

Life Cycle Assessment (LCA) overview

- “cradle to grave” environmental accounting
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 - the “compilation and evaluation of the inputs and outputs and the potential environmental impacts of a product system throughout its life cycle” (ISO 14040)



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 - energy carriers
 - Products & co-products
 - emissions, waste



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- impact categories:
 - Energy use
 - global climate change potential
 - land use
 - water use
 - Eutrophication potential
 - Acidification potential
 - human toxicity, eco-toxicity

Application of LCA to food/ag



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Cradle-to-grave

Application of LCA to food/ag



Cradle-to-farm gate

Cradle-to-grave

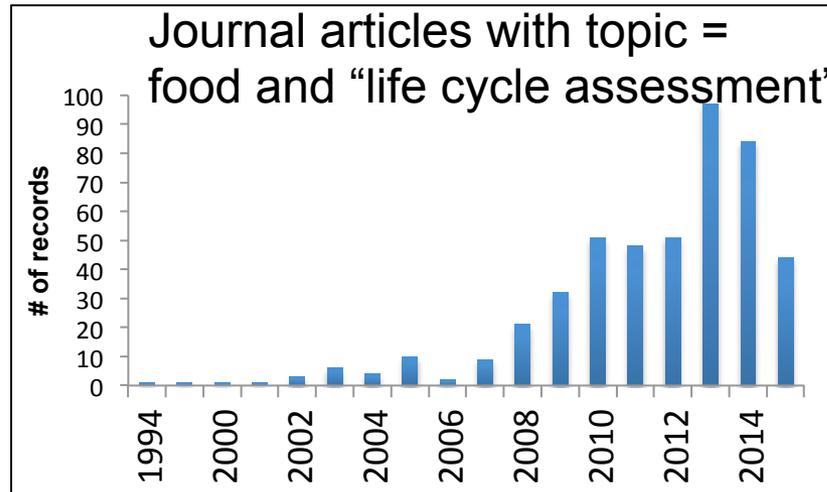
Application of LCA to food/ag



Cradle-to-farm gate

Cradle-to-grave

...challenging, but has accelerated



(web of Science search, June, 2015)
with manual culling

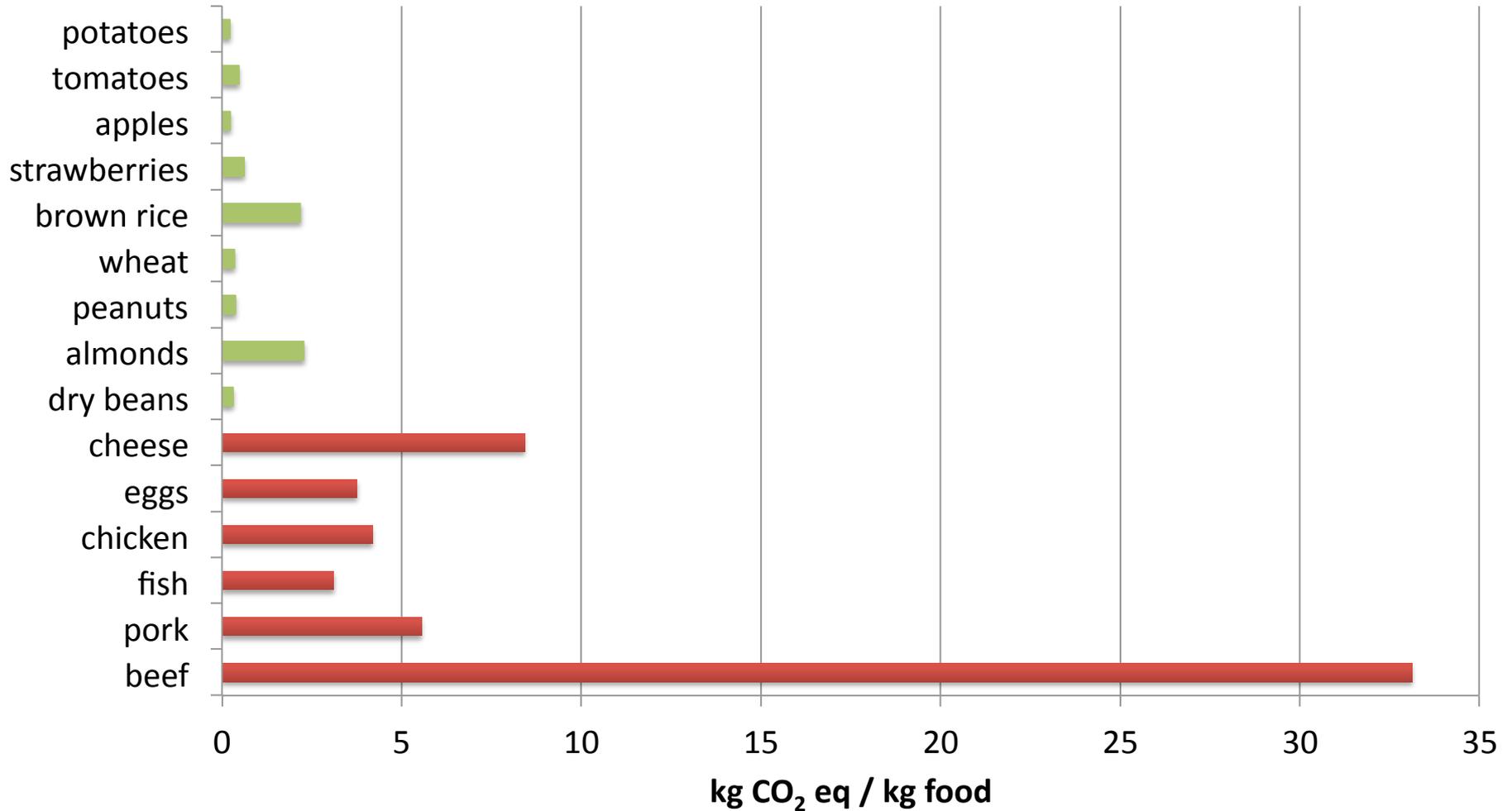
Application of LCA to food/ag



...challenging, but has accelerated

- Hundreds of food LCAs exist in the literature
 - majority from Europe
- For most commodities, farm impacts dominate
- Beyond GHGE and energy use, strong geo-spatial dependence

Greenhouse gas emissions from farming vary considerably by food...



Approach

NHANES

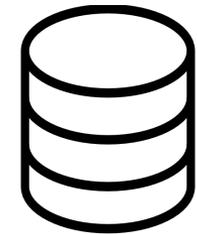
(National Health and Nutrition Examination Survey)



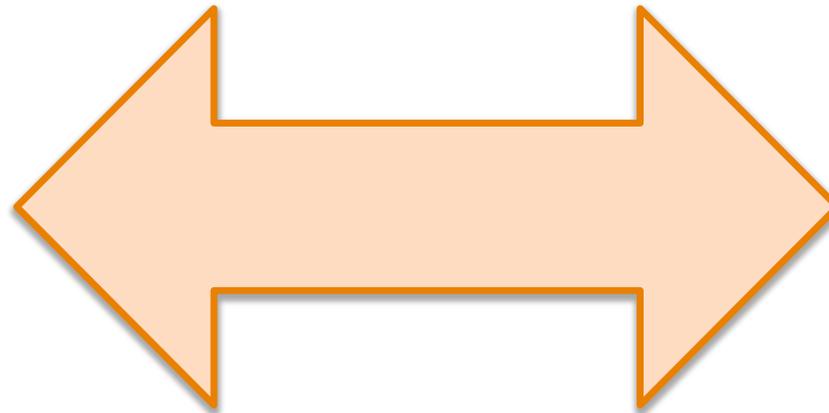
16,800 individuals
(18+ years of age)
>7000 as-consumed
food items

Food Environmental Impact DB

Populated with literature-
based emission factors



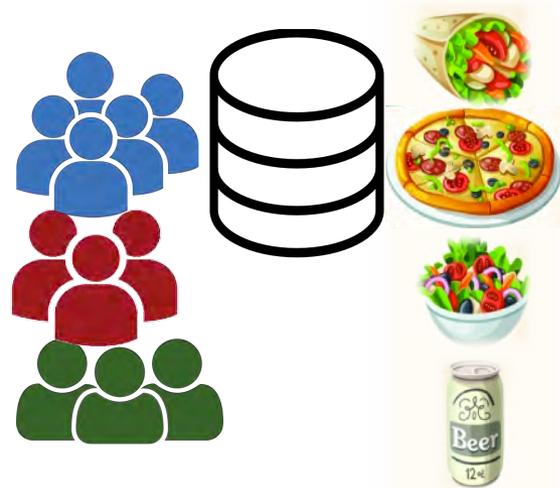
Primarily food
commodity basis



Approach

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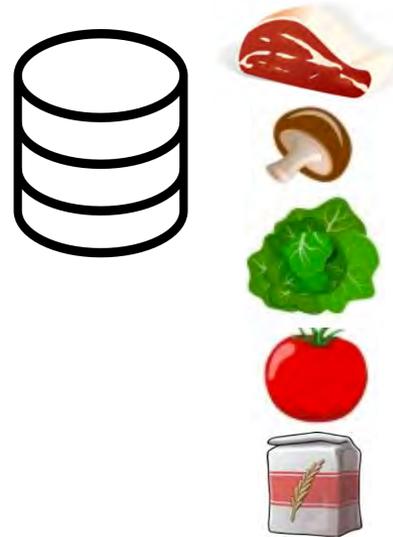
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FCID

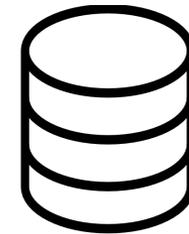
(Food Commodities Intake Database)



