of CFBs, considers issues of reverse causality, and adjusts for potential confounders to address gaps and limitations in the evidence. *Am J Clin Nutr* 2019;109(Suppl):956S–977S.

Keywords: complementary feeding, growth, size, body composition, systematic review, infants, toddlers

Introduction

To promote health and prevent disease throughout the life span, early-life nutrition is critically important. The USDA Nutrition Evidence Systematic Review (NESR), formerly known as the Nutrition Evidence Library (NEL), conducted a series of systematic reviews (SRs) as part of the Pregnancy and Birth to 24 Months Project (P/B-24 project) (1–3) on topics of public health importance to better understand how dietary factors during pregnancy, infancy, and toddlerhood may influence health outcomes. An overview of all SRs completed for this project is available and indicates that 10 SRs were conducted in a dual manner that focused on aspects of complementary

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Abbreviations used: BMIZ, BMI *z* score; CF, complementary feeding; CFB, complementary food and beverage; EBF, exclusively breastfed; EFF, exclusively formula-fed; HAZ, height-for-age *z* score; HC, head circumference; LAZ, length-for-age *z* score; NEL, Nutrition Evidence Library; NESR, Nutrition Evidence Systematic Review; P/B-24, Pregnancy and Birth to 24 Months Project; RCT, randomized controlled trial; SR, systematic review; SSB, sugar-sweetened beverage; TEC, Technical Expert Collaborative; WAZ, weight-for-age *z* score; WC, waist circumference; WHZ, weight-for-height *z* score; WLZ, weight-for-length *z* score.

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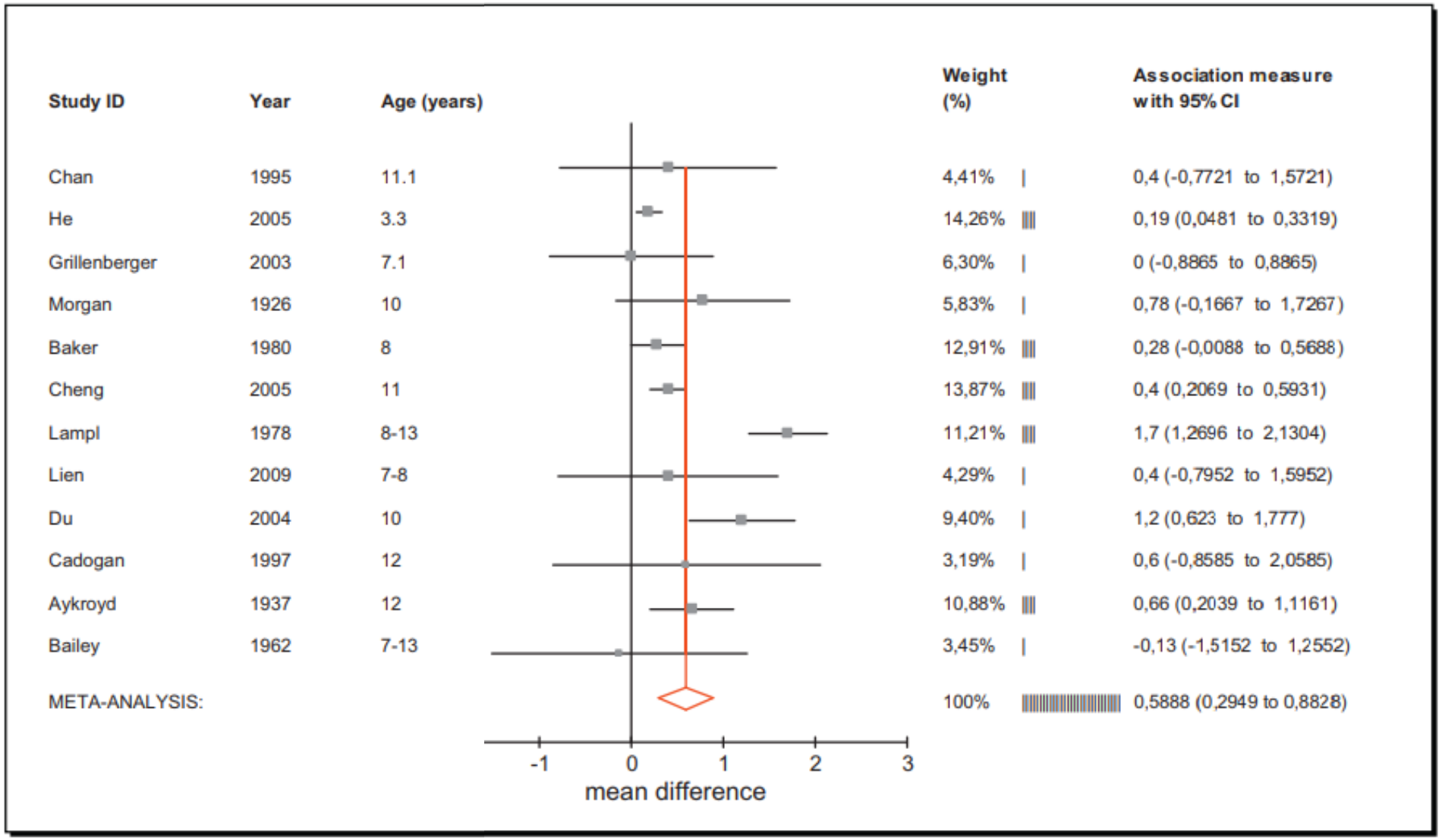
Am J Clin Nutr 2019;109(Suppl):956S–977S. Printed in USA.

Effect of ASF on growth in children <2 y

- Nutrition Evidence Systematic Review Team, for the USDA DHHS Pregnancy and Birth to 24 mo Project
- 7 RCTs from high income countries
- Summary:
  - Meat intake for ~3mo "does not favorably or unfavorably influence growth, size, or body composition."
  - Too few studies of eggs, fish, or dairy to draw conclusions

English et al, AJCN, 2019

Effect of dairy on child & adolescent growth



De Beer, 2012

Effect of animal source foods on linear growth in children <5 y (LAZ)

