
DTU

Case study: The health impact of substituting red and processed meat by fish

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RBA of substituting red and processed meat by fish

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Investigating the risk-benefit balance of substituting red and processed meat with fish in a Danish diet

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Danish food-based dietary guidelines

Eat more fish

350 g/week – minimum 200 g of fatty fish

Eat lean meat and lean processed meat

Maximum 500 g/week

https://altomkost.dk/

Current situation…

Consumption – amounts as consumed in g/day:

Scenario and food	Mean	SD	P10	P50	P90
Reference scenario					
Fish	31.5	32.1	0.0	23.2	73.4
Total red and processed meat	115.2	67.6	44.6	101.1	202.6
Red meat	76.1	46.2	26.7	68.1	134.5
Processed meat	39.0	38.6	4.3	28.3	86.4

78% < 50 g of fish/day
73% > 70 g of meat/day

Thomsen *et al.,* Investigating the risk-benefit balance of substituting red and processed meat with fish in a Danish diet, Food and Chemical Toxicology, Volume 120, 2018, p. 50-63, https://doi.org/10.1016/j.fct.2018.06.063.

Problem formulation

Eat more fish

350 g/week – minimum 200 g of fatty fish

Eat lean meat and lean processed meat

Maximum 500 g/week

Risk-benefit question:

What is the overall health impact of increasing fish consumption to the recommended 350 g/week in the Danish adult diet while substituting red and processed meat?

https://altomkost.dk/

Scenario definition

Scenarios:

Reference scenario: ***current consumption*** in Danish adults

Alternative scenario 1: 350 g/week of ***mix of lean and fatty fish***
Alternative scenario 2: 350 g/week of ***fatty fish***
Alternative scenario 3: 350 g/week of ***lean fish***
Alternative scenario 4: 350 g/week of ***tuna***

Types of fish consumed before substitution also changed.

Meat consumption decreased according to individual increases in fish consumption

https://altomkost.dk/

Relevant health outcomes

Non-cardia stomach cancer

Colorectal cancer

DHA + EPA → Fatal coronary heart disease

Fetal neurodevelopment

MeHg

Fetal neurodevelopment

… *In addition to vitamins, minerals, etc.*

Dioxin and dl-PCBs

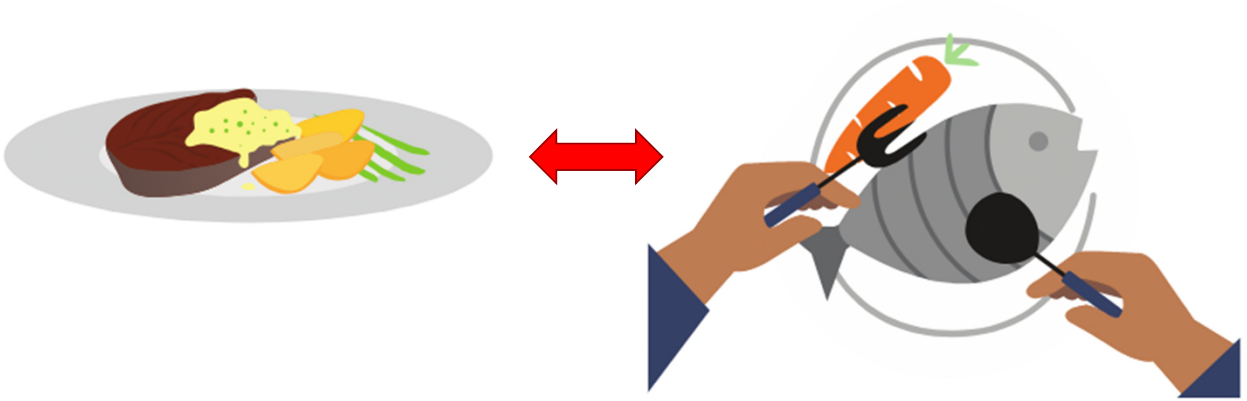
Male infertility

Hypothyroidism

Substitution model

30g fish in cold meals 5x/week

(150g/week)