332 food
commodities

Food Environmental Impact DB

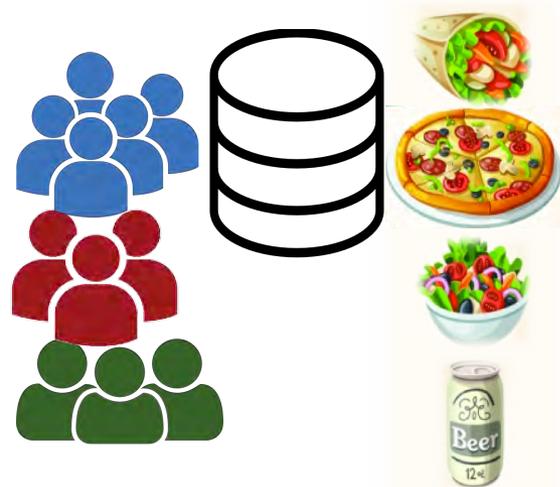
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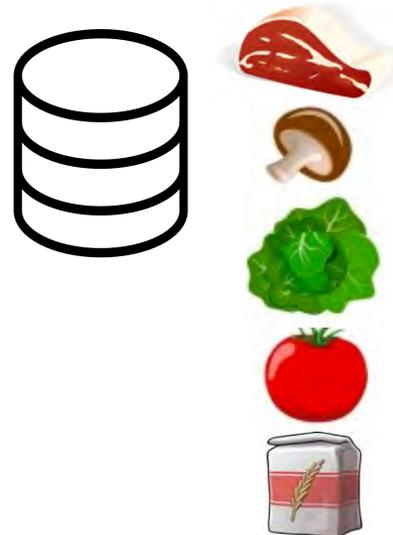
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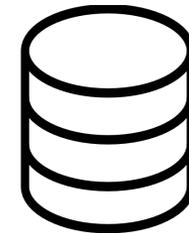
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332 food
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dataFIELD =
**database of
Food Impacts
on the Environment
for Linking to Diets**

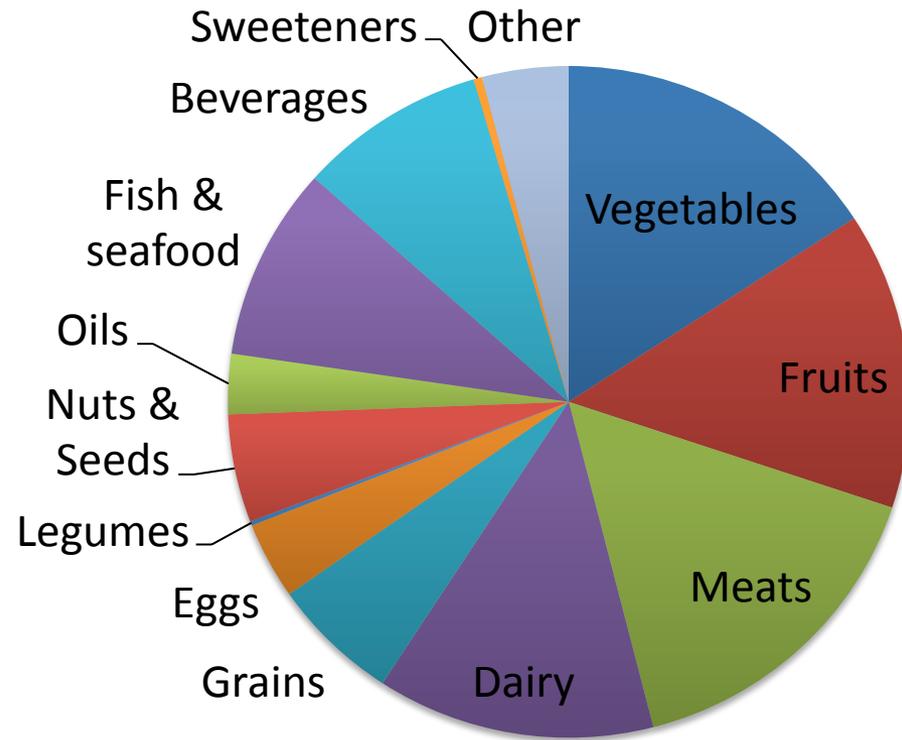
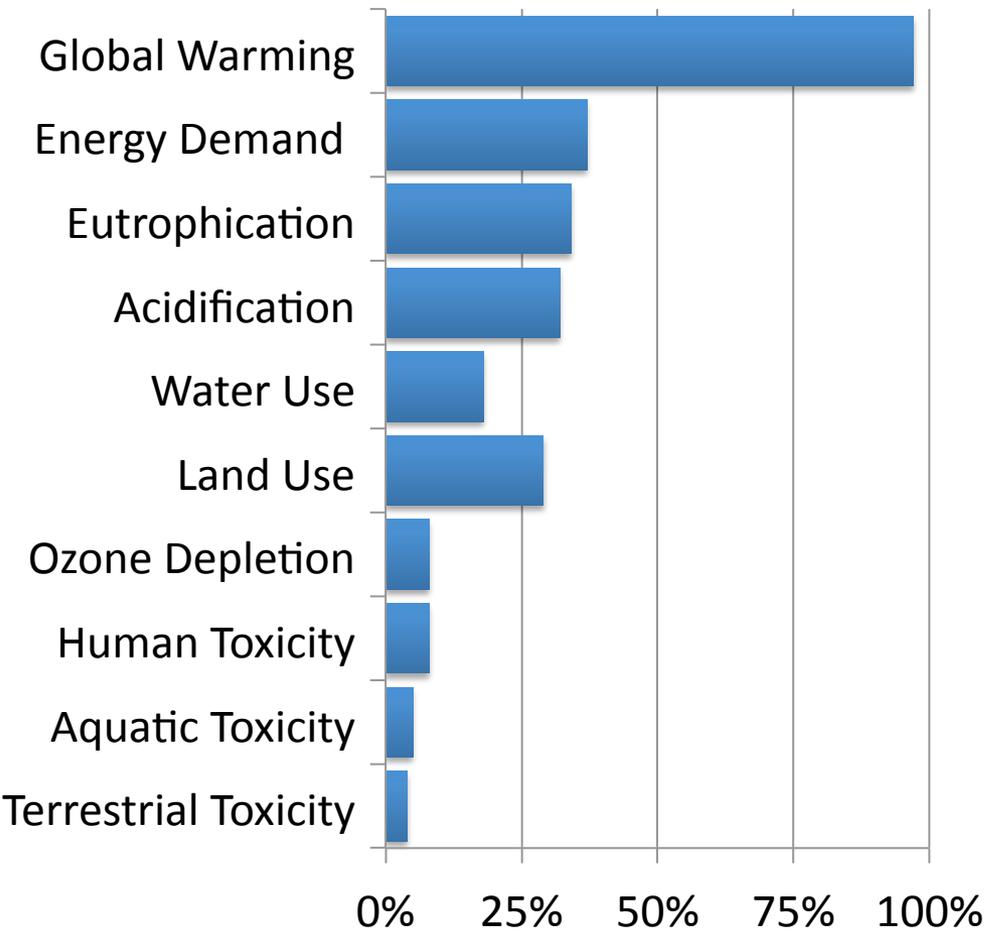
Literature review

to populate database

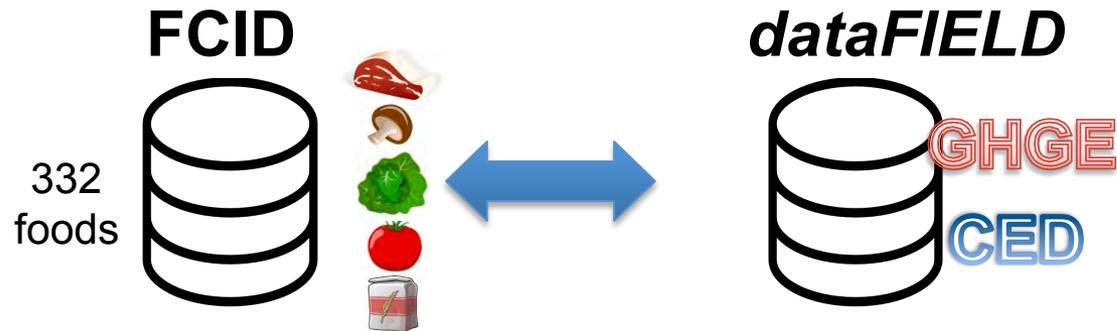
- Literature considering environmental impact of food production
 - Using LCA methods
 - 2005-2016
 - in English
 - public domain
- Adjusted basis to per “kg food” (“kg edible boneless weight”)

LCA Food Lit Characterization

- 805 “entries”, 193 unique sources
- 60% on food production in Europe; 17% from N. America

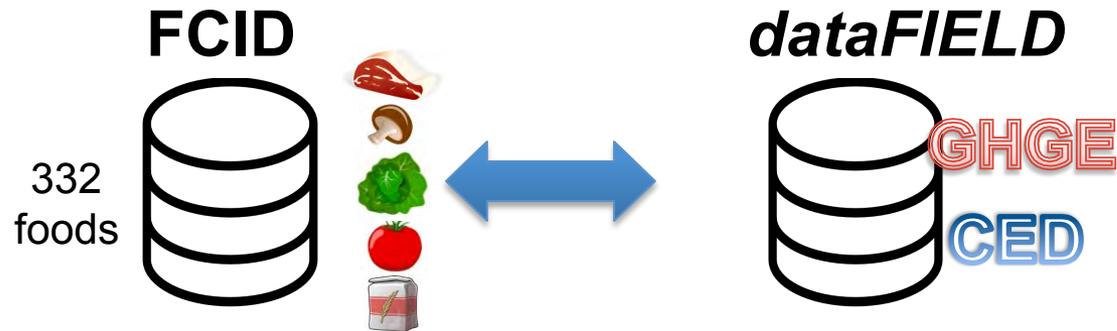


Linking to Food Intake Database



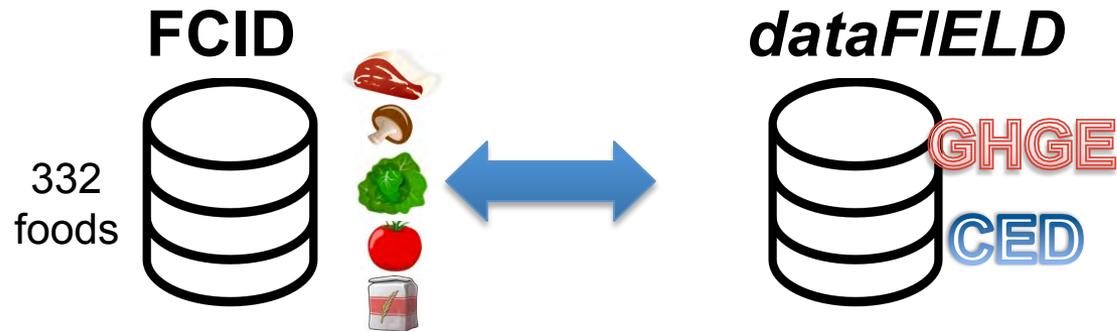
Examples of FCID foods	# of entries averaged	Average emission factor (kg CO ₂ eq/ kg)	Standard deviation
beef	95	33.1	12.6