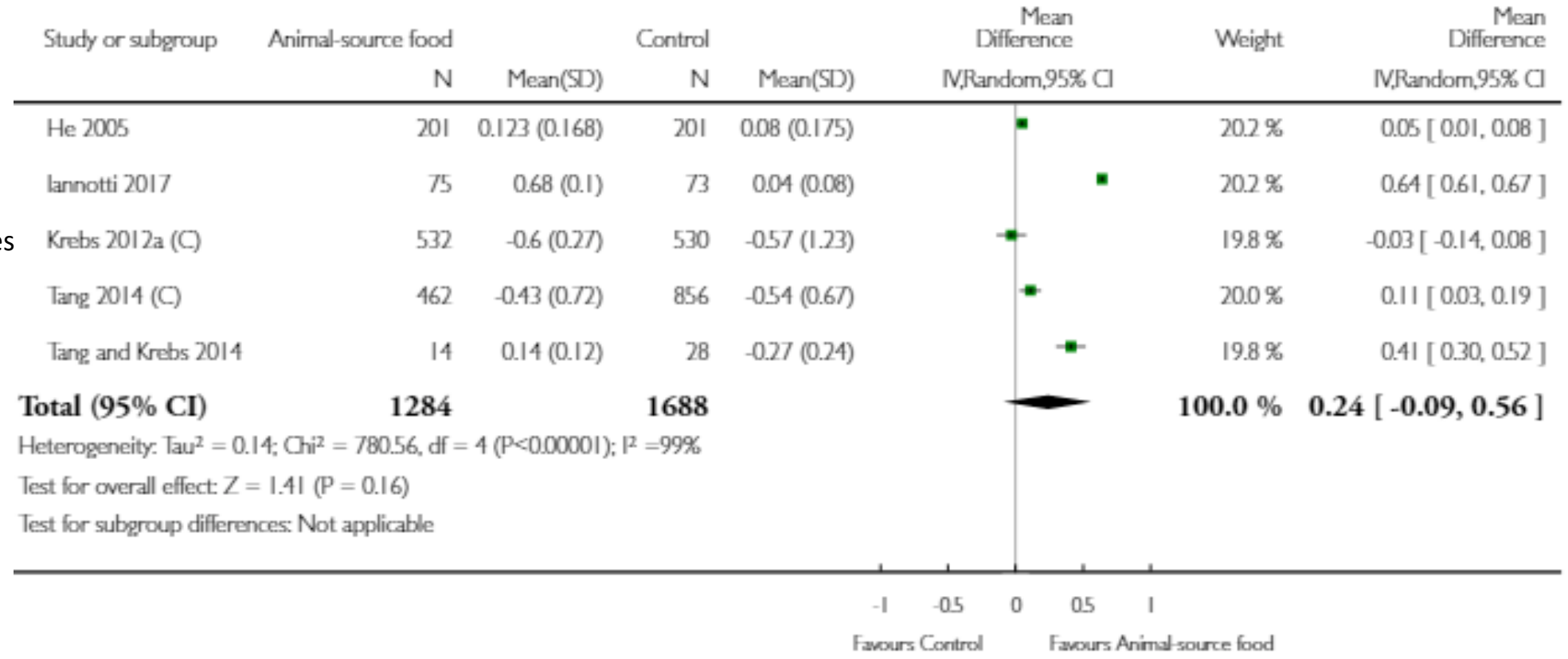
Yogurt vs. no intervention, China

Eggs vs. no intervention, Ecuador

Beef vs. fortified cereal, 5 countries

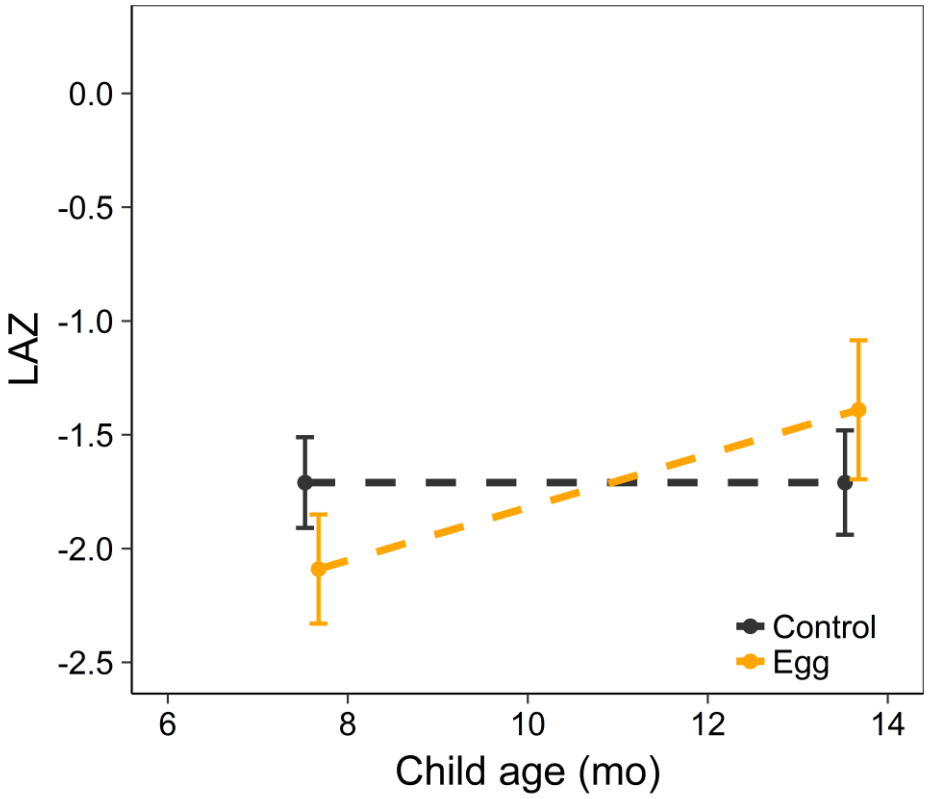
Pork vs. fortified cereal, China

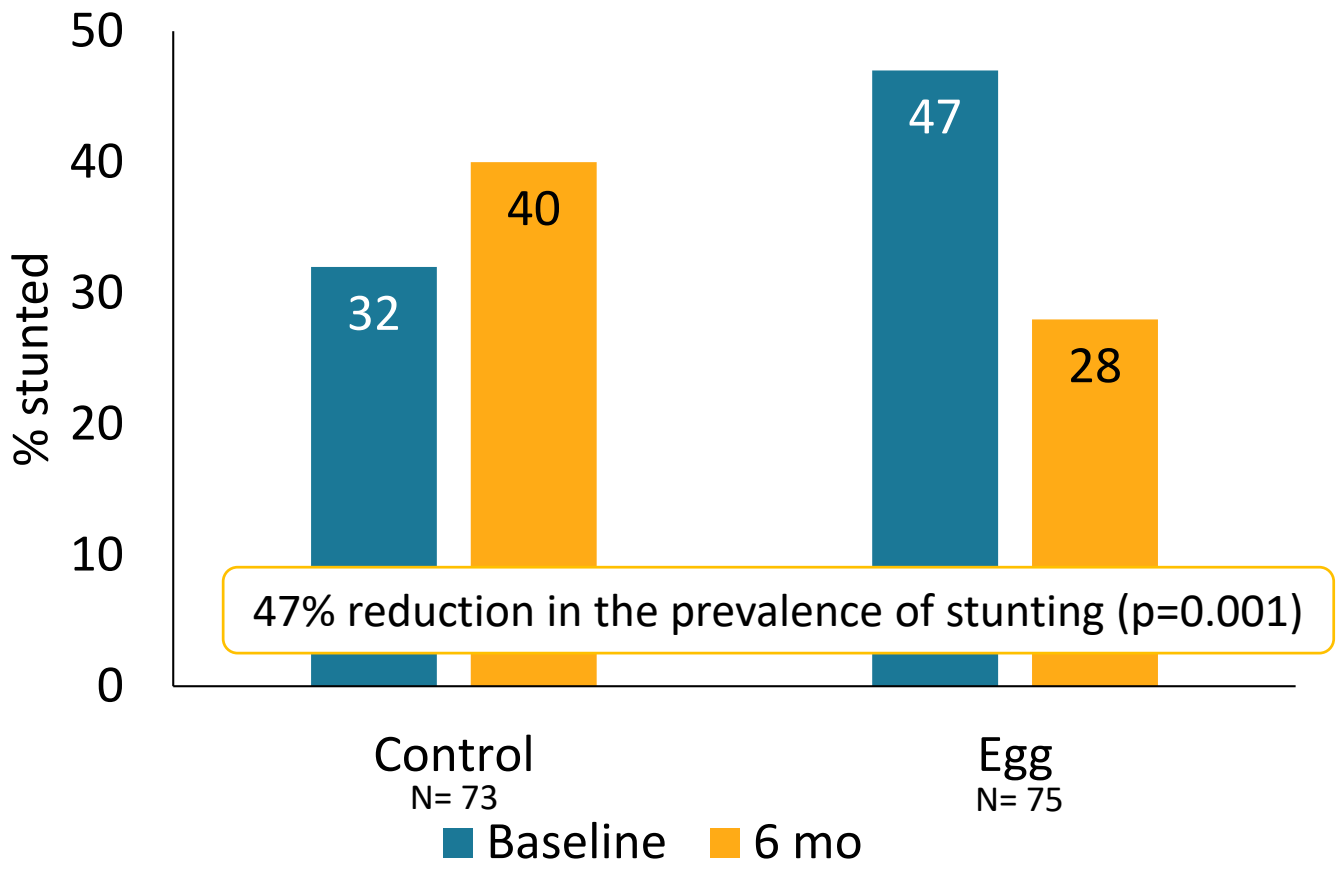
Meat vs. fortified cereal, USA



Eaton et al, Cochrane Library, 2019

Effect of eggs on stunted growth in children: Ecuador





Effect of eggs on stunting in a 6 mo randomized trial among children 6-9 m old at baseline in Ecuador

Iannotti et al, Pediatrics, 2017

Mazira Project: an evaluation of eggs on child growth and development in Malawi

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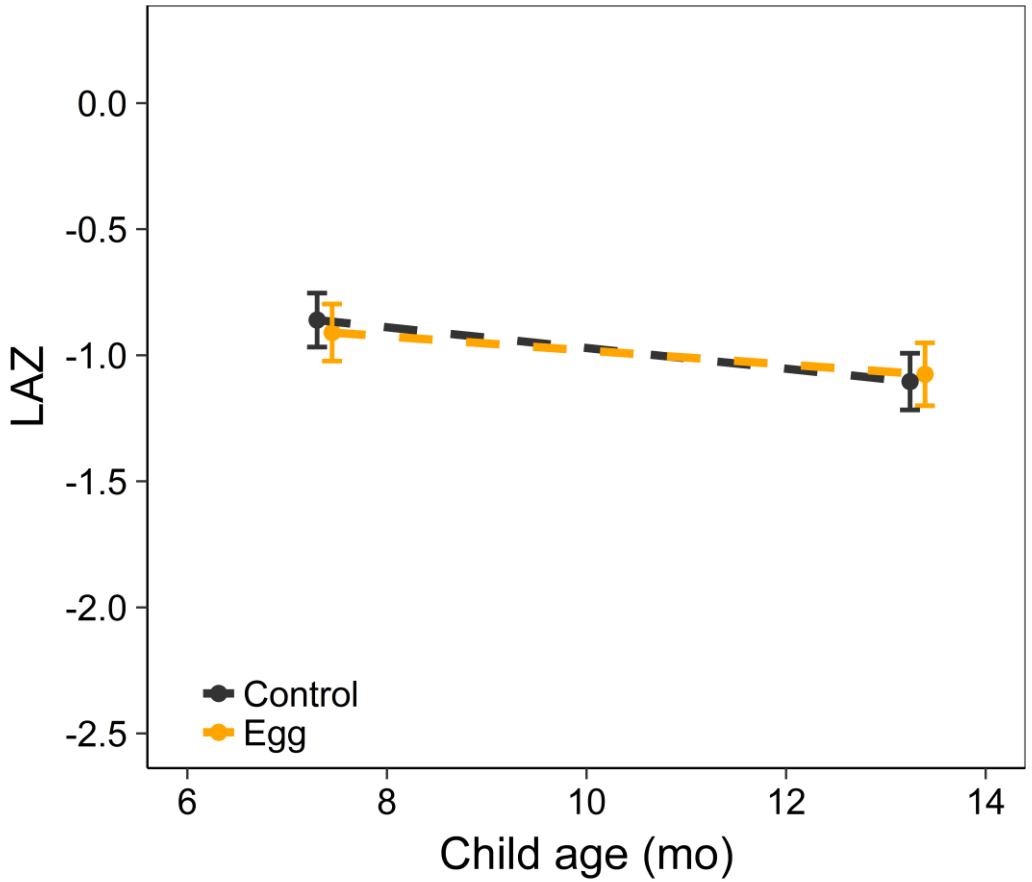
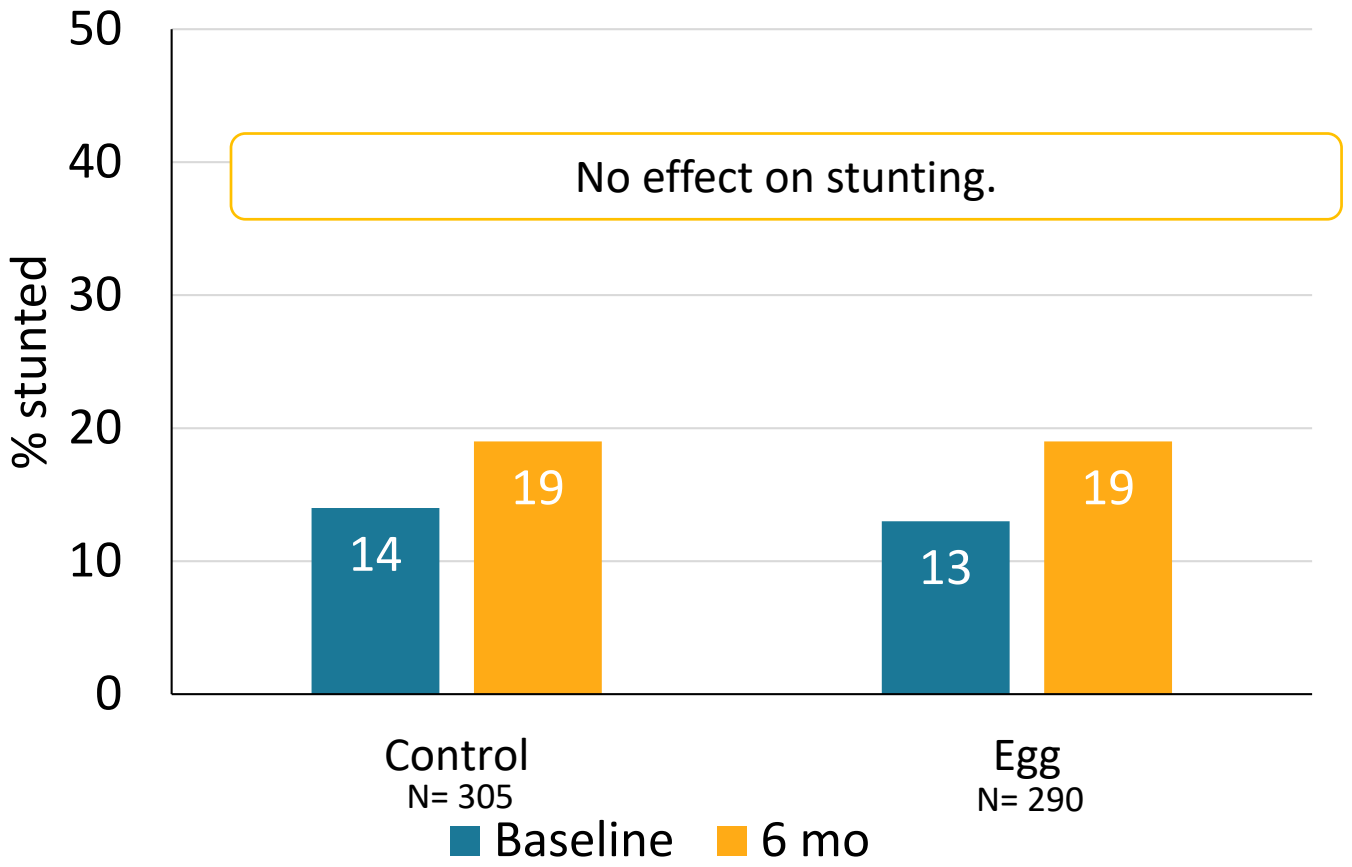
UNIVERSITY OF MARYLAND

