IHME

Mapping Food Supply and Demand:

Data Inputs, Metrics and Measures

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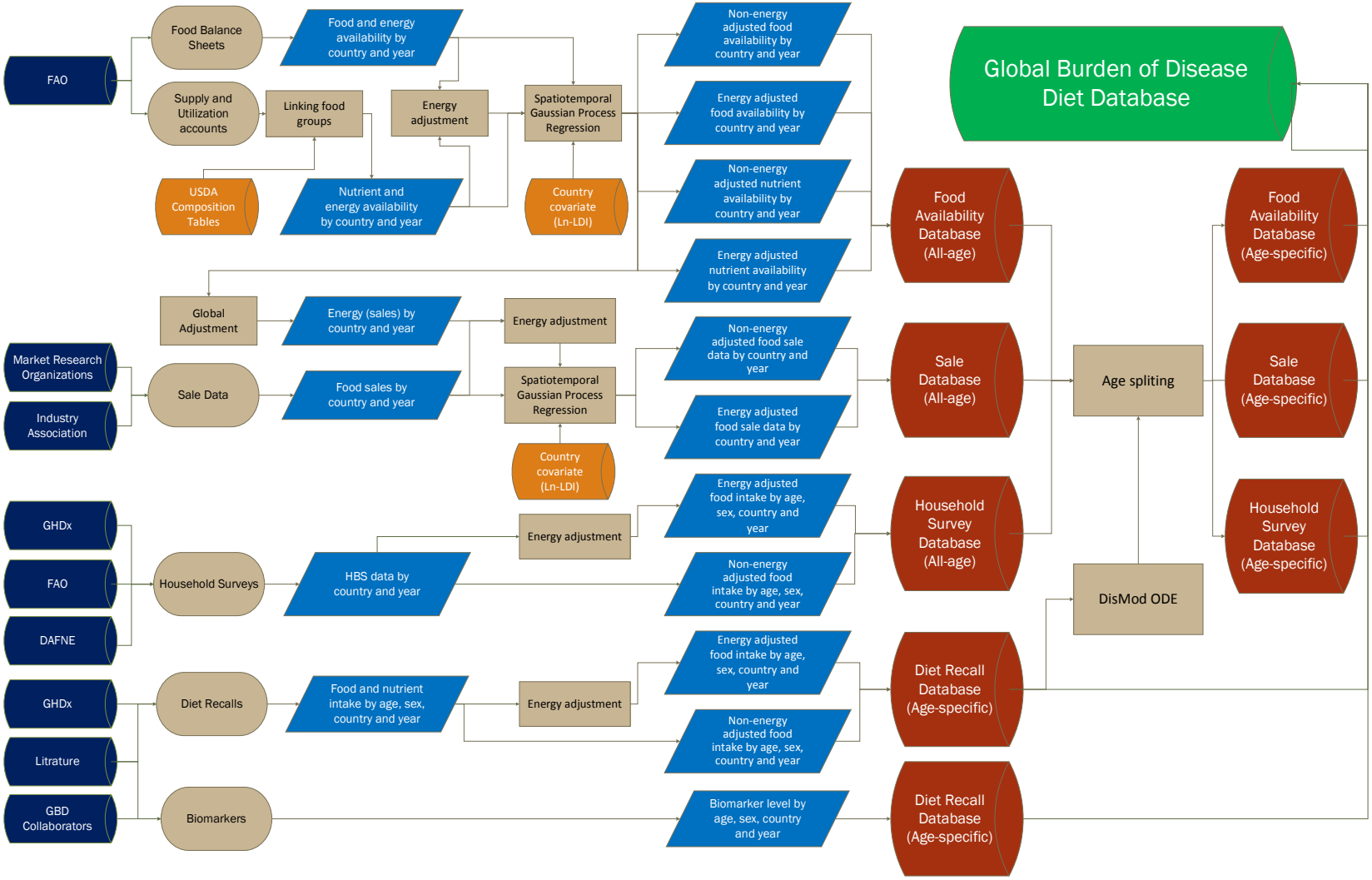
Data landscape for food system

- Data availability: limited and scattered
- Data accessibility: not all data in the public domain
- Data consistency: inconsistent across countries and sources
  - Inconsistencies within countries and across domains
  - Incomparable across sources
  - No vertical integration: no links between agriculture and nutrition/health, no food systems approach in data collection