Linking to Food Intake Database



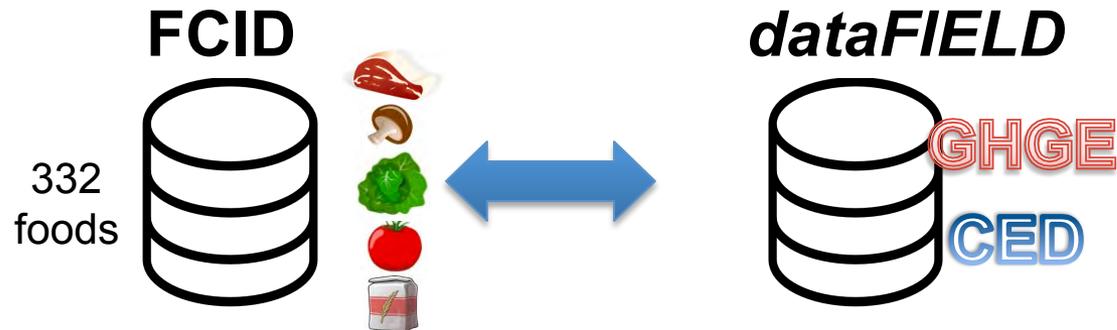
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Linking to Food Intake Database



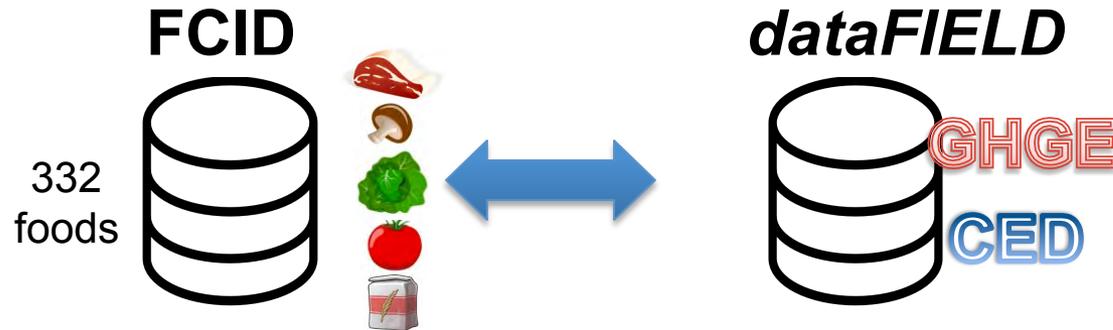
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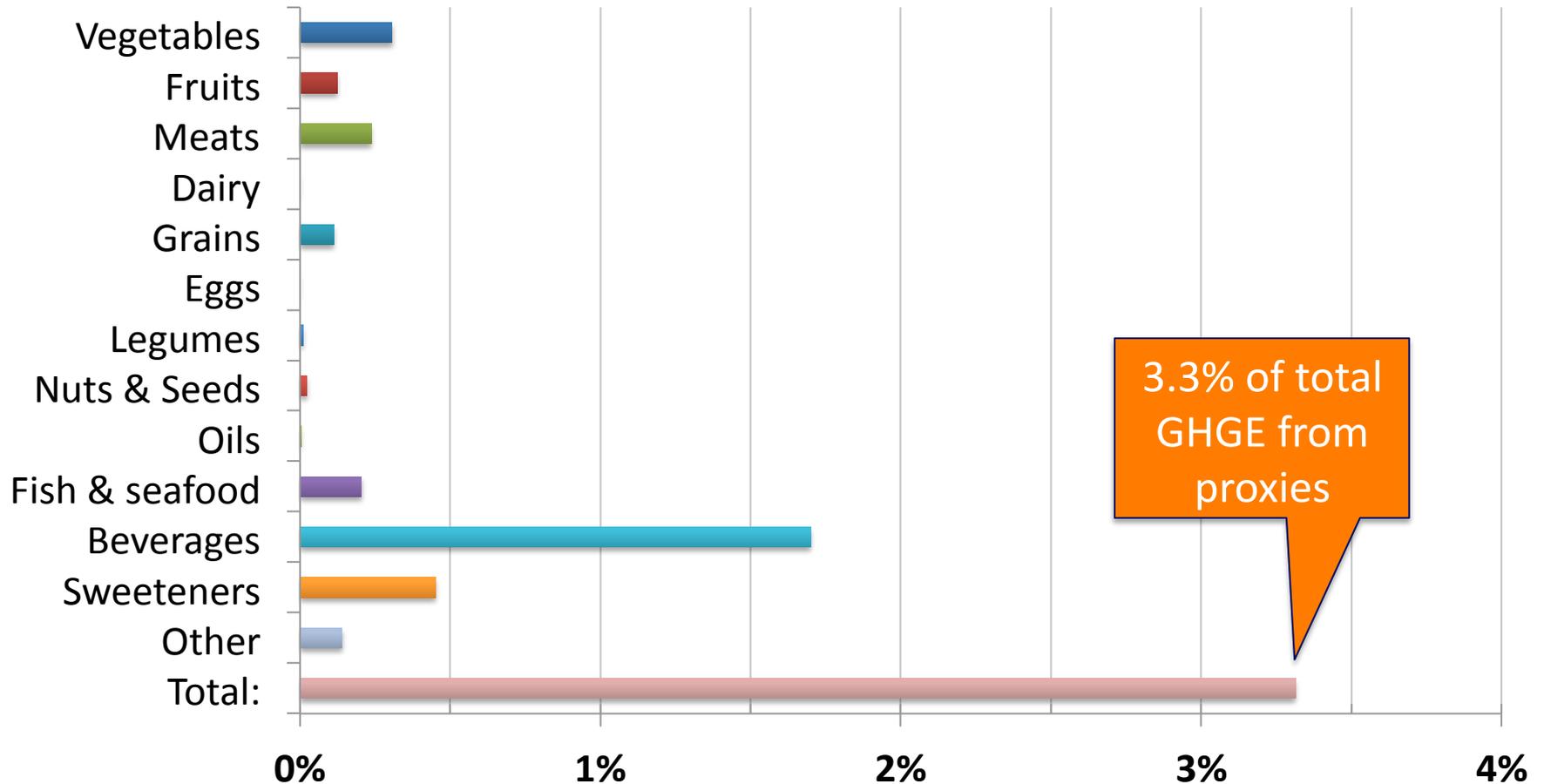
proxy assignments