Effect of eggs on stunted growth in children: Malawi





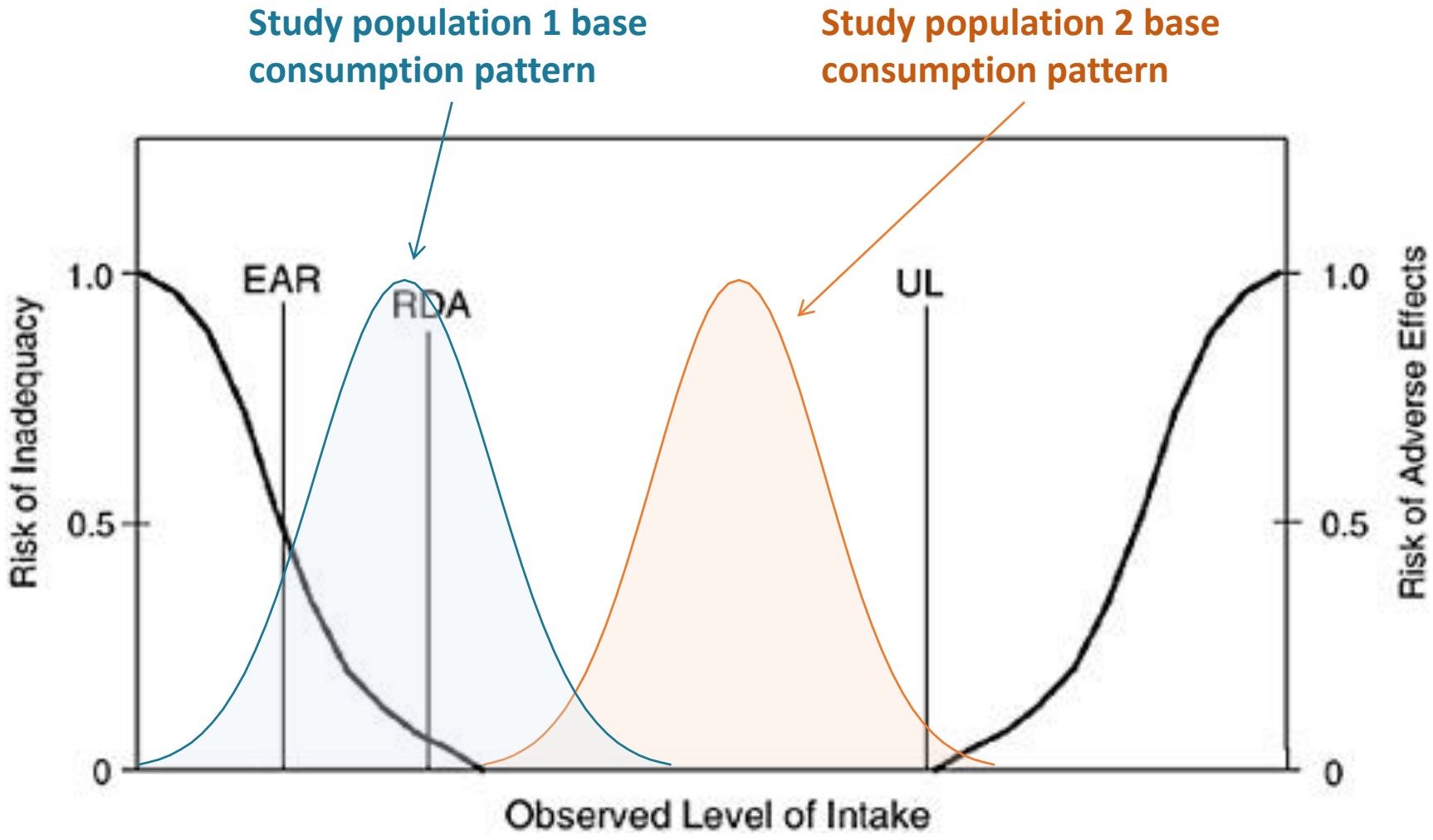
Effect of eggs on stunting in a 6 mo randomized trial among children 6-9 m old at baseline in Ecuador

Stewart et al, under review

Differences between the Malawi & Ecuador trials

- Child stunting was much more common in Ecuador
- Infection & inflammation prevalence may have differed
  - Malawi site has higher rates of malaria & lower rates of improved water and sanitation than the Ecuador site
- Animal source food consumption (fish) was very high in the background diet in Malawi (see poster presented during lunch)
  - ~65% of children consumed meat on the previous day during the study, most of which was fish

Possible differences in results from RCTs due to differences in underlying levels of intake



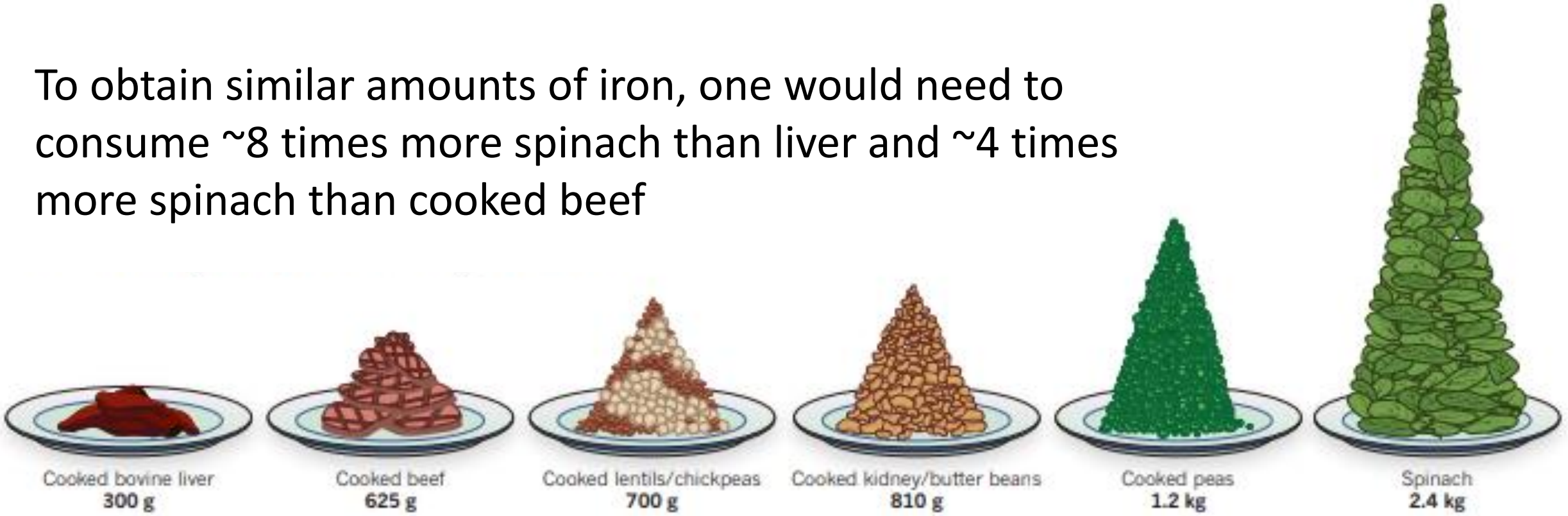
“Hidden Hunger”: anemia, iron, and other micronutrient deficiencies