100g fish in hot meals 2x/week

(200g/week)

Substitution model

Consumption data: Danish National Survey of Diet and Physical Activity 2011-2013 (2841 individuals, 15-75 years)

Exposure: observed individual mean daily intakes (average over 7 days)

Meal-based substitution

→ Distinguishing between fish and meat consumed in cold and hot meals

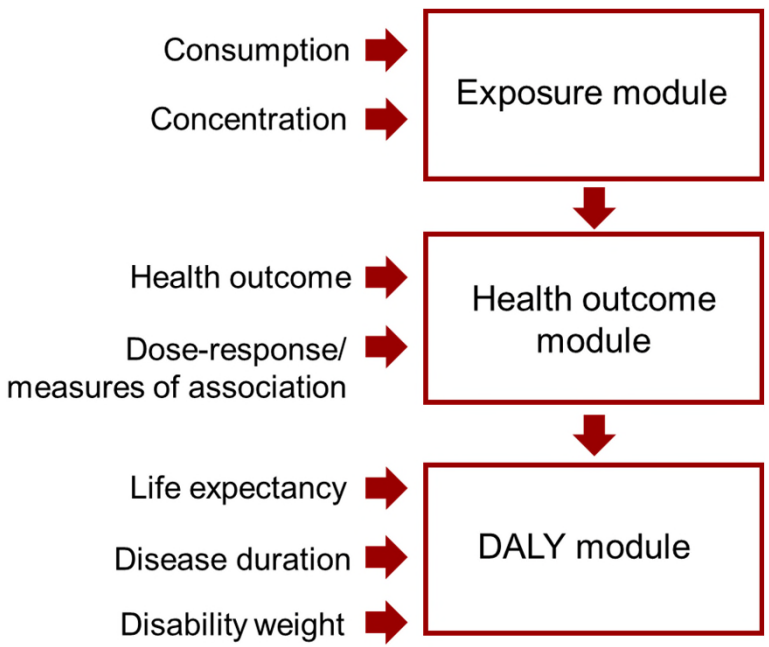
→ Individual mean daily intakes of fish increased to reach 50g/day

→ Substitution factors used to account for differences in portion sizes

→ Decreases in meat intake depended on the increases in fish intake

→ All individuals assumed to behave in the same way

Health impact modelling



The burden of disease was estimated for each scenario

Modelled by sex and 5-year age groups for the whole Danish adult population (>15 years of age)

Difference in total disease burden (ΔDALYs) calculated as an estimate of health impact

Results

Consumption before and after substitution (amounts as consumed in g/day)