51% of FCID foods for GHGE

62% for energy demand

Minor contribution to diet GHGE from proxies

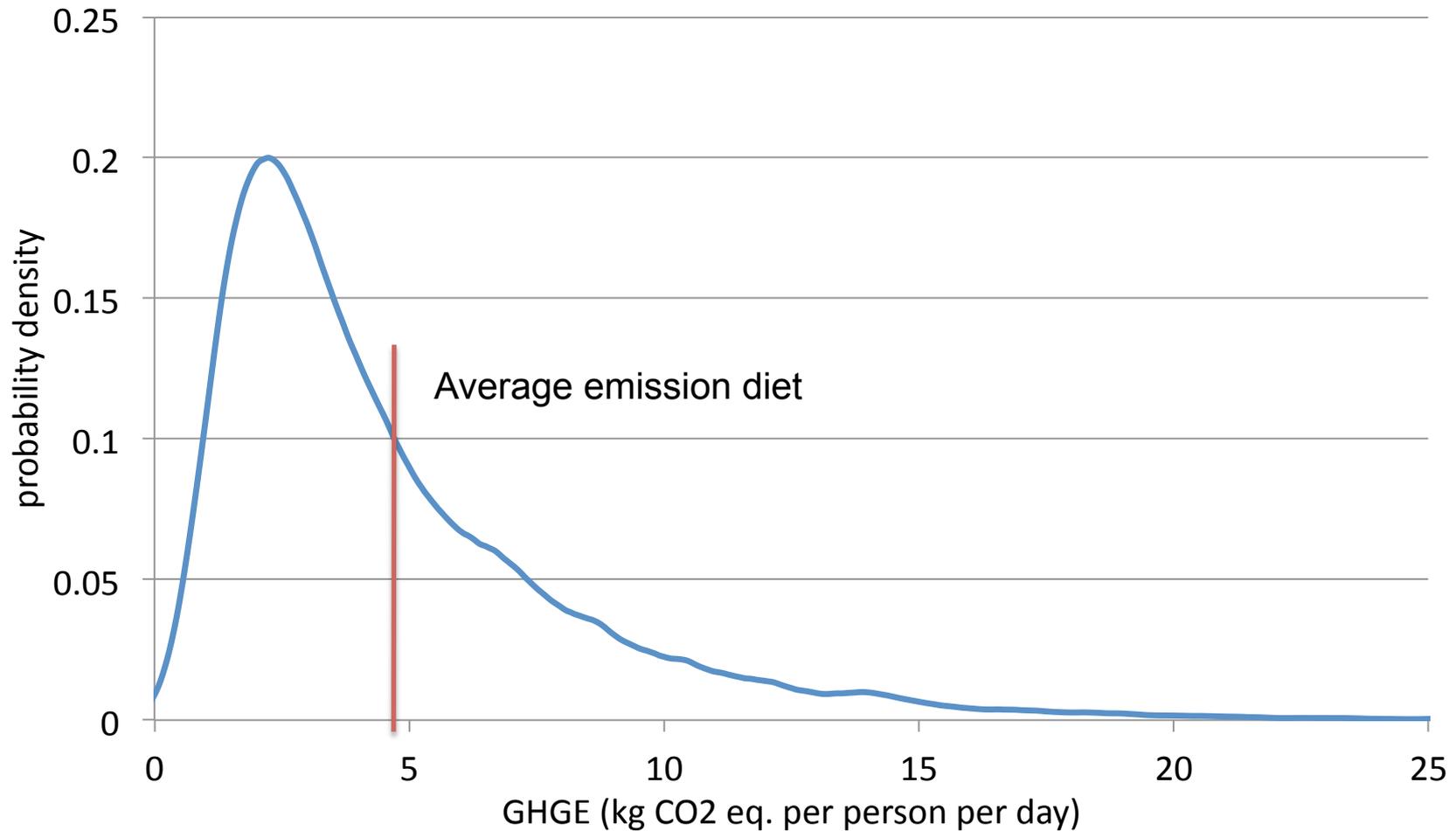
% of diet impacts from proxy



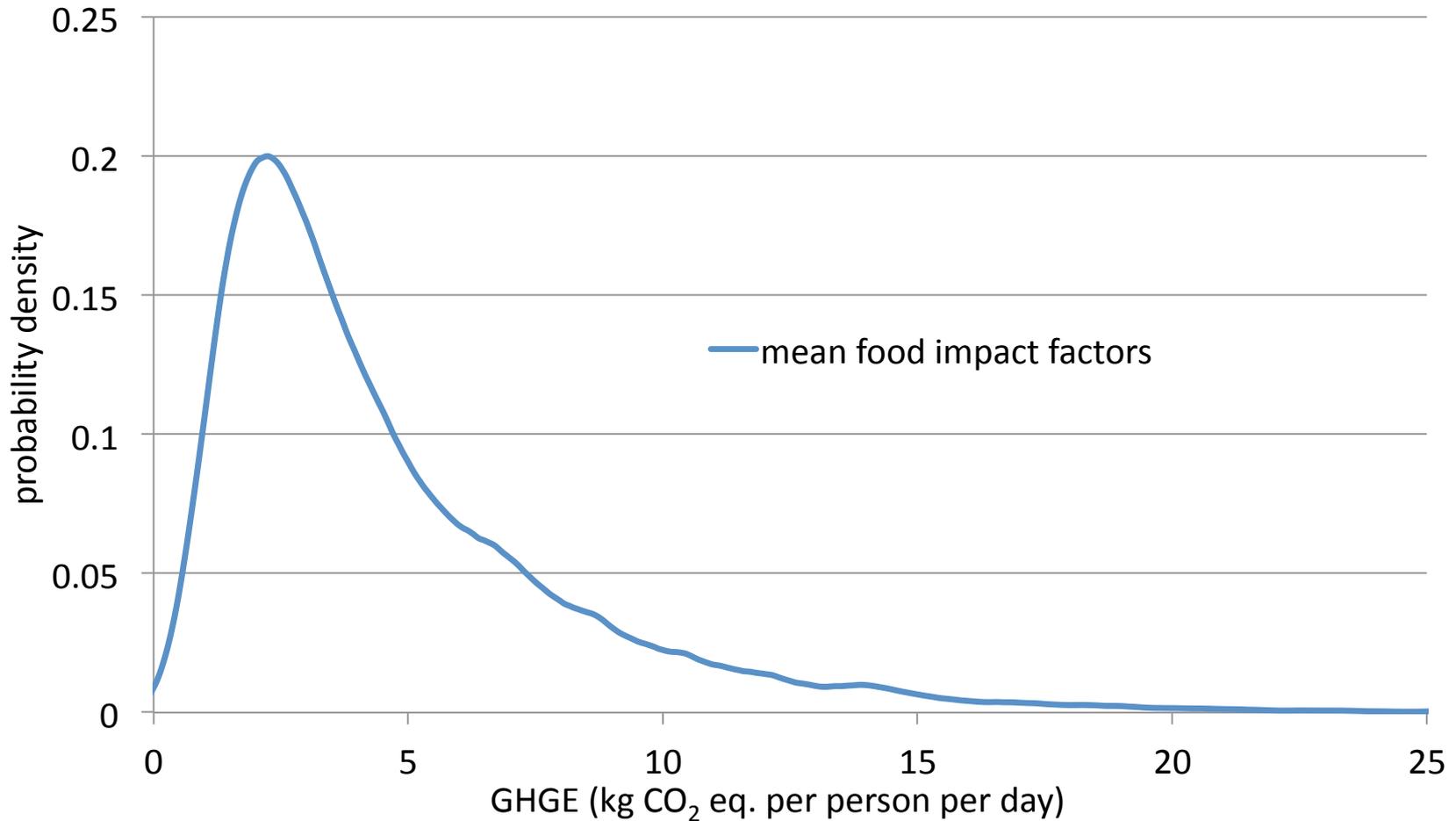
Results at the mean of population

		Consumed		Food loss contributions		Consumed + all losses	
		Mean	SE	Retail losses	Consumer losses	Mean	SE
GHGE (kg CO ₂ eq. per capita)	per day	3.6	0.04	0.3	0.9	4.7	0.05
	per 1000 kcal	1.7	0.01	0.1	0.4	2.2	0.02
Energy Demand (MJ per capita)	per day	18.9	0.2	1.4	4.9	25.2	0.3
	per 1000 kcal	8.9	0.07	0.7	2.4	12.0	0.1

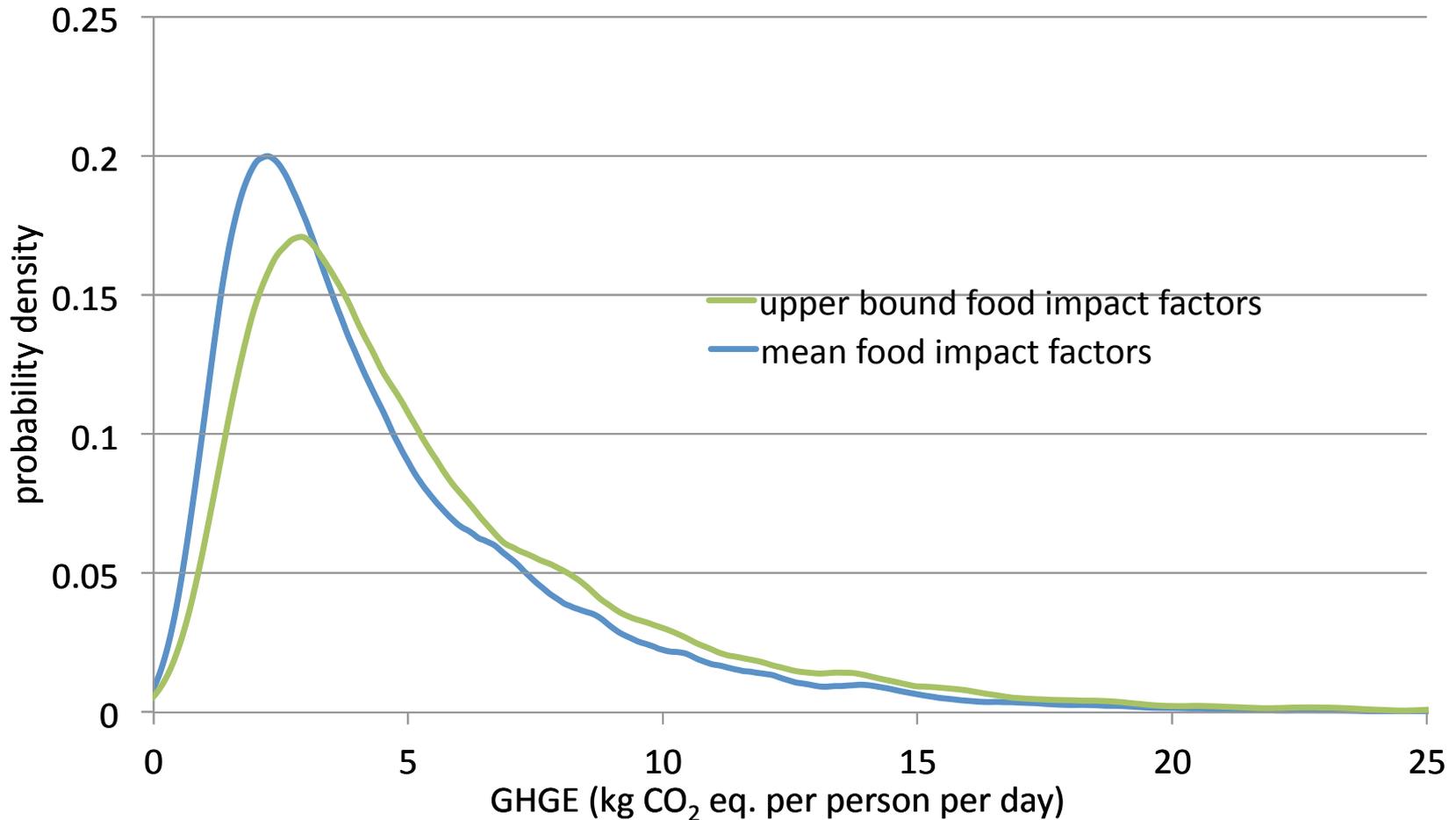
Distribution of GHGE from production of nationally representative 1-day diets