- Iodine, iron, zinc, vitamin A, B12, and folate deficiencies cause impairments in development, growth, and cognitive function
- ~1.6 billion people globally are anemic
- Contributes to infant & child mortality, poor cognitive development (irreversible), poor school performance, lower work productivity
- Roughly 50% of anemia is due to iron deficiency.
- USA: 14% of women are iron deficient

Iron requirements (mg/d)	
	Adult male
	8

Nutrient Density of Meat

To obtain similar amounts of iron, one would need to consume ~8 times more spinach than liver and ~4 times more spinach than cooked beef



These data are approximate and will vary depending on factors such as preparation technique, soil or feeding conditions, and time between harvesting and intake.
Analysis by F. Mori Sarti based on data from http://ndb.nal.usda.gov and http://www.unicamp.br/

Gupta, Nature, March 2016

Complementary feeding and micronutrient status: a systematic review

Julie E Obbagy,[1] Laural K English,[2] Tricia L Psota,[1] Yat Ping Wong,[1] Nancy F Butte,[3] Kathryn G Dewey,[4] Mary Kay Fox,[5] Frank R Greer,[6] Nancy F Krebs,[7] Kelley S Scanlon,[1] and Eve E Stoody[1]

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ABSTRACT

Background: Proper nutrition during early life is critical for growth and development.

Objectives: The aim was to describe systematic reviews conducted by the Nutrition Evidence Systematic Review team for the USDA and the Department of Health and Human Services Pregnancy and Birth to 24 Months Project to answer the following: What is the relation between *1*) timing of introduction of complementary foods and beverages (CFBs) or *2*) types and/or amounts of CFBs consumed and micronutrient status (iron, zinc, vitamin D, vitamin B-12, folate, and fatty acid status)?

Methods: A literature search identified articles from developed countries published from January 1980 to July 2016 that met the inclusion criteria. Data were extracted and risk of bias assessed. Evidence was qualitatively synthesized to develop a conclusion statement, and the strength of the evidence was graded.

Results: Nine articles addressed the timing of CFB introduction and 31 addressed types or amounts or both of CFBs. Moderate evidence suggests that introducing CFBs at age 4 mo instead of 6 mo offers no advantages or disadvantages in iron status among healthy full-term infants. Evidence is insufficient on the timing of CFB introduction and other micronutrient status outcomes. Strong evidence suggests that CFBs containing iron (e.g., meat, fortified cereal) help maintain adequate iron status or prevent deficiency in the first year among infants at risk of insufficient iron stores or low intake. Benefits for infants with sufficient iron stores (e.g., infant formula consumers) are less clear. Moderate evidence suggests that CFBs containing zinc (e.g., meat, fortified cereal) support zinc status in the first year and CFB fatty acid composition influences fatty acid status. Evidence is insufficient with regard to types and amounts of CFBs and vitamin D, vitamin B-12, and folate status, or the relation between lower-iron-containing CFBs and micronutrient status.

Conclusions: Several conclusions on CFBs and micronutrient status were drawn from these systematic reviews, but more research that addresses specific gaps and limitations is needed. *Am J Clin Nutr* 2019;109(Suppl):852S–871S.

Keywords: complementary feeding, complementary food and beverages, micronutrient status, iron, zinc, vitamin D, vitamin B-12, folate, fatty acids, systematic review

Introduction

Ensuring that pregnant women, infants, and toddlers receive proper nutrition is essential for healthy growth and development during childhood and for promoting health and disease prevention across the life span. In order to better understand the relation between diet and health in these population groups, the USDA and Department of Health and Human Services initiated the Pregnancy and Birth to 24 Months Project (P/B-24 project). The USDA's Nutrition Evidence Systematic Review (NESR) team, formerly known as the Nutrition Evidence Library (NEL), conducted systematic reviews (SRs) on select topics of public health importance as part of this project (1–3).

This article addresses the relation between complementary feeding and micronutrient status (1, 3). Complementary feeding is the process that starts when human milk or infant formula is

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Abbreviations used: AA, arachidonic acid; ALA, α-linolenic acid; BF, breastfed; CFB, complementary food and beverage; DPA, docosapentaenoic acid; FEP, free erythrocyte protoporphyrin; FF, formula-fed; FVF, full vegetable fat; GLA, γ-linolenic acid; Hb, hemoglobin; Hct, hematocrit; LA, linoleic acid; LC, long-chain; MCV, mean corpuscular volume; NESR, Nutrition Evidence Systematic Review; PVF, partial vegetable fat; RCT, randomized controlled trial; RDW, red blood cell distribution width; SF, serum ferritin; SR, systematic review; TEC, Technical Expert Collaborative; Tf, transferrin; TfR, transferrin receptor; TIBC, total iron-binding capacity; ZPP, zinc-protoporphyrin.

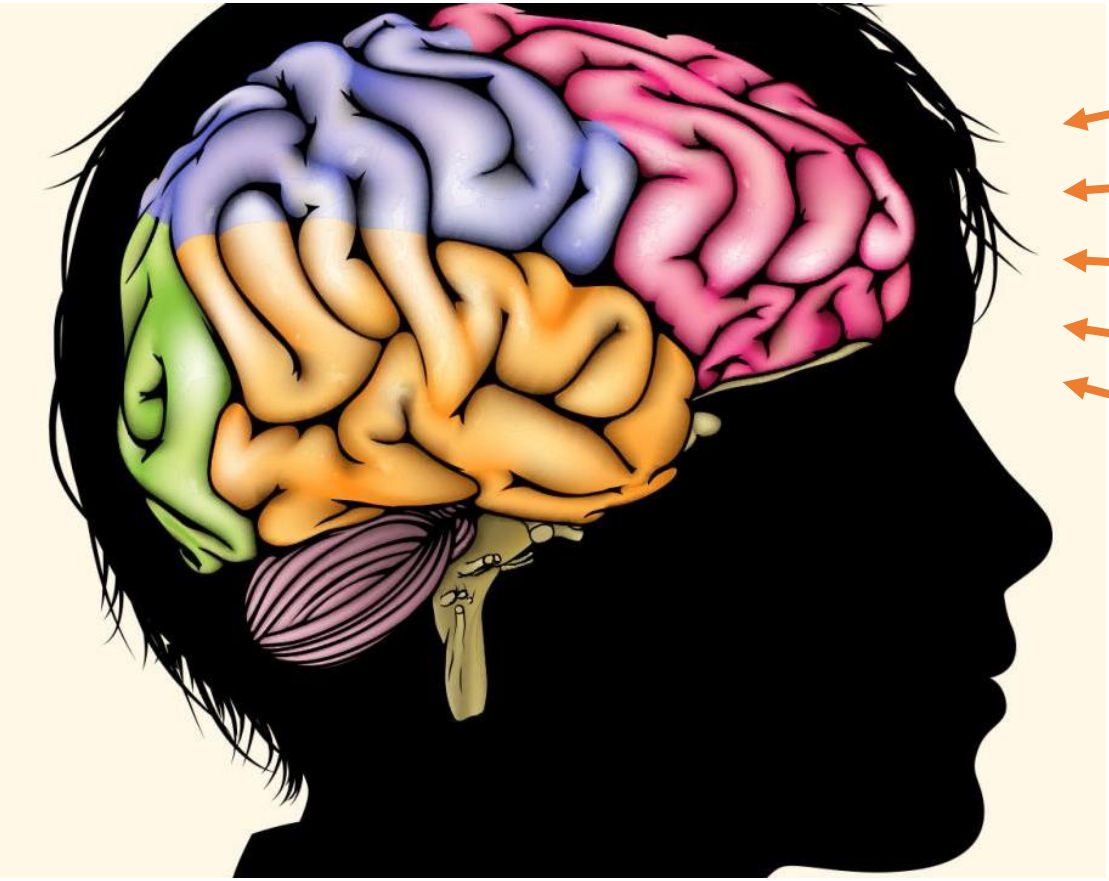
First published online March 28, 2019; doi: https://doi.org/10.1093/ajcn/nqy266.

Anemia & MN status in children <2 y

- 15 studies, including 8 RCTs & 7 cohort studies examined the effect of meat on micronutrient status (esp. iron status)
- Most RCTs compared meat vs. a fortified cereal or formula. Found no difference in iron or zinc status.
- Other studies of iron and/or zinc-fortified cereal vs. unfortified cereal found significant improvements in iron and zinc status.
- Conclusion: "Strong evidence suggests that consuming complementary foods and beverages that contain substantial amounts of iron, such as meats or iron-fortified cereal, helps maintain adequate iron status or prevent iron deficiency…"

Obbagy et al, AJCN, 2019

Brain development & cognition



- Iron
- Iodine
- Essential fatty acids (LC-PUFAs)
- Vitamin B12
- Choline

All of these nutrients are more concentrated and more bioavailable in animal source foods.