Applying lessons learned from health system to food system

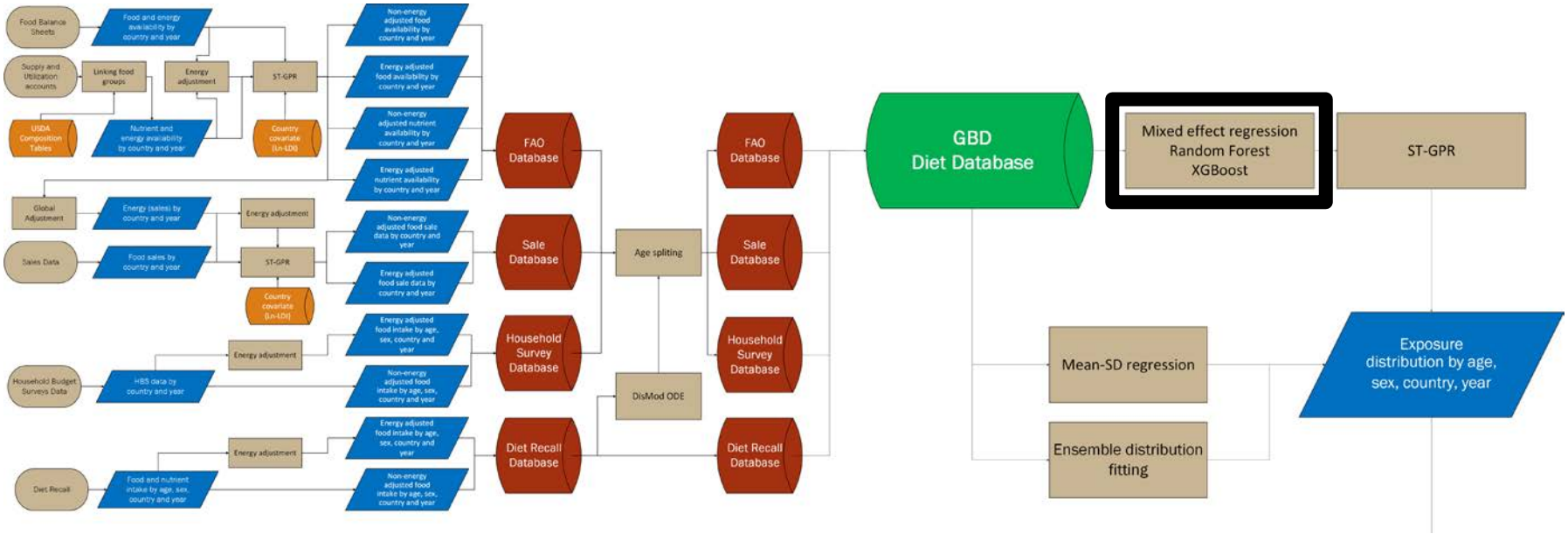
- Systematic identification of all relevant data sources
- Standardizing data across various sources (crosswalking) and correcting data for known errors
- Estimating all quantities of interest in all time periods and communicating uncertainty level for each quantity
- Ensuring internal consistency
- Harnessing new data sources and new data processing methods to improve and update existing estimates


Global Burden of Disease Diet Database
FAO
Food Balance Sheets
Food and energy availability by country and year
Supply and Utilization accounts
Linking food groups
Energy adjustment
Spatiotemporal Gaussian Process Regression
USDA Composition Tables
Nutrient and energy availability by country and year
Country covariate (Ln-LDI)
Non-energy adjusted food availability by country and year
Energy adjusted food availability by country and year
Non-energy adjusted nutrient availability by country and year
Energy adjusted nutrient availability by country and year
Food Availability Database (All-age)
Food Availability Database (Age-specific)
Global Adjustment
Energy (sales) by country and year
Energy adjustment
Market Research Organizations
Industry Association
Sale Data
Food sales by country and year
Spatiotemporal Gaussian Process Regression
Country covariate (Ln-LDI)
Non-energy adjusted food sale data by country and year
Energy adjusted food sale data by country and year
Sale Database (All-age)
Sale Database (Age-specific)
Age spliting
GHDx
FAO
DAFNE
Household Surveys
HBS data by country and year
Energy adjustment
Energy adjusted food intake by age, sex, country and year
Non-energy adjusted food intake by age, sex, country and year
Household Survey Database (All-age)
Household Survey Database (Age-specific)
DisMod ODE
GHDx
Litrature
GBD Collaborators
Diet Recalls
Biomarkers
Food and nutrient intake by age, sex, country and year
Energy adjustment
Energy adjusted food intake by age, sex, country and year
Non-energy adjusted food intake by age, sex, country and year
Biomarker level by age, sex, country and year
Diet Recall Database (Age-specific)
Diet Recall Database (Age-specific)