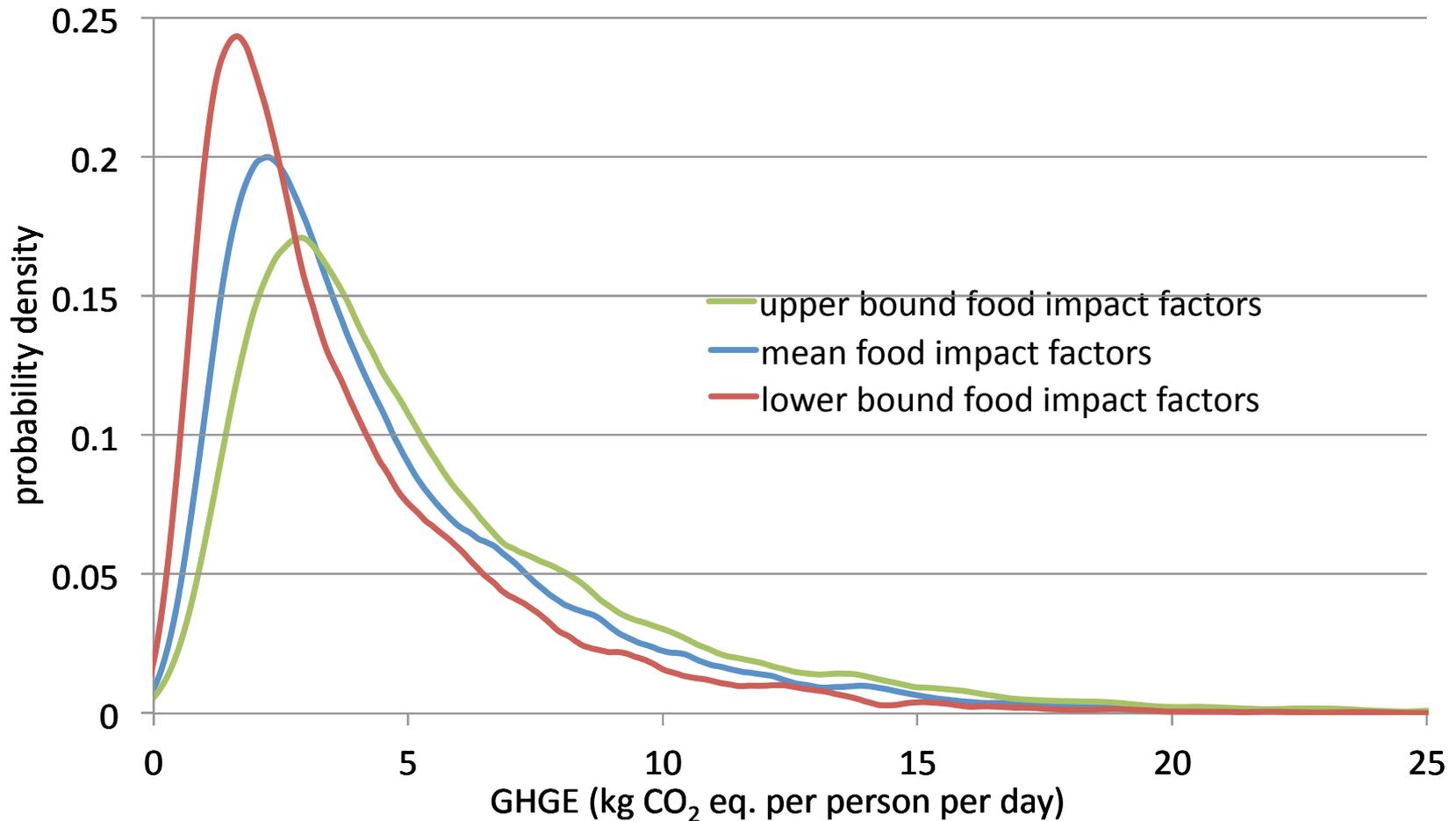
Distribution, showing food impact factor variability



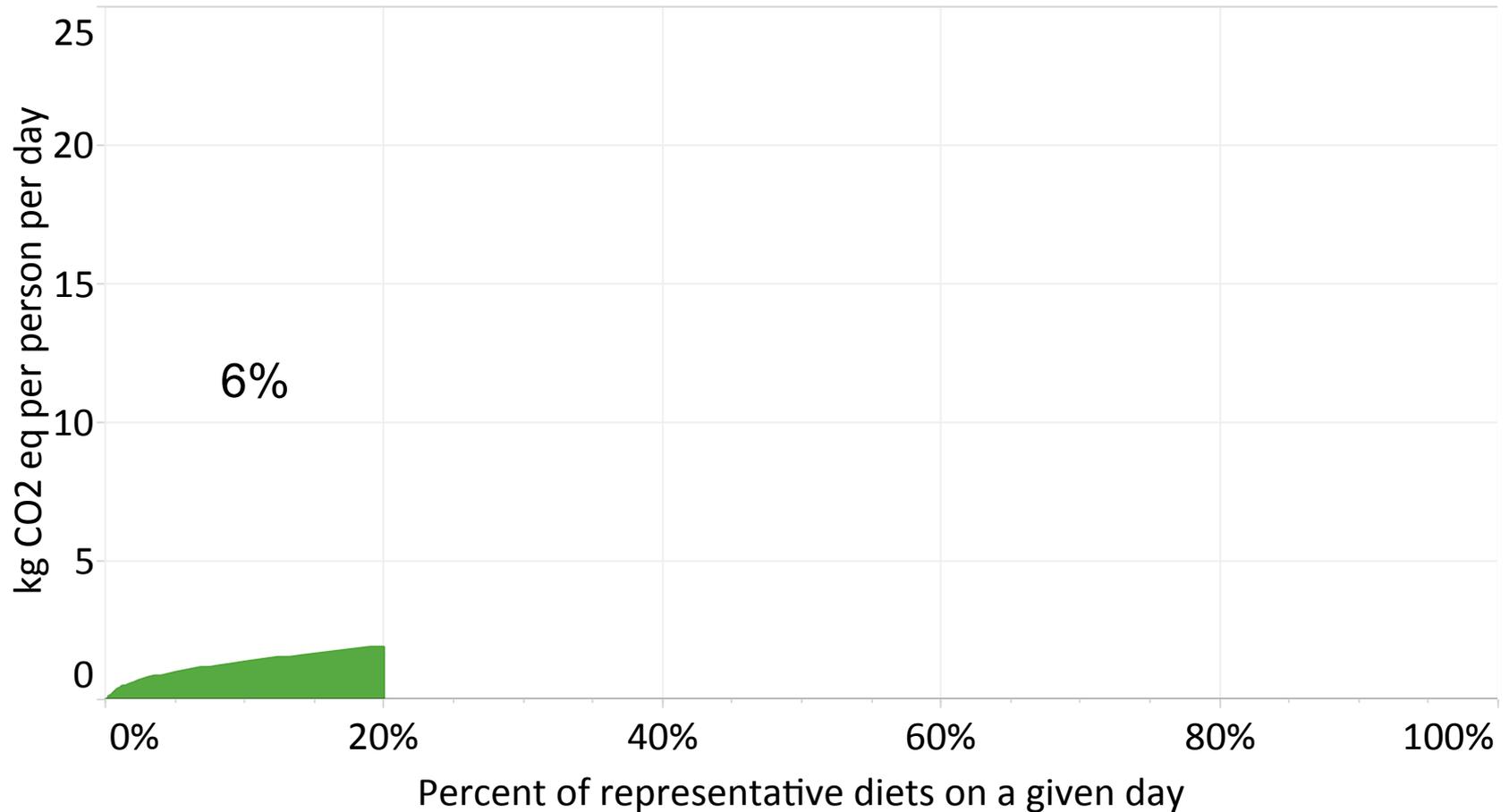
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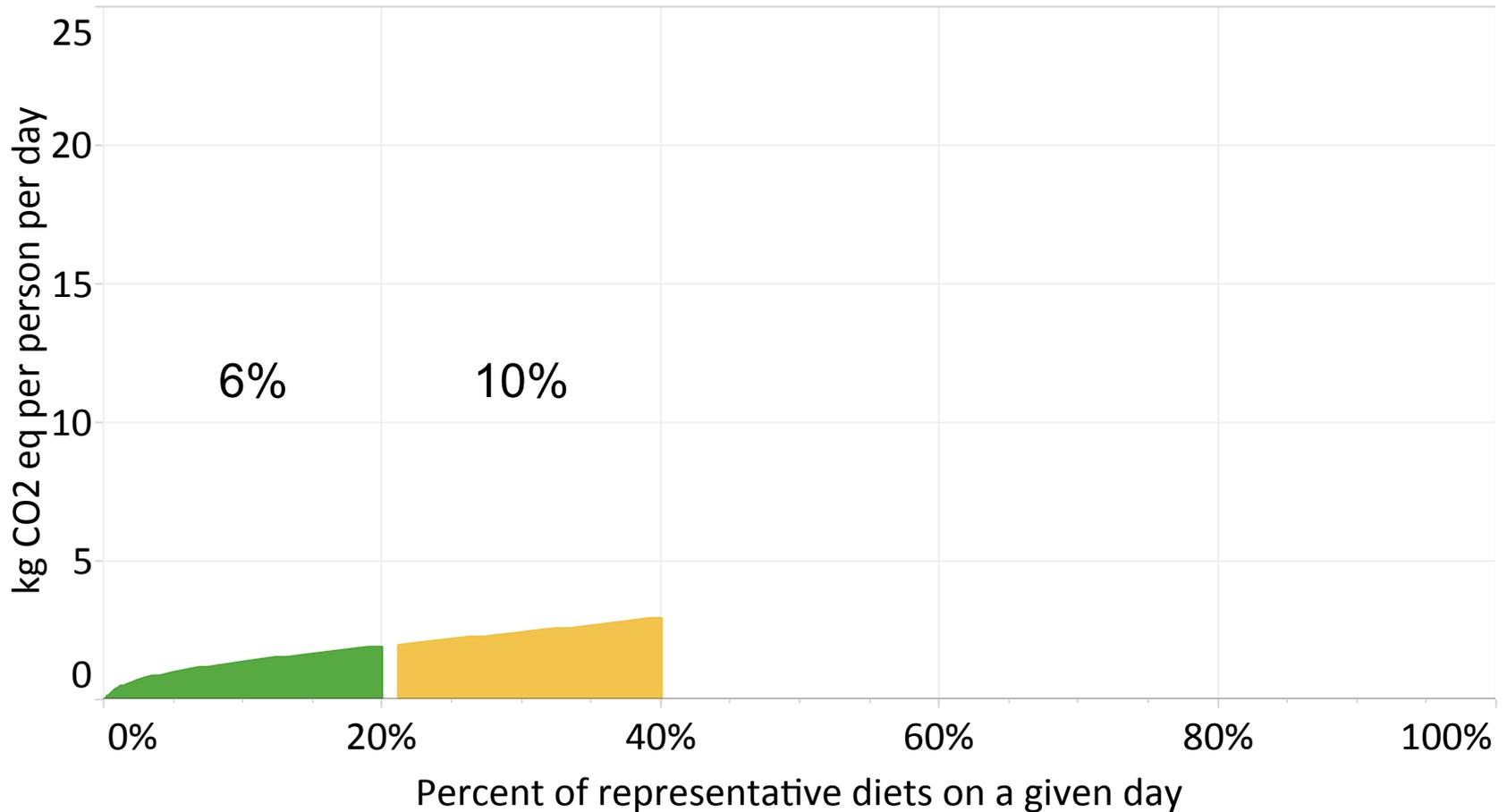
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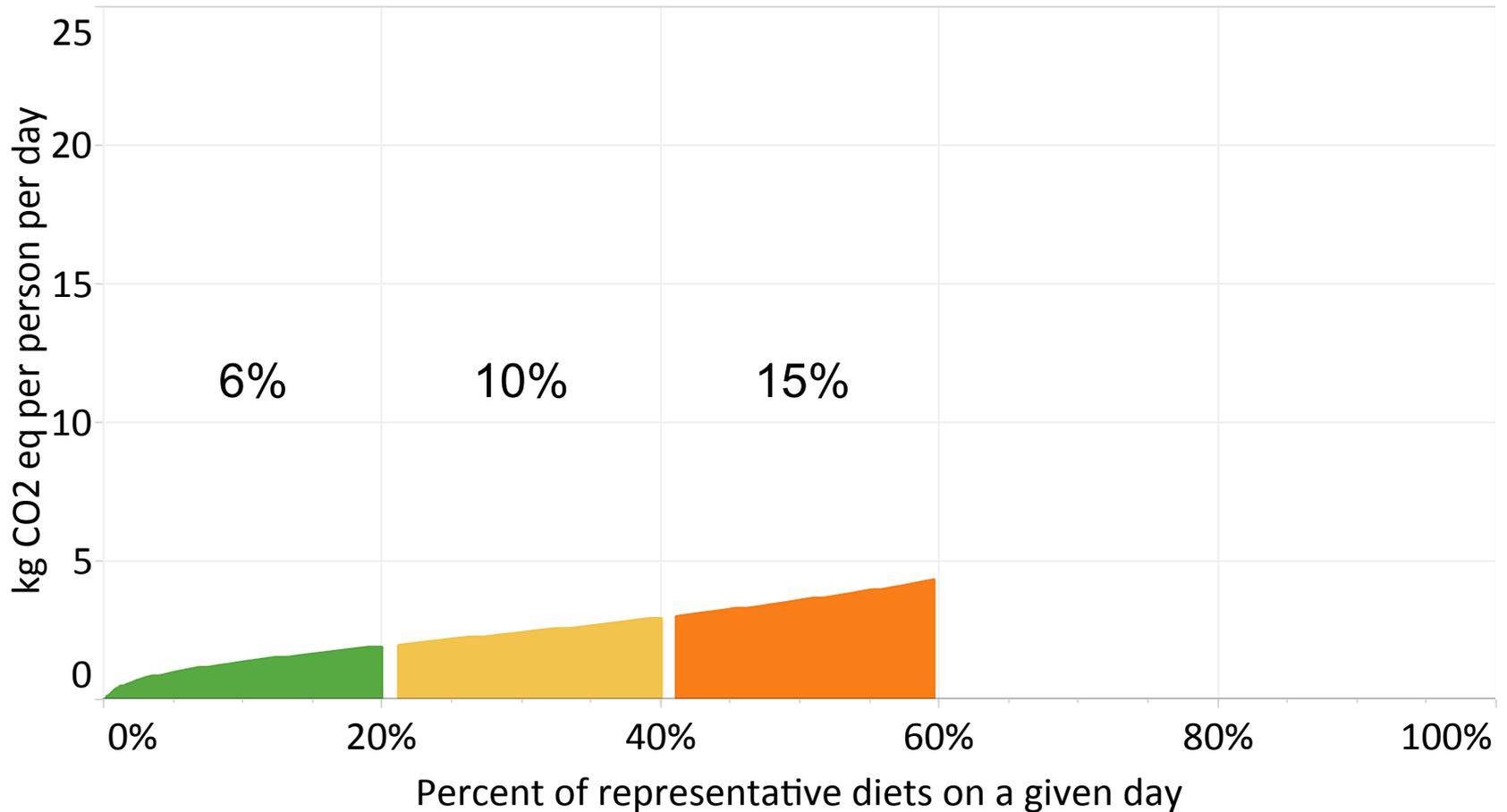
Cumulative emission intensity of U.S. one-day diets, divided into quintiles