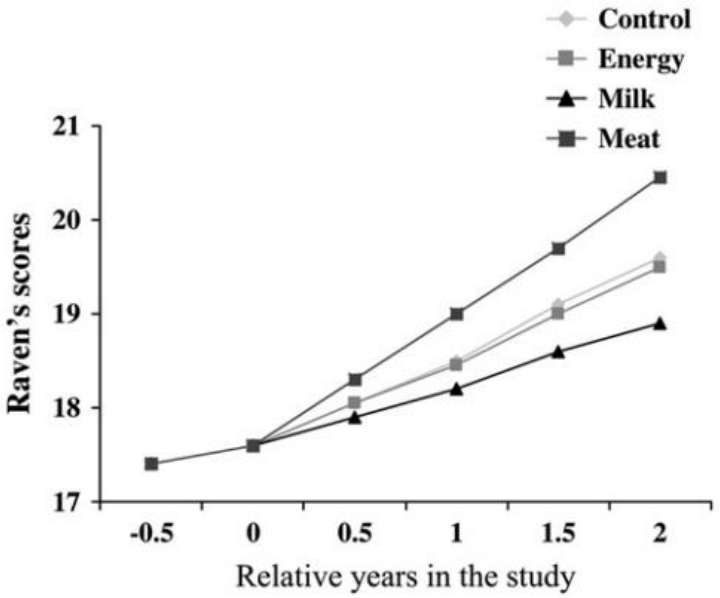
Effect of meat or milk on cognition and school performance

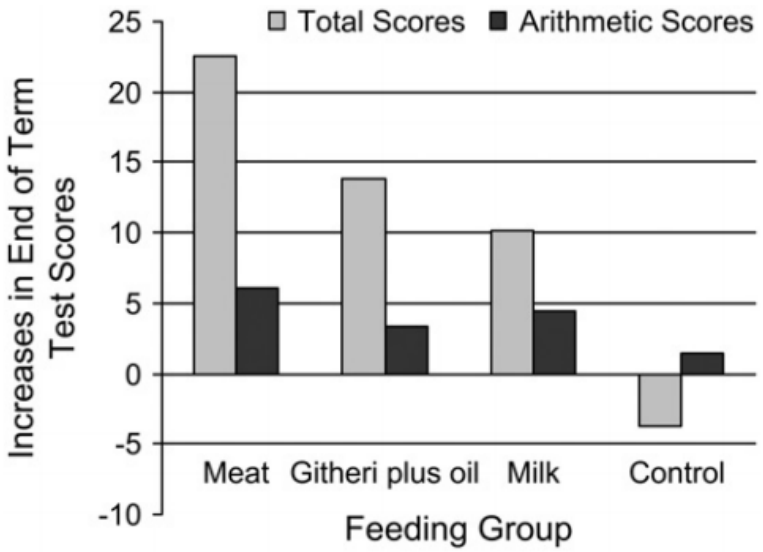
Kenyan school children (6-14 y) randomized to meat or milk vs. isocaloric energy group or control group for ~2 year study

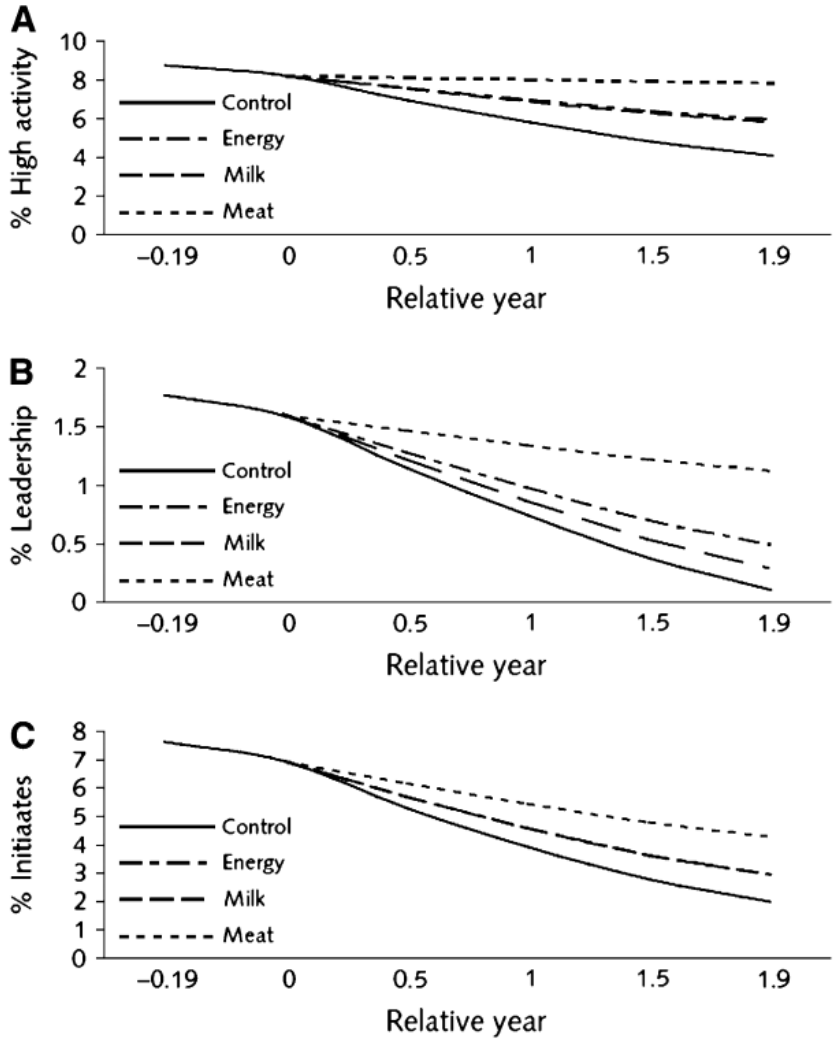
Control group	No intervention
Githeri + Minced beef	Provided daily during the school week. ~20% of required energy for children in this age range
Githeri + Milk	
Githeri + Oil	

Neumann et al, J Nutr, 2007

Effect of meat or milk on cognition and school performance







Neumann et al, J Nutr, 2007

Effect of fish on cognition and school performance

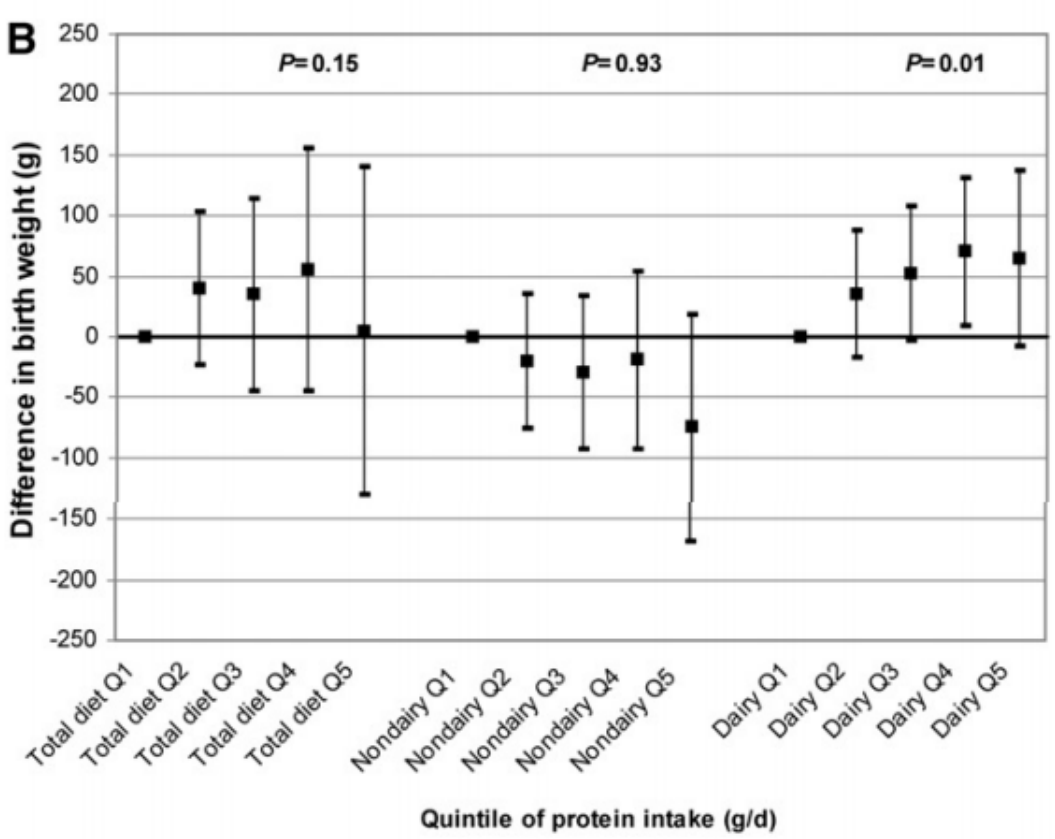
South African school children (7-9 y) randomized to receive fish spread vs isocaloric control spread