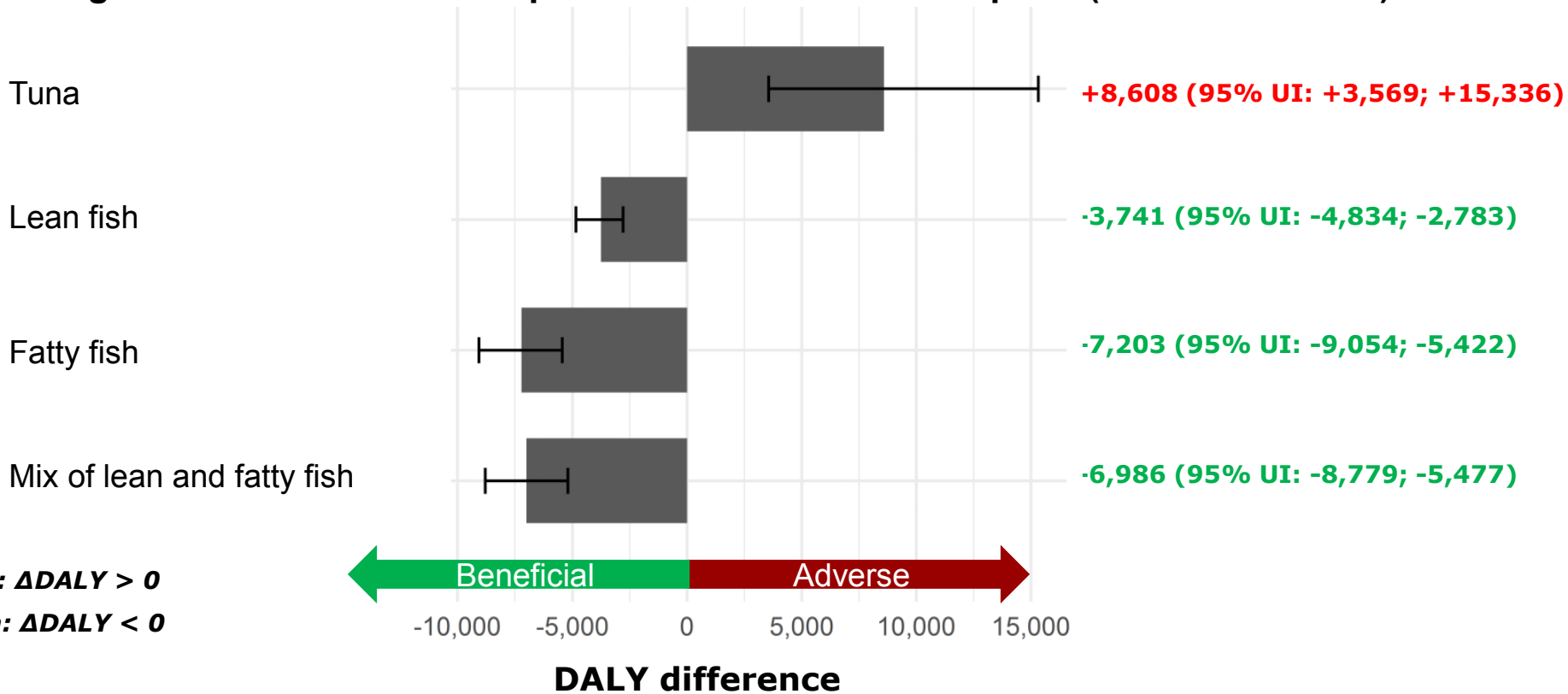
Scenario and food	Mean	SD	P10	P50	P90
Reference scenario					
Fish	31.5	32.1	0.0	23.2	73.4
Total red and processed meat	115.2	67.6	44.6	101.1	202.6
Red meat	76.1	46.2	26.7	68.1	134.5
Processed meat	39.0	38.6	4.3	28.3	86.4
Alternative scenario					
Fish	56.5	18.9	50.0	50.0	73.4
Total red and processed meat	98.2	67.4	26.5	85.0	185.6
Red meat	62.0	46.3	9.5	53.7	121.5
Processed meat	36.2	38.4	0.4	24.9	83.1

78% < 50 g of fish/day
73% > 70 g of meat/day

0% < 50 g of fish/day
59% > 70 g of meat/day

Results

Change in disease burden compared with current consumption (DALY difference)