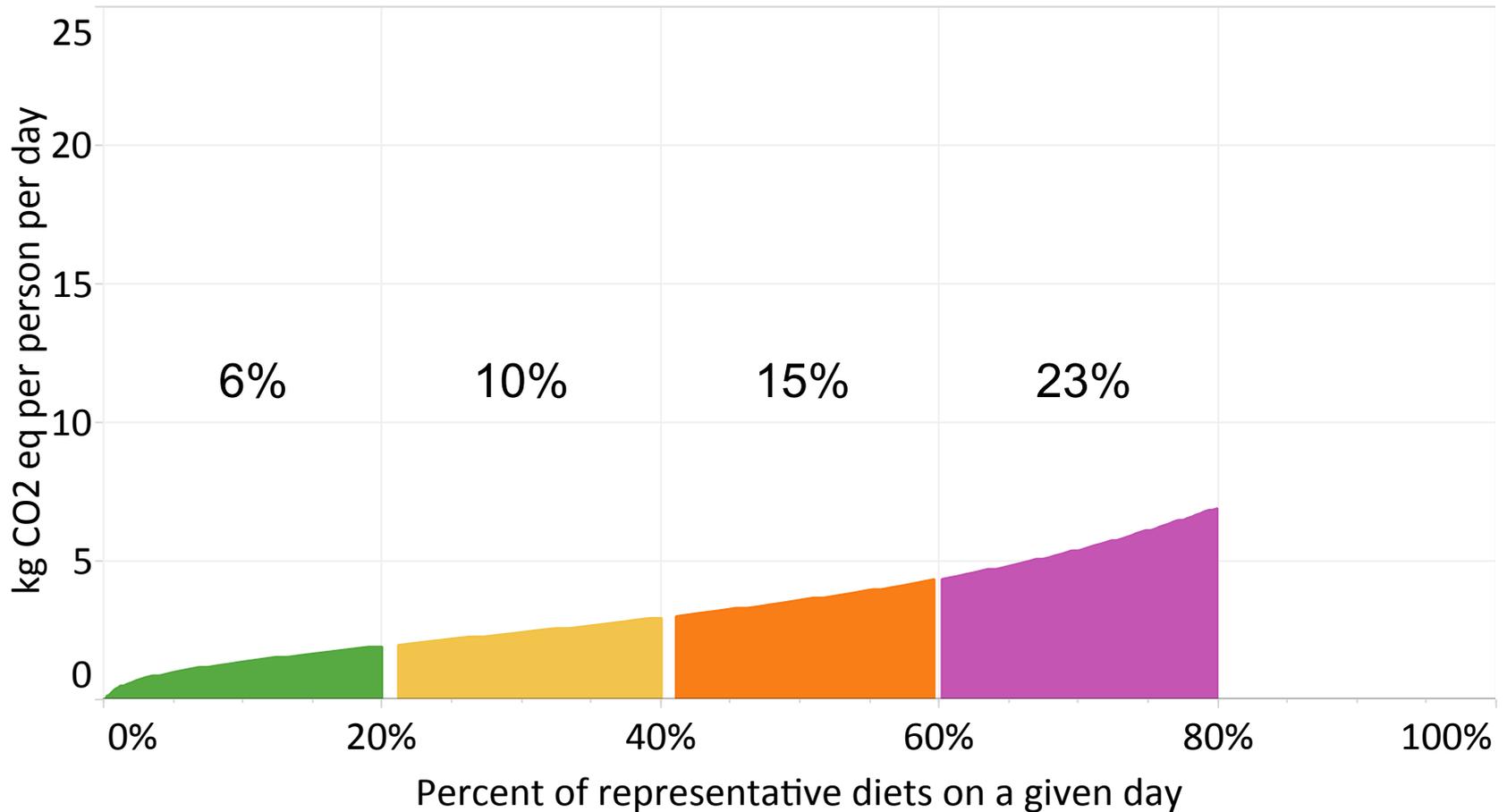
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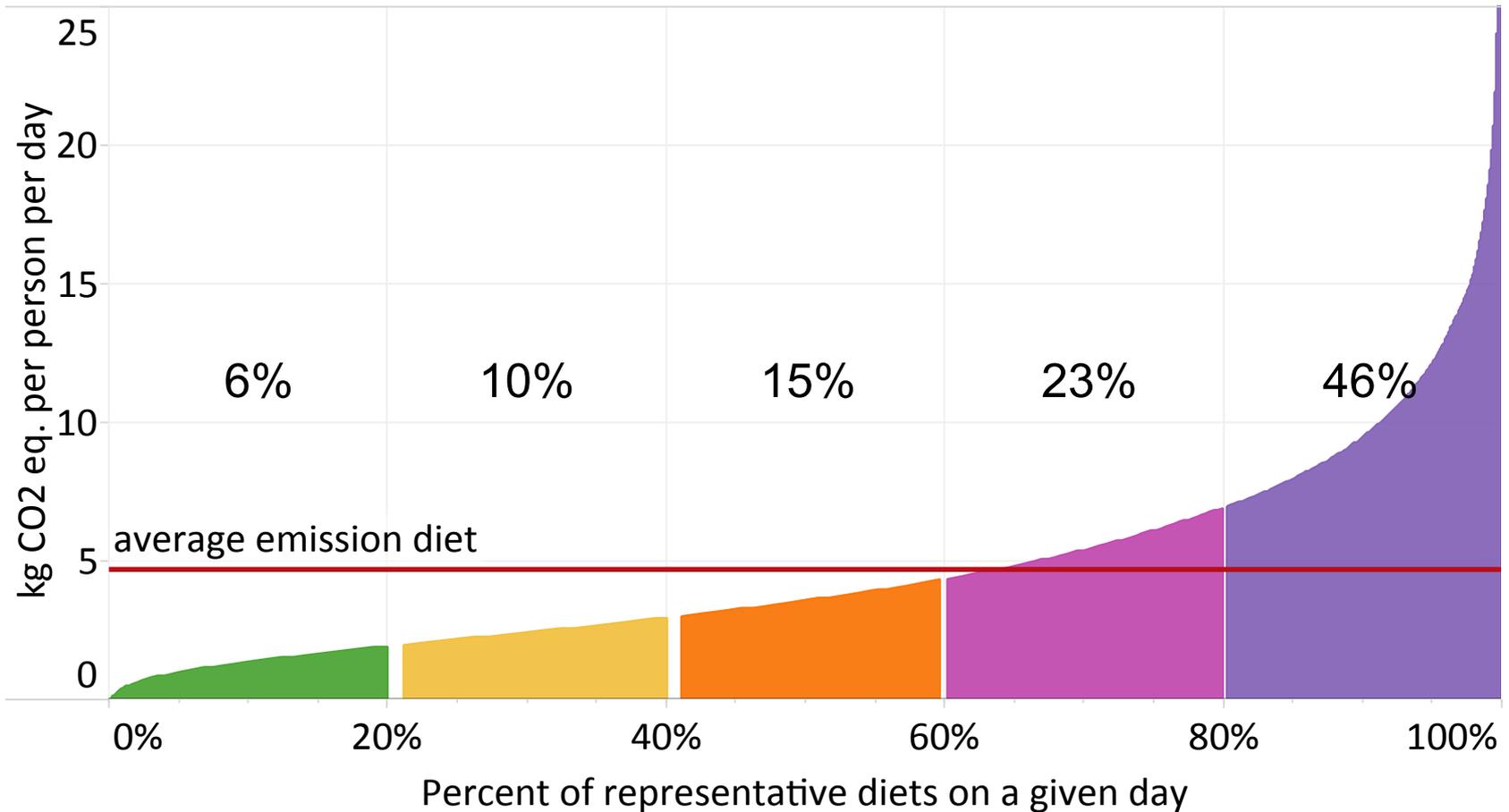
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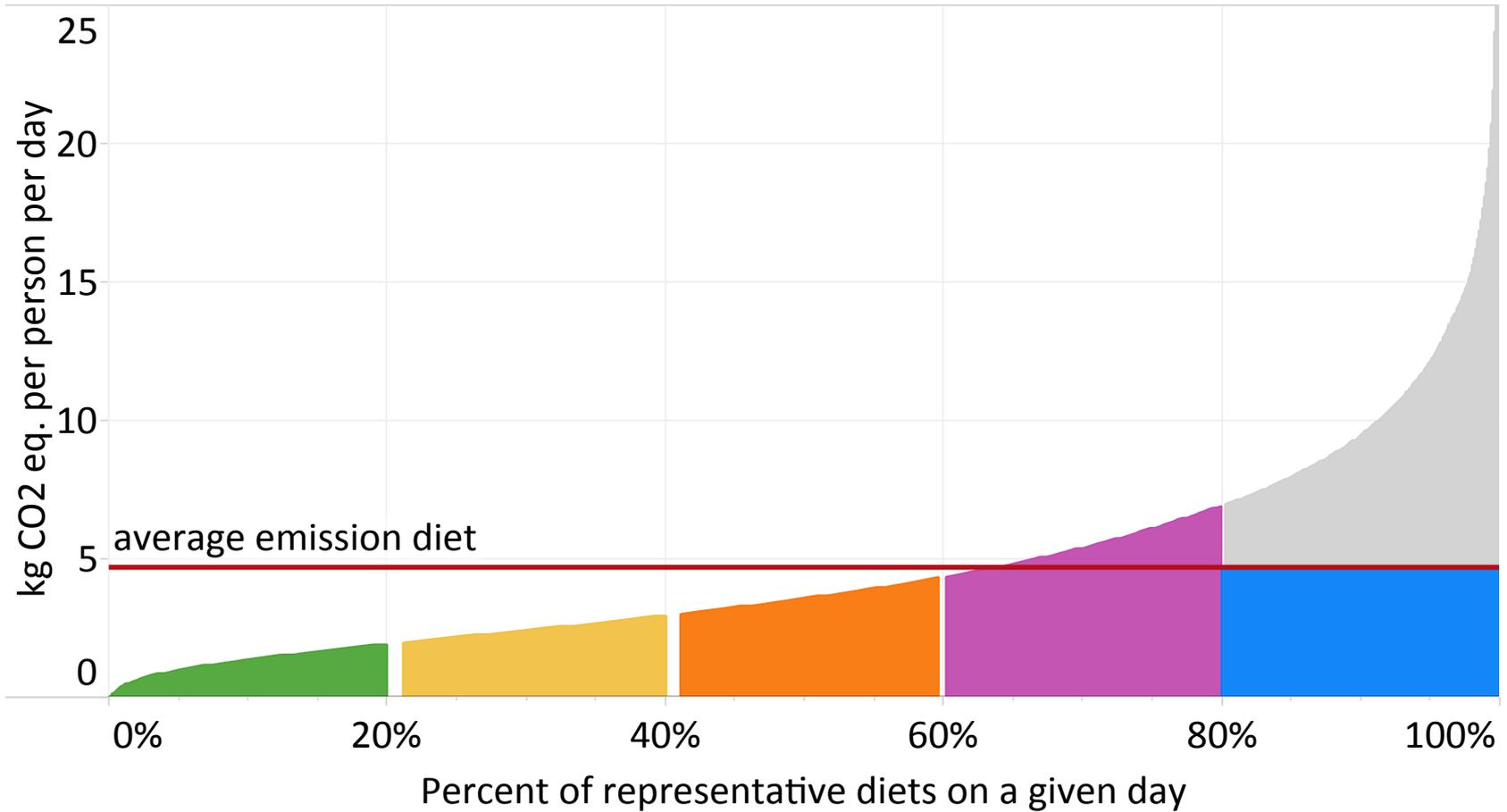
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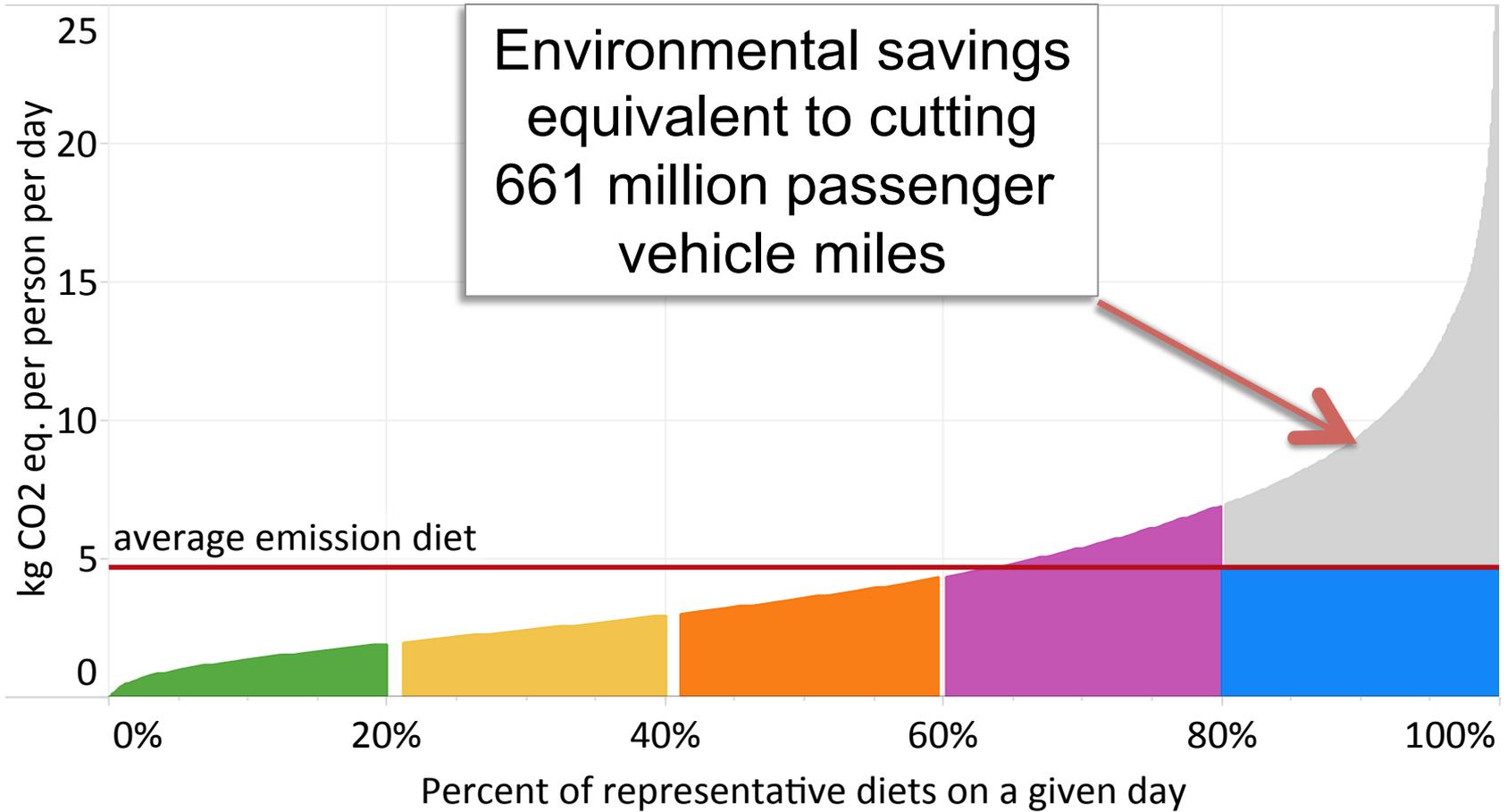
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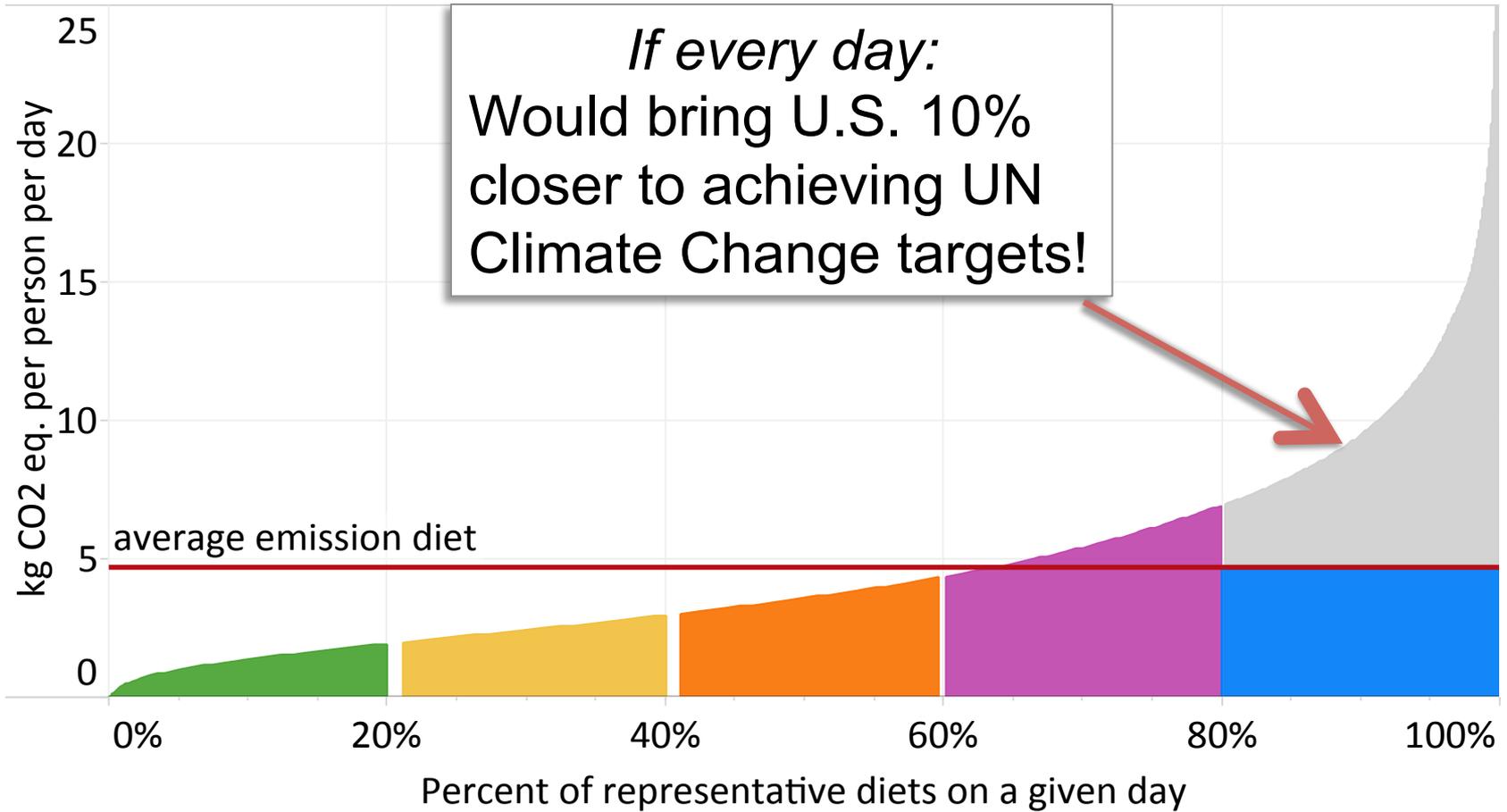
Hypothetical diet shift: top quintile to “average emission diet”