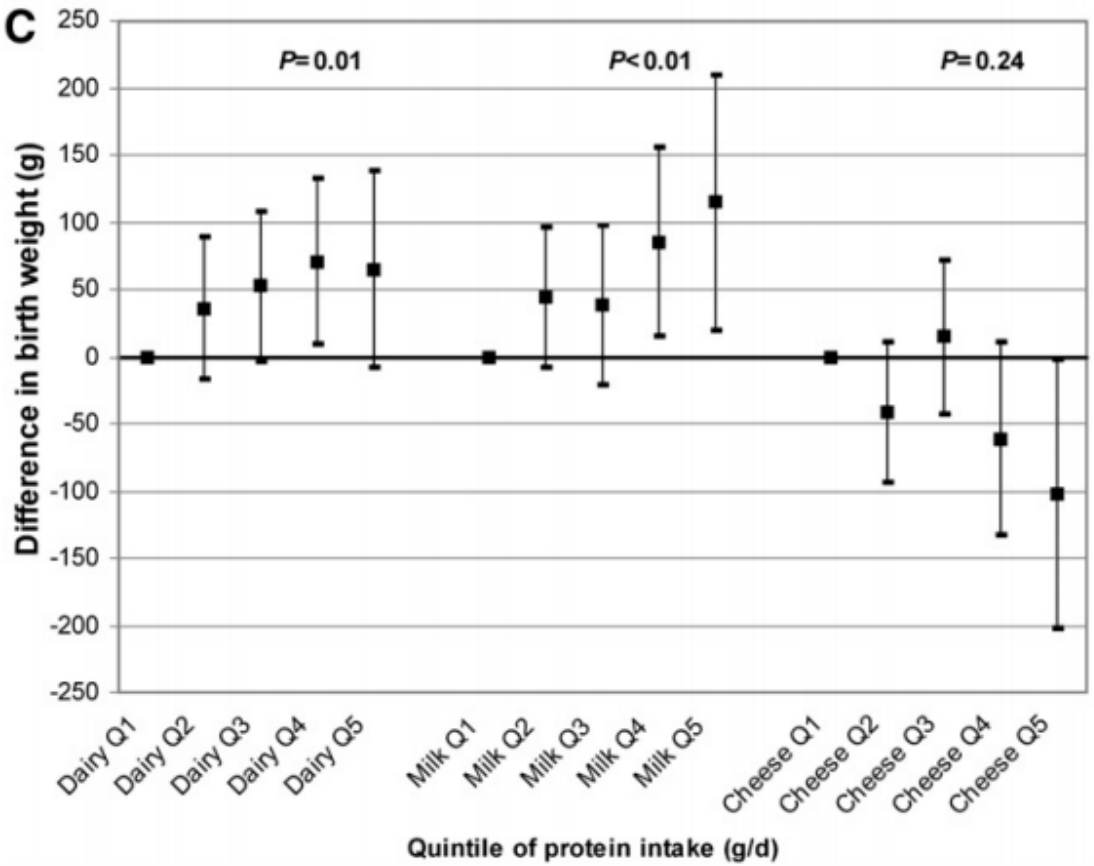
- Significant improvements in measures of learning and memory (recognition, discrimination, spelling)
- Marginally significant improvement in recall and reading

Pregnancy & birth outcomes

- Very little data on eggs or meat
- Dairy: Some observational studies
- Fish: Many large observational cohort studies

Dairy consumption and birth weight





Heppe et al, AJCN 2011

Fish consumption and birth weight

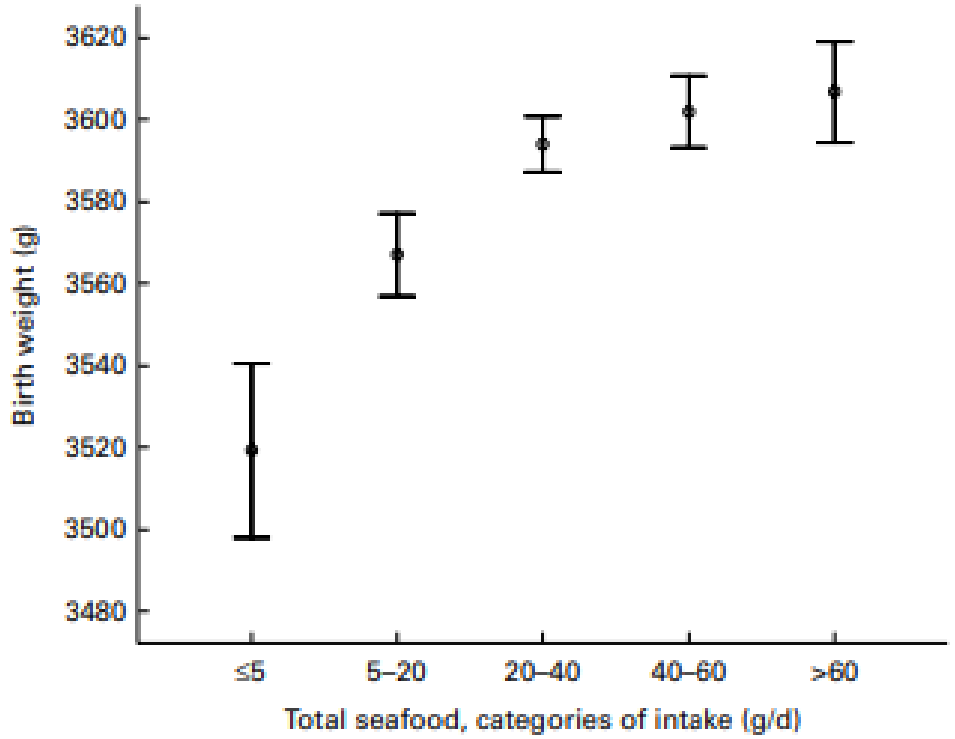


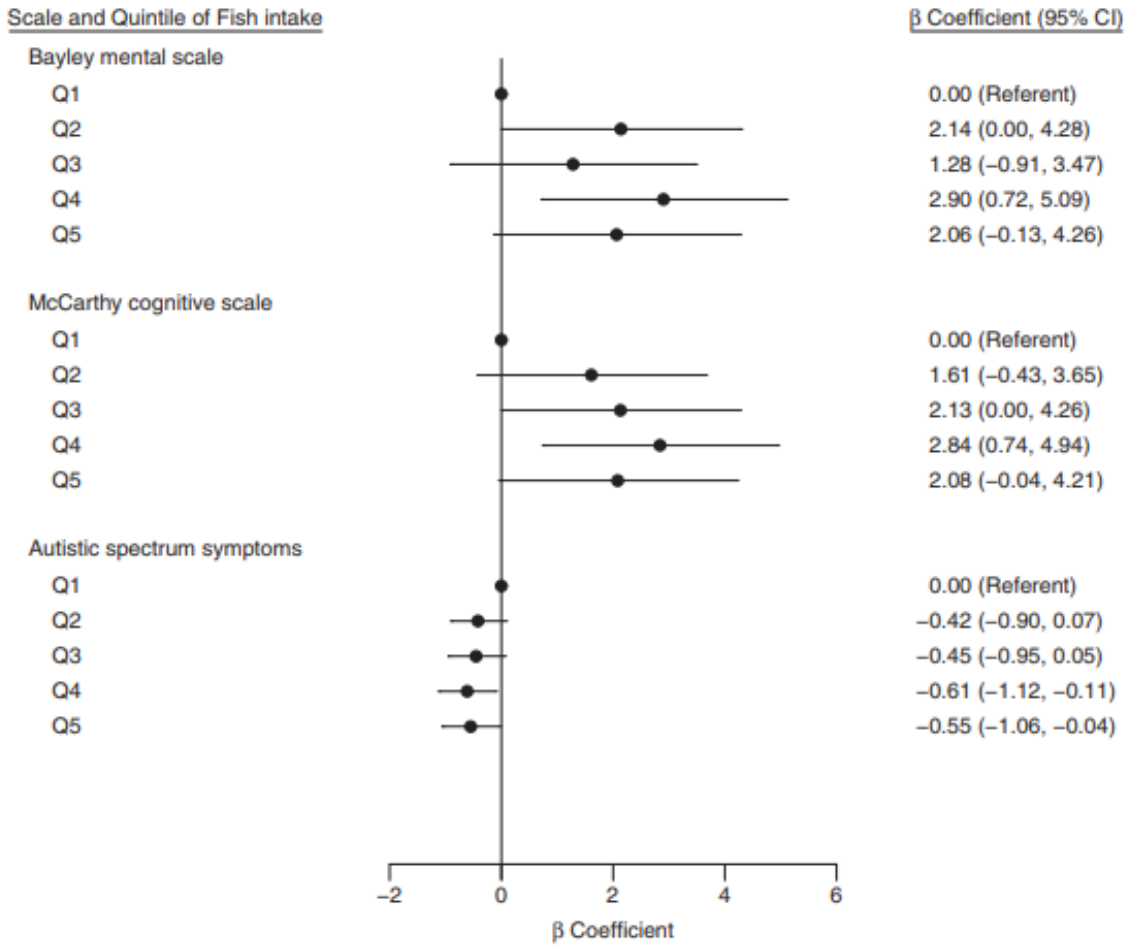
Fig. 2. Birth weight by categories of total seafood intake in 62 099 women in the Norwegian Mother and Child Cohort Study. The values are means and 95 % CI.

Branstaeter et al, BJN, 2012

Large observational cohorts in Europe have found a significant positive association between fish intake with birth weight and duration of gestation (Leventakou et al, AJCN, 2014)