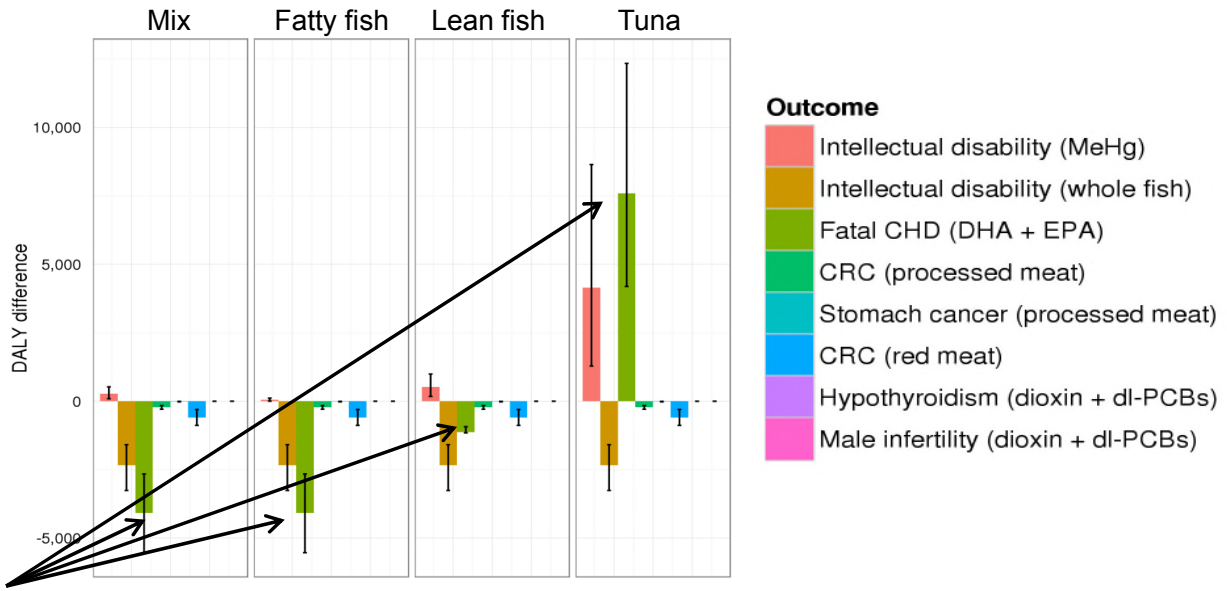


Health loss: ΔDALY > 0

Health gain: ΔDALY < 0

Results

DALY difference by outcome

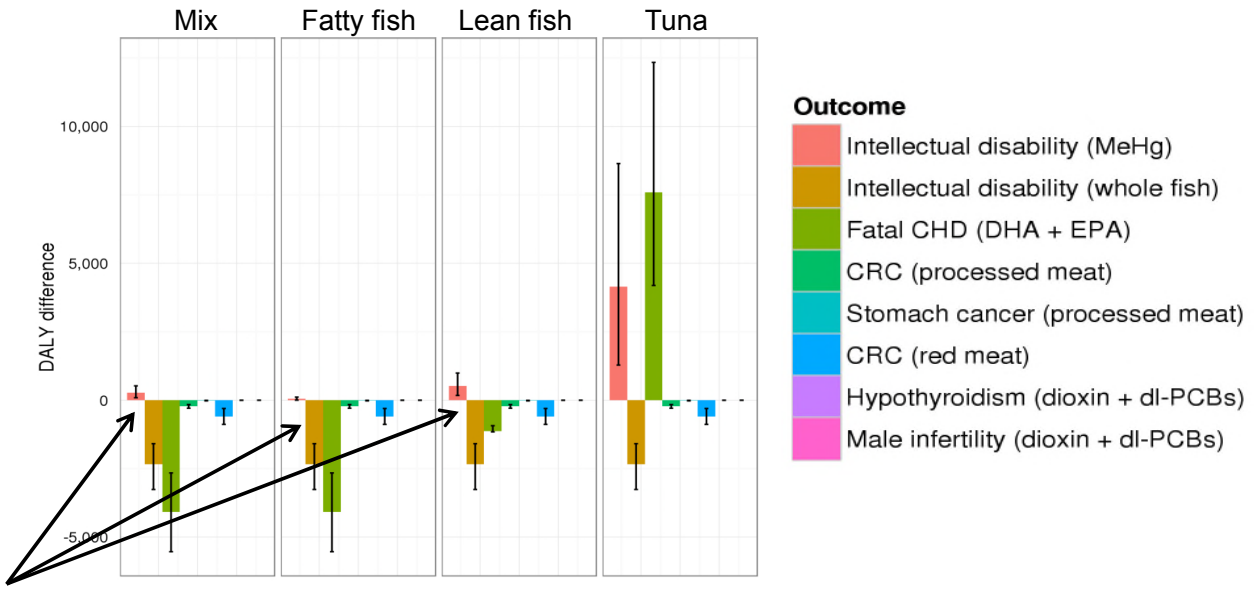


The effects on coronary heart disease mortality had a particular impact