Strengths and limitation of each diet data source

Data Type	Food waste (Retail)	Food waste (Consumer)	Time trend (Overall)	Time Trend (Recent)	Coverage (National)	Coverage (Subnational)	Demographic Information	Total Intake	Measurement Error
FAO Supply/Utilization Accounts	●	●	●		●				●
Sales		●		●	●	●			●
Household Budget Surveys		●	●		●	●			●
Food Frequency Questionnaires			●	●	●		●		●
24-hour Dietary Recall					●		●	●	●
Biomarkers							●		●

Dietary risk factor exposure estimation



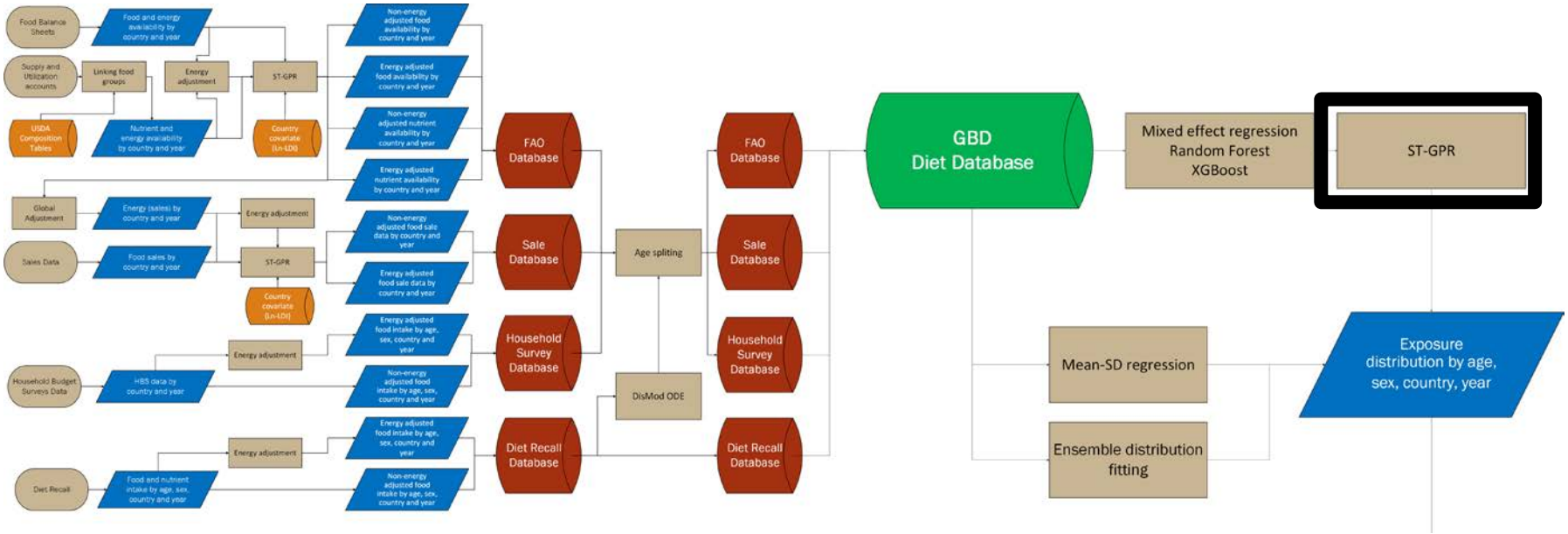
Adjustment of dietary data

- Linear, mixed-effects regression fit using location-year-age-sex matched data between FAO and our Gold Standard data
  - $Intake_{c,a,s,t} = \beta * Availability_{c,a,s,t} + age + sex + \alpha_{super-region}$
- Same dataset is used to train a Random Forest model
  - Included parameters: age, sex, super region, data type
- Same dataset is used to train a XGBoost model
  - Included parameters: age, sex, super region, data type