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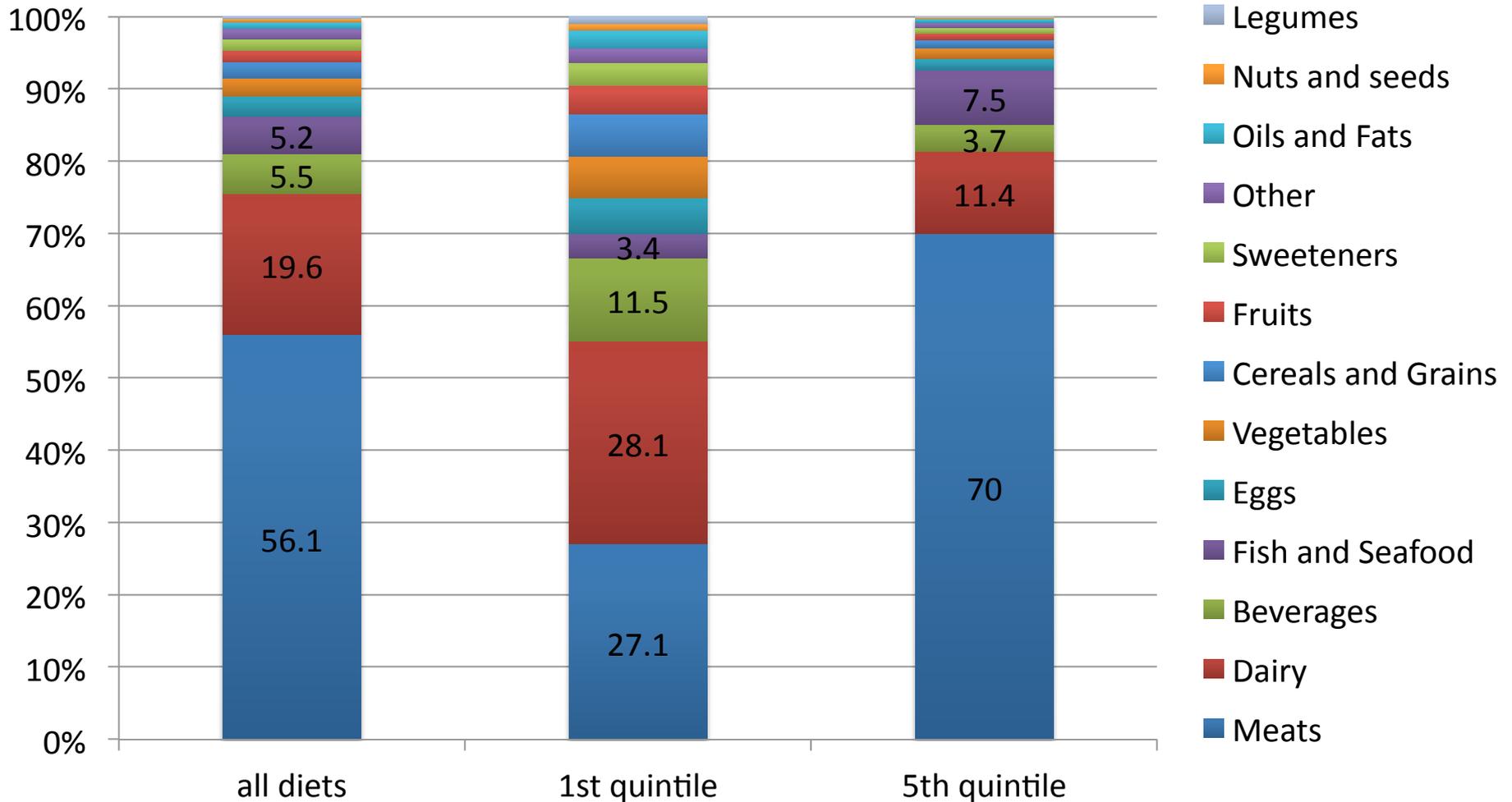