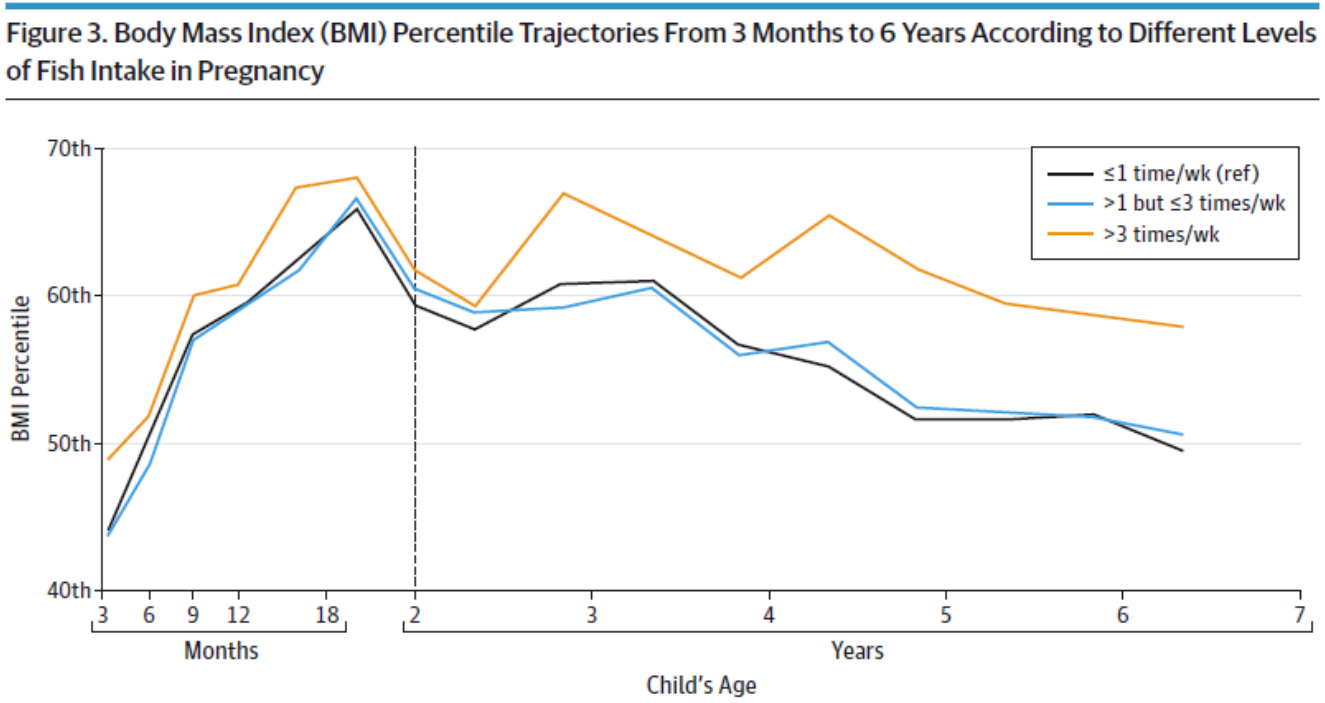
Fish consumption during pregnancy and long-term child outcomes

Cognitive performance



Julvez et al, AJE, 2016

BMI percentile trajectories

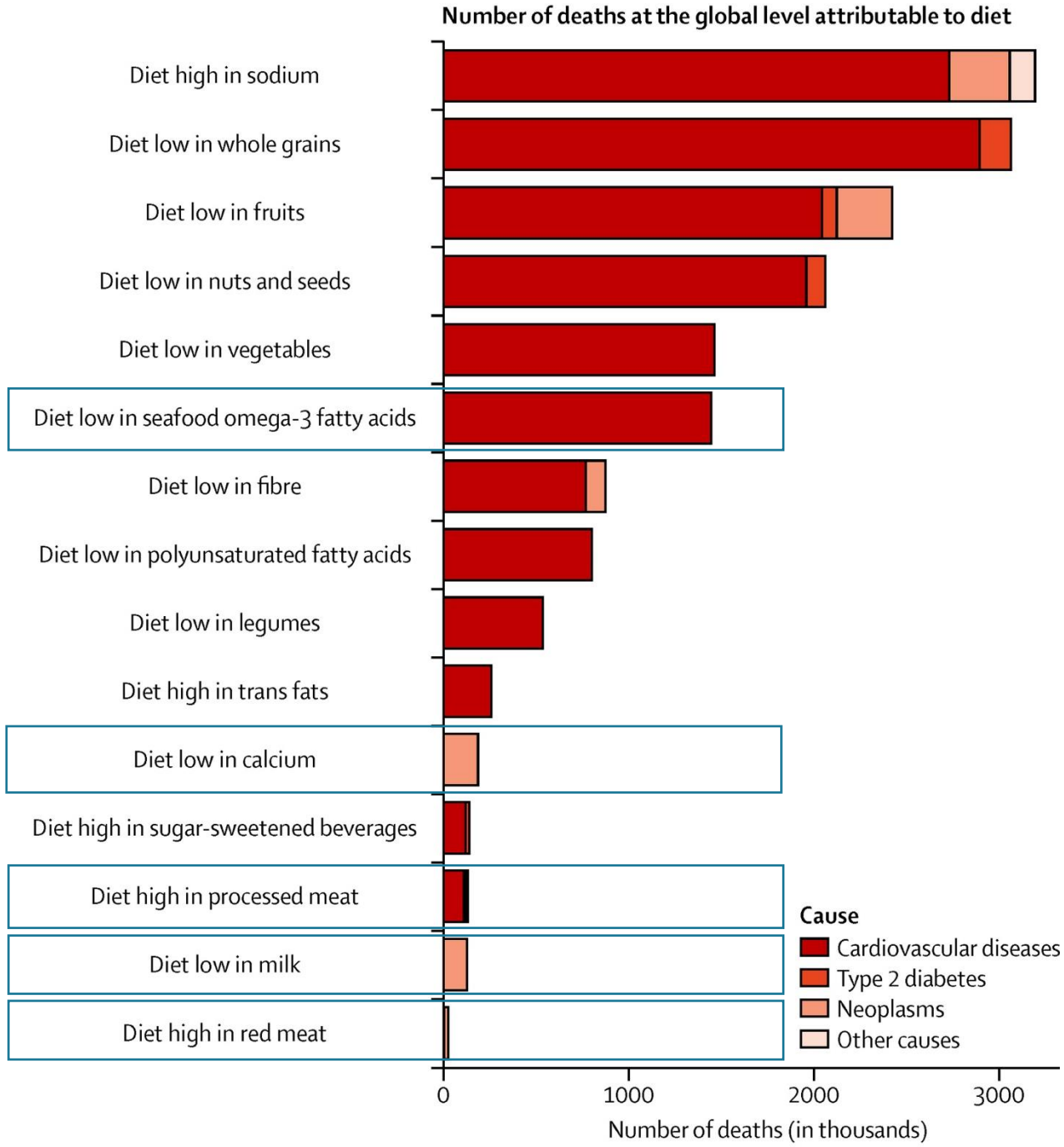


Pooled analysis of data from European and North American cohort studies. N=26,184 mother/child pairs with data from pregnancy to 6 y of age.

Stratakis et al, JAMA Pediatrics, 2016

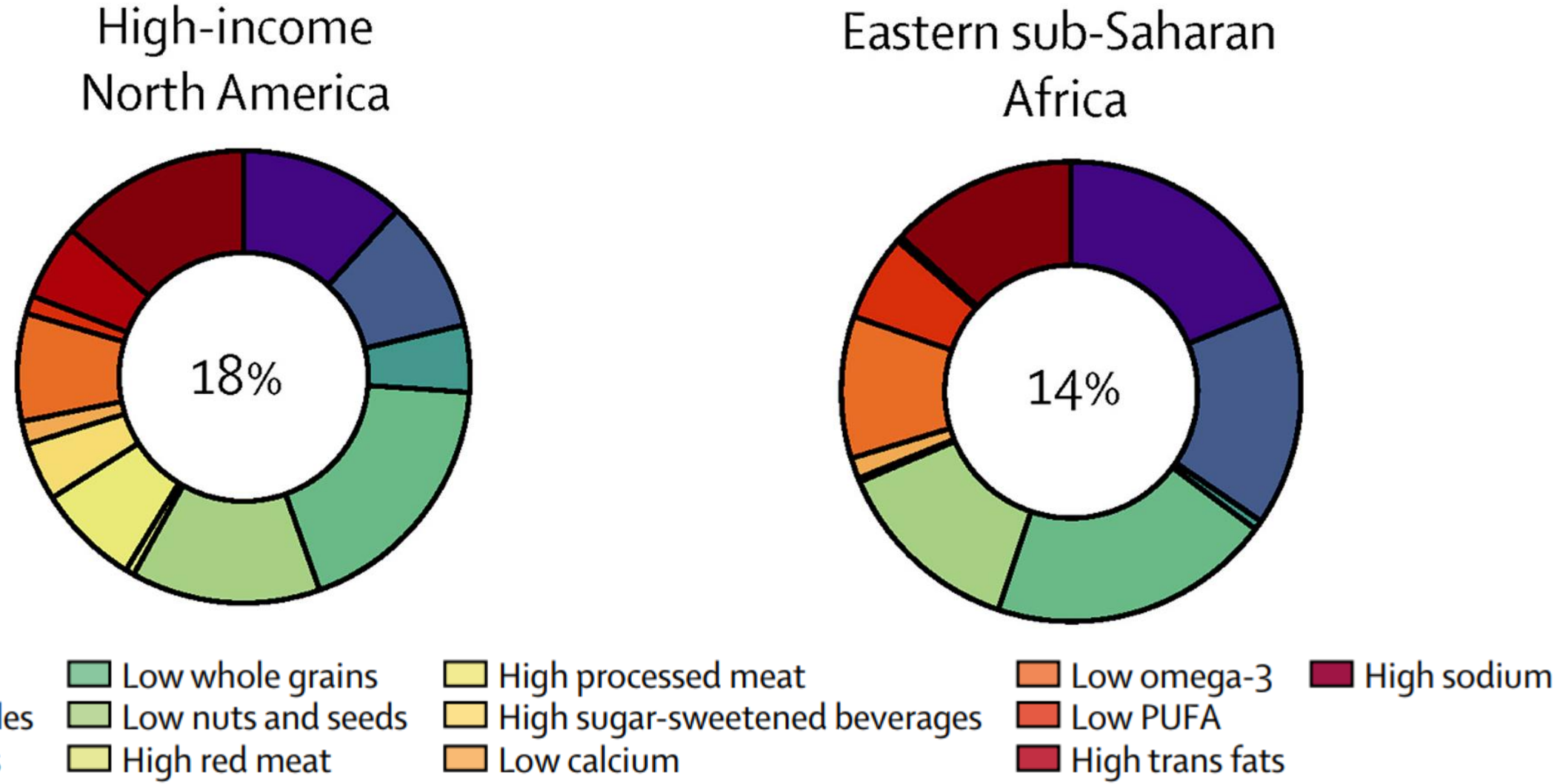
Diet related non-communicable diseases

- Suboptimal diet is responsible for more deaths than any other risk factors globally.
- Non-optimal intake of sodium, whole grain, fruits, vegetables and nuts were the leading risk factors