The changes in fish consumption had the highest impact on the results

Results

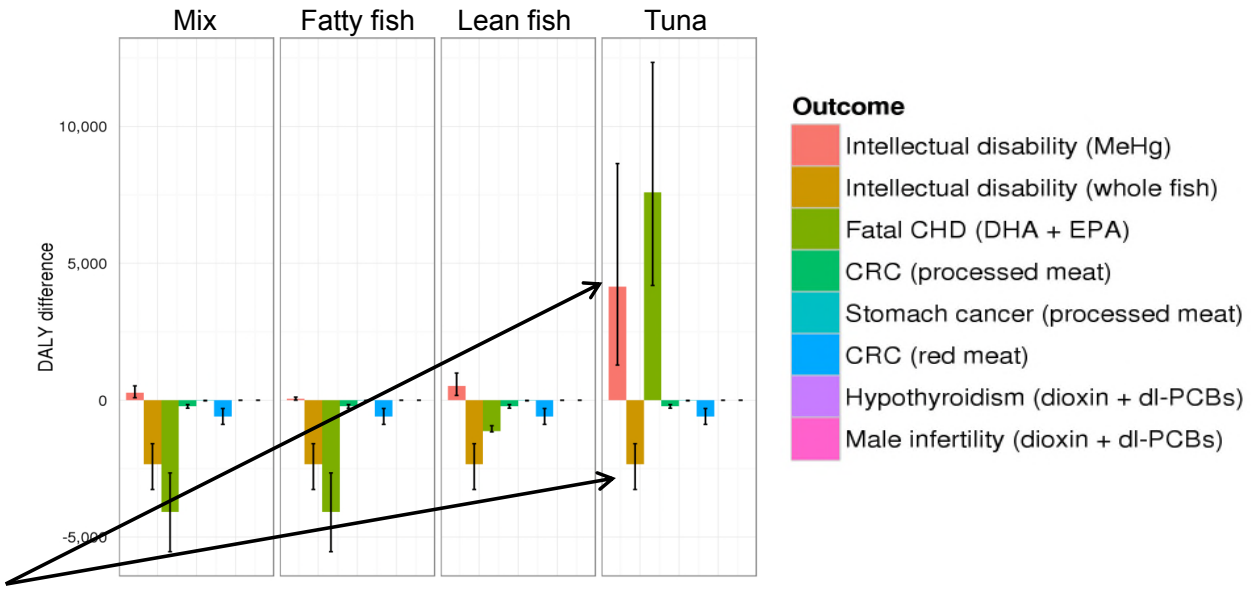
DALY difference by outcome



Beneficial effects of fish consumption on fetal neurodevelopment appeared to outweigh adverse effects of MeHg *at low exposures*