Percent contributions from food groups to total GHGE

Avg. Calories: 2153

1323

2984

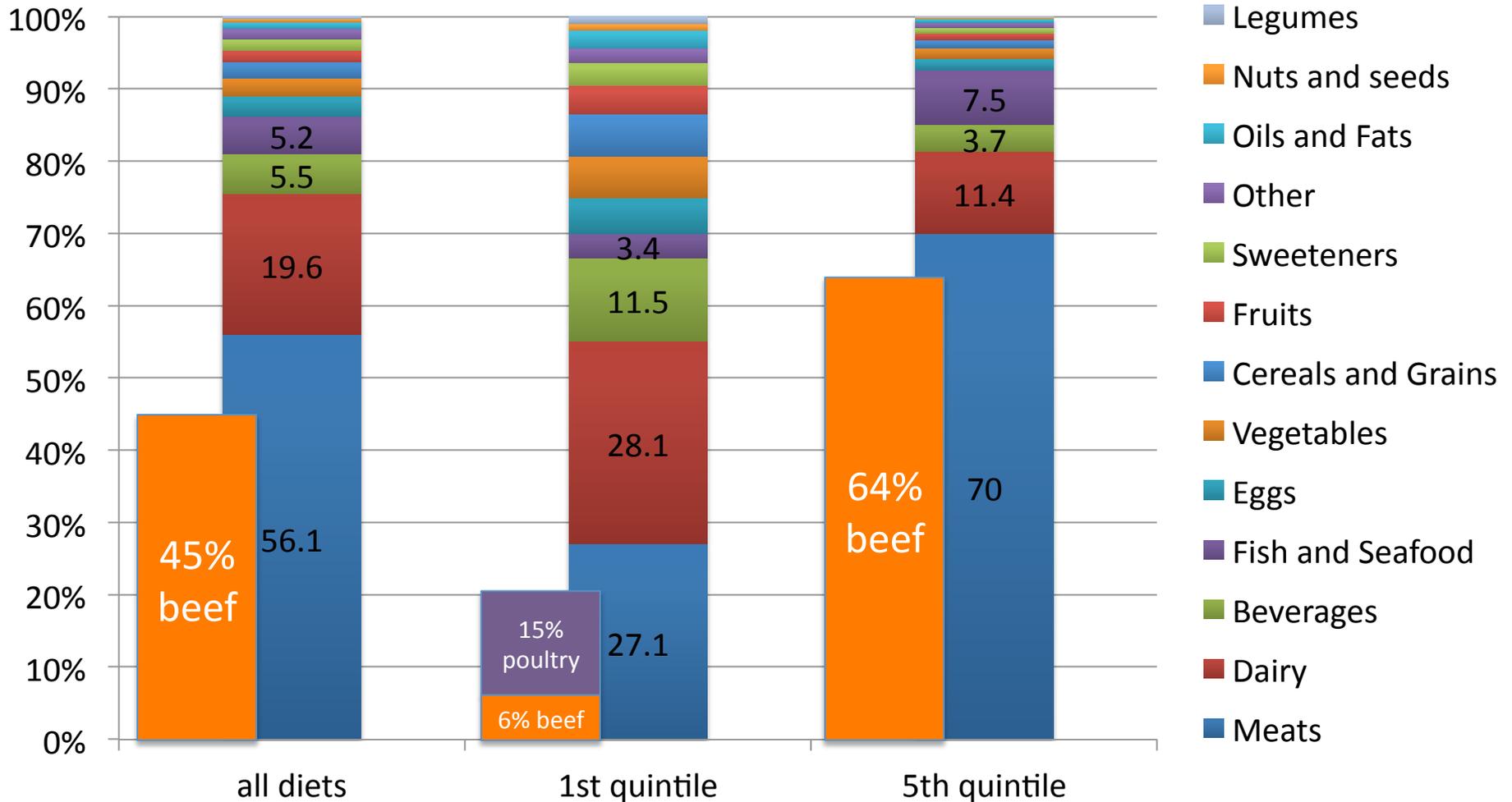


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Caveats

- Only considering farm gate impacts
 - Including food processing and packaging would increase average carbon footprint an estimated 27%
 - Transportation adds ~ another 5%
- Food production emission factors are not U.S. specific (data not currently available)
- Based on 1-day diets, so distributions more dispersed than usual diets