GBD Diet Collaborators, Lancet, April 2019

Regional differences in attributable risk

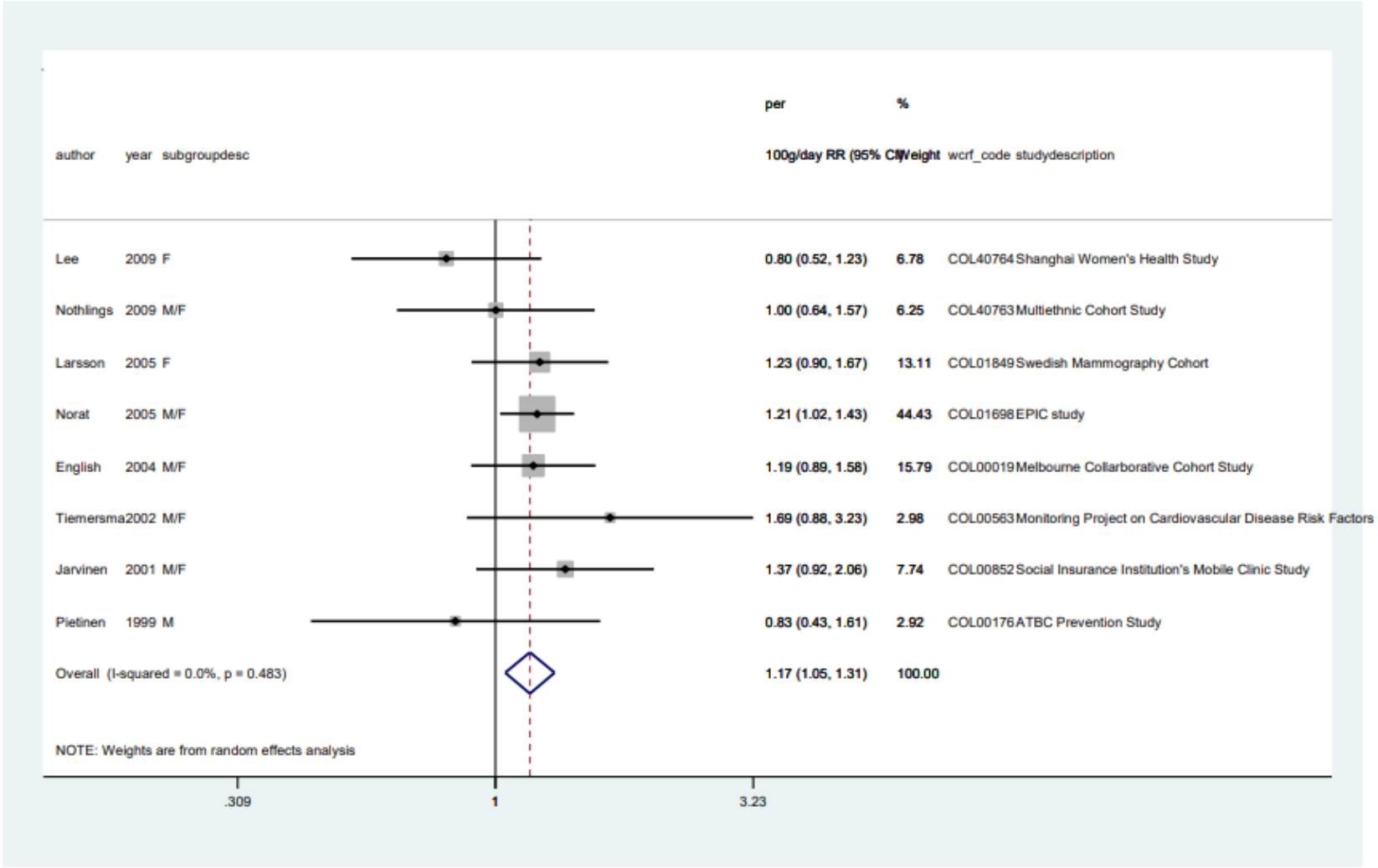


Association between red & processed meat and colorectal cancer

17% increased risk per **100 g/day** of red meat consumed

18% increased risk per **50 g/day** of processed meat consumed

Figure 70 Dose-response meta-analysis of red meat and colorectal cancer – per 100g/day



World Cancer Research Fund, American Institute for Cancer Research, Imperial College London. 2010

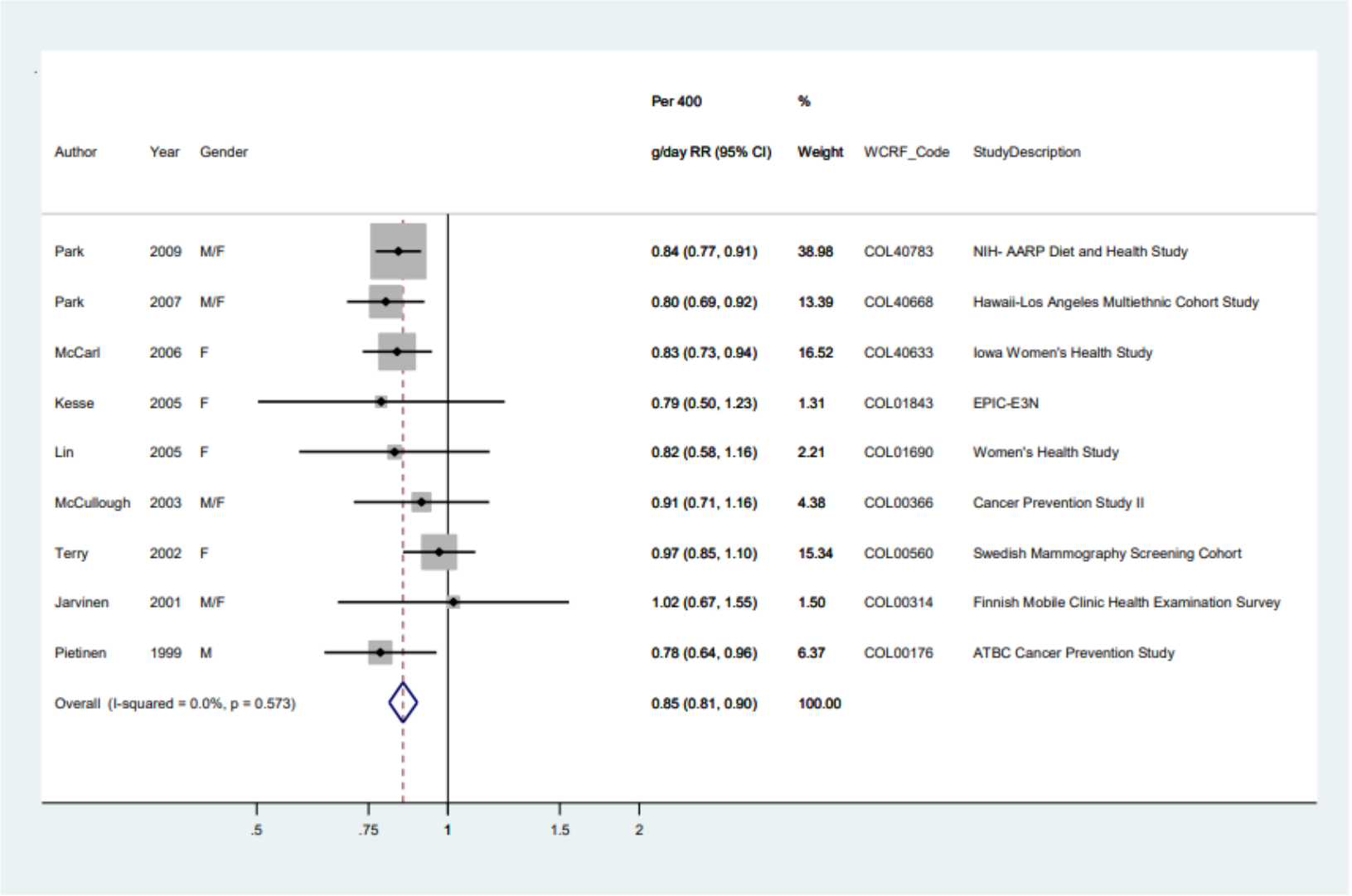
Red and processed meat consumption & CVD or diabetes

- Meta-analyses of observational cohort studies report positive associations with heart disease, stroke, and diabetes mellitus
- Evidence is more consistent for processed meat than for red meat

Association between dairy and colorectal cancer

15% lower risk per **400 g/day** of dairy consumed

Figure 98 Dose-response meta-analysis of total dairy products and colorectal cancer - per 400 g/day



World Cancer Research Fund, American Institute for Cancer Research, Imperial College London. 2010

Limitations of diet and NCD research

1. Evidence comes from observational studies with self-reported dietary intake
   - Reporting errors– difficult to accurately estimate long-term usual intake, simple forgetfulness
     - If the error is unbiased, it will underestimate the true relationship between the dietary factor and the disease
   - Reporting bias– social desirability, portion size estimation
     - Could lead to a systematic overestimate or an underestimate of the true relationship
2. Most studies fail to account for correlations between foods or nutrients within a diet pattern
3. Many studies do not provide enough detail on cooking methods
   - Ex. grilled or blackened cooking methods may be more risky than sautéed preparation methods
4. Most studies fail to account for multiple hypothesis testing

Summary

- Animal source foods are likely important for adequate child growth, development, and school performance. To provide stronger evidence of causality, we need more randomized trials in populations with a low base levels of consumption.
- Moderate to high fish consumption during pregnancy is positively associated with birth weight and cognitive development, but frequent consumption (>3x/wk) is also associated with high BMI in childhood. Very little data on other types of ASFs in pregnancy. More RCTs are needed.
- Consistent evidence that high consumption of processed meats are associated with an increased risk of some cancers, CVD, and diabetes. Dairy is associated with a reduced risk of some cancers.

Thank you

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