Results

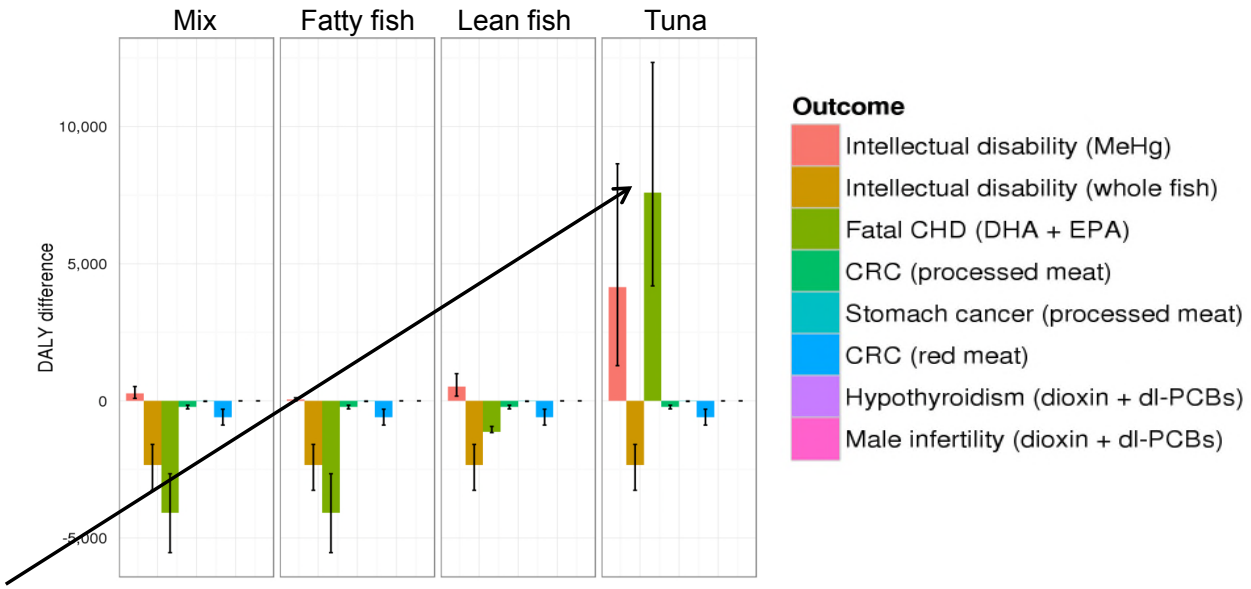
DALY difference by outcome



Adverse effect of MeHg estimated to dominate over beneficial effects on fetal neurodevelopment at 350 g of tuna/week compared with current consumption

Results

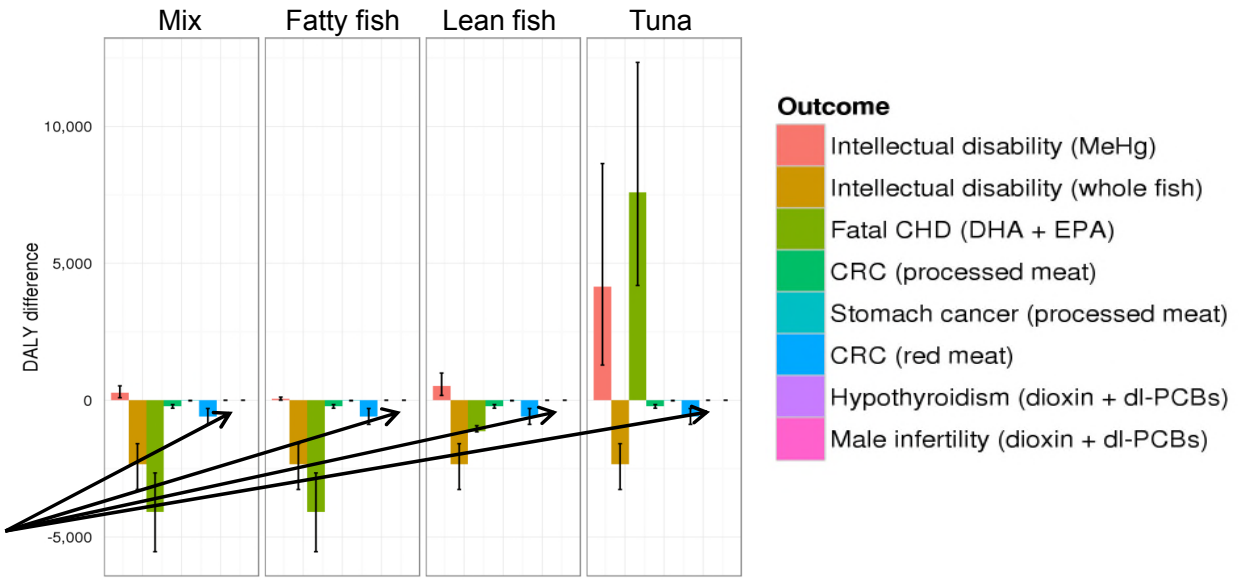
DALY difference by outcome



Lower intake of DHA + EPA compared with current consumption lead to estimated increase in fatal CHD