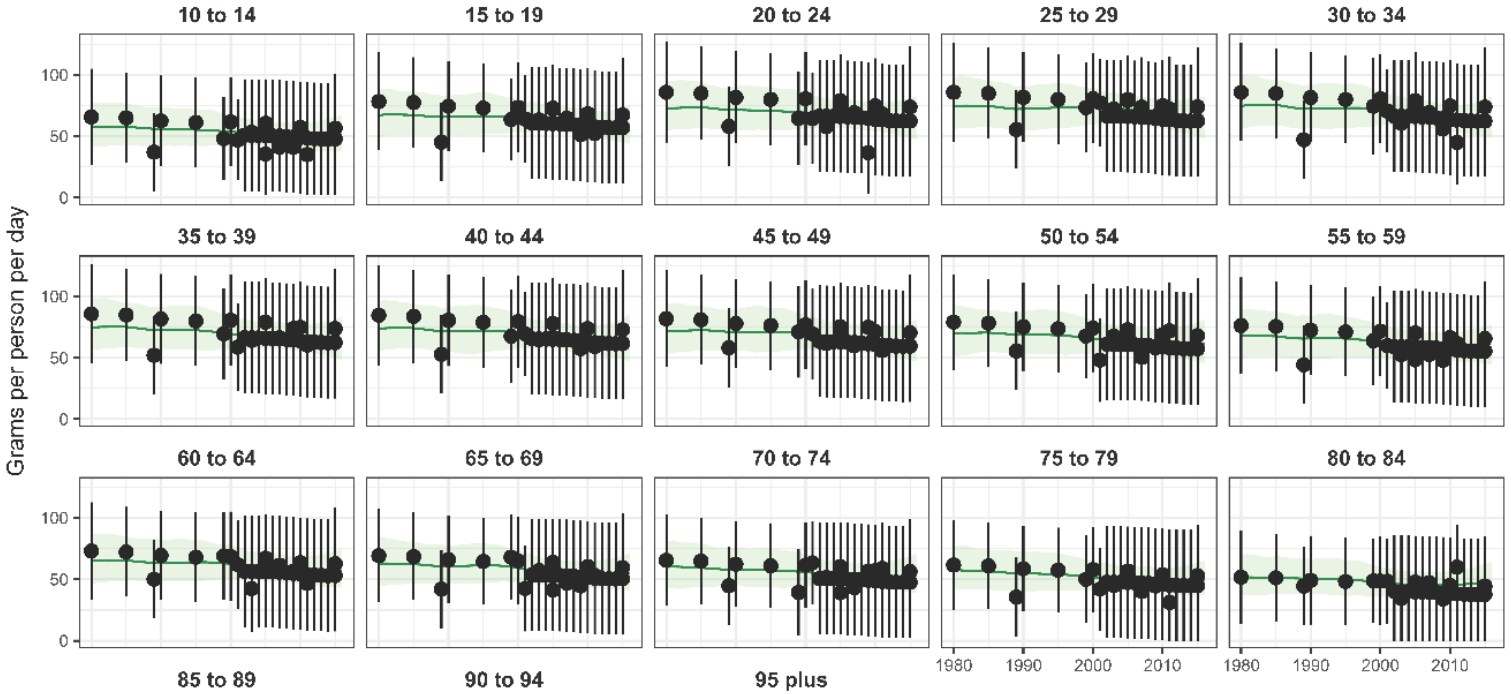
Comparative performance of models (vegetables)

Linear, Mixed Effects		Random Forest		XGBoost	
Correlation:	0.45	Correlation:	0.95	Correlation:	0.92
OOS RMSE:	85.74	OOS RMSE:	38.06	OOS RMSE:	39.14