Results

DALY difference by outcome



Negligible role of dioxin + dl-PCBs on overall health impact

Accounting for variability in substitution

Methods in brief

- Builds on substitution with mix of lean and fatty fish
- Accounting for variability in adherence to guidelines and consumption preferences
- 70% of the adult population reach the recommended fish intake
- Some above, some below
- Individual health impact estimated

Food and Chemical Toxicology 126 (2019) 79–96

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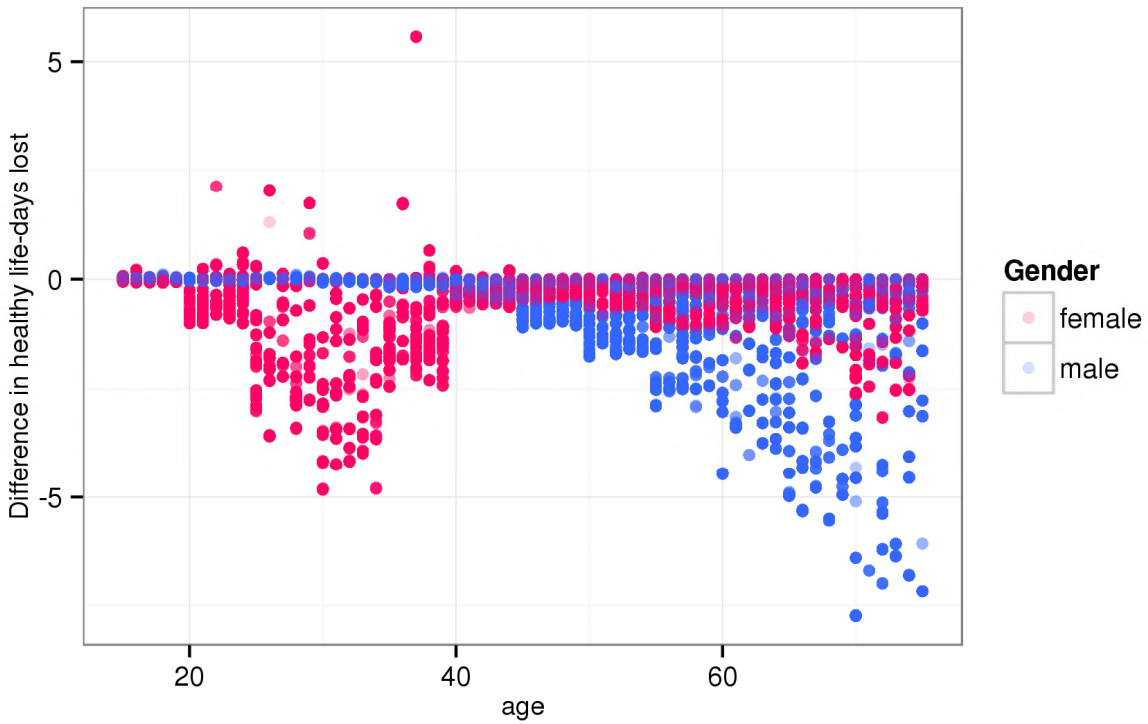
A probabilistic approach for risk-benefit assessment of food substitutions: A case study on substituting meat by fish

Sofie Theresa Thomsen[a,*], Waldo de Boer[b], Sara M. Pires[a], Brecht Devleesschauwer[c,d], Sisse Fagt[e], Rikke Andersen[a], Morten Poulsen[a], Hilko van der Voet[b]

Results

DALY difference by age and gender



Interpretation of individual DALYs:

Average health impact for individual of same age, gender and consumption habits/changes.

Different from the healthy life years lost for those that actually will fall ill.

Results

TWI: tolerable weekly intake
AI: adequate intake
AR: average requirement

Semi-quantitative comparison of risks and benefits

Scenario	MeHg % > TWI[a]	Dioxin + dl-PCBs % > TWI[b]	DHA + EPA % < AI[c]	Vitamin D % < AR[d]	Iron % < AR[e] (men)	Iron % < AR[e] (women > 49 years)	Iron % < AR[e] (women 15–49 years)
Reference	0.3	0.5	58.0	94.0	5.0	5.0	60.0
Alternative	6.0	7.0	4.0	69.0	5.0	4.0	60.0

[a] The tolerable weekly intake for MeHg is 1.3 µg/kg bw/week (EFSA CONTAM Panel, 2012).
[b] The tolerable weekly intake for dioxin and dl-PCBs is 14 pg TEQ/kg bw/week (Scientific Committee on Food, 2001).
[c] The adequate intake of DHA and EPA is 250 mg/day (300 mg/day for pregnant/lactating women) (EFSA NDA Panel, 2010a; FAO, 2010).
[d] The average requirement for vitamin D is 7.5 µg/day (Nordic Council of Ministers, 2014).
[e] The average requirement for iron is 7 mg/day for men, 6 mg/day for postmenopausal women, and 10 mg/day for women in the fertile age (Nordic Council of Ministers, 2014).

New TWI for dioxin + dl-PCBs

EFSA Scientific Opinion from 2018: new TWI of 2 pg TEQ/kg bw/day (7-fold lower) based on new epidemiological evidence on reproductive adverse effects in exposed boys

How does that impact the results of the RBA?

- Investigate newly available data
- What is the current disease burden?
- Will a change in fish consumption change the disease burden?
- Risk managers need to consider possible mitigation strategies

SCIENTIFIC OPINION

EFSA Journal

ADOPTED: 14 June 2018

doi: 10.2903/j.efsa.2018.5333

Risk for animal and human health related to the presence of dioxins and dioxin-like PCBs in feed and food

EFSA Panel on Contaminants in the Food Chain (CONTAM),
Helle Katrine Knutsen, Jan Alexander, Lars Barregård, Margherita Bignami, Beat Brüschweiler, Sandra Ceccatelli, Bruce Cottrill, Michael Dinovi, Lutz Edler, Bettina Grasl-Kraupp, Christer Hogstrand, Carlo Stefano Nebbia, Isabelle P Oswald, Annette Petersen, Martin Rose, Alain-Claude Roudot, Tanja Schwerdtle, Christiane Vleminckx, Günter Vollmer, Heather Wallace, Peter Fürst, Helen Håkansson, Thorhallur Halldorsson, Anne-Katrine Lundebye, Raimo Pohjanvirta, Lars Rylander, Andrew Smith, Henk van Loveren, Ine Waalkens-Berendsen, Marco Zeilmaker, Marco Binaglia, José Ángel Gómez Ruiz, Zsuzsanna Horváth, Eugen Christoph, Laura Ciccolallo, Luisa Ramos Bordajandi, Hans Steinkellner and Laurentius (Ron) Hoogenboom

Need for continuous update of RBAs as new contaminants, new knowledge and new data arise

Limitations and uncertainties

We quantified some but not all uncertainties

Different types of human studies, different populations, animal studies…

Health outcomes linked with both whole food and food components/contaminants

Weight of evidence: preferably the same for nutrition and toxicology, but may be difficult

Individual foods in isolation from whole diet (although substitution is accounted for)

How will people actually behave upon communication of food-based dietary guidelines?

Key messages

Up to **7,000 DALYs/year** could be averted by the substitution in the Danish population

- Coronary heart disease accounted for approx. 84,000 DALYs in Denmark in 2015 (www.ghdx.healthdata.org)

- Approximately 5% of Danish fatal CHD cases could be prevented by the substitution

Highest benefit estimated when **50-100% of fish was fatty**

The results overall support the Danish Food-Based Dietary Guidelines

Despite adverse effects of MeHg, women in the childbearing age should not limit consumption of small and fatty fish species low in MeHg to below 200-350 g/week

Estimates for the Danish population – need for other national RBAs of fish

Need to be continuously updated due to emerging new contaminants and evidence