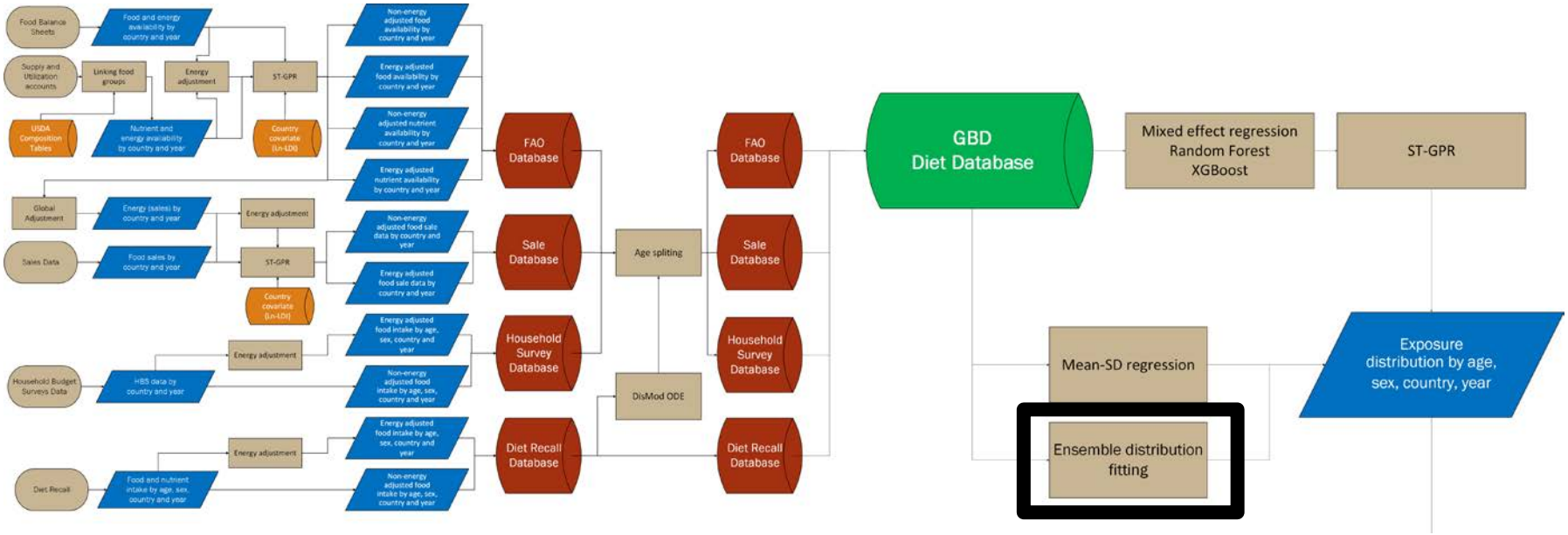
Dietary risk factor exposure estimation



Spatiotemporal Gaussian process regression model for red meat (g/day)

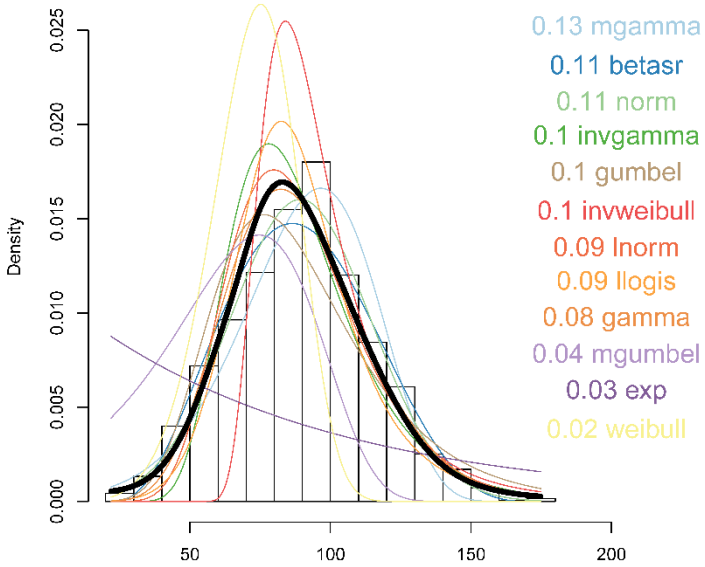


Dietary risk factor exposure estimation

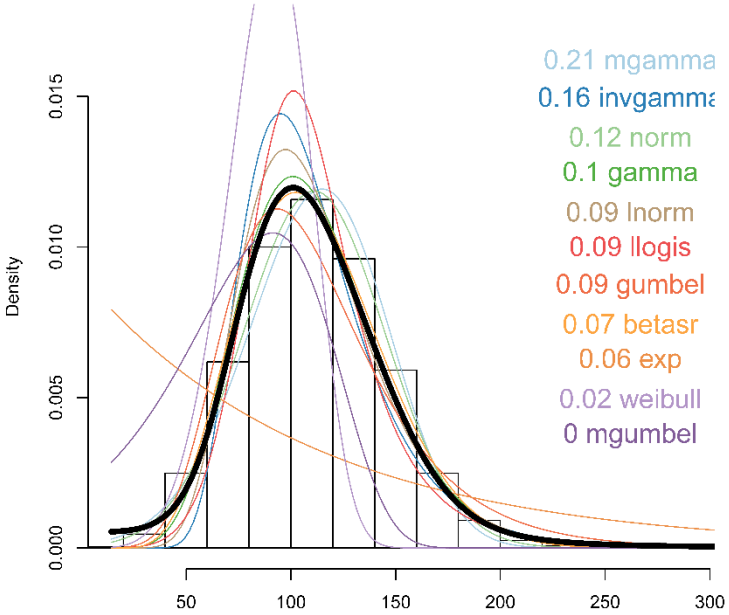


Characterizing the dietary intake at the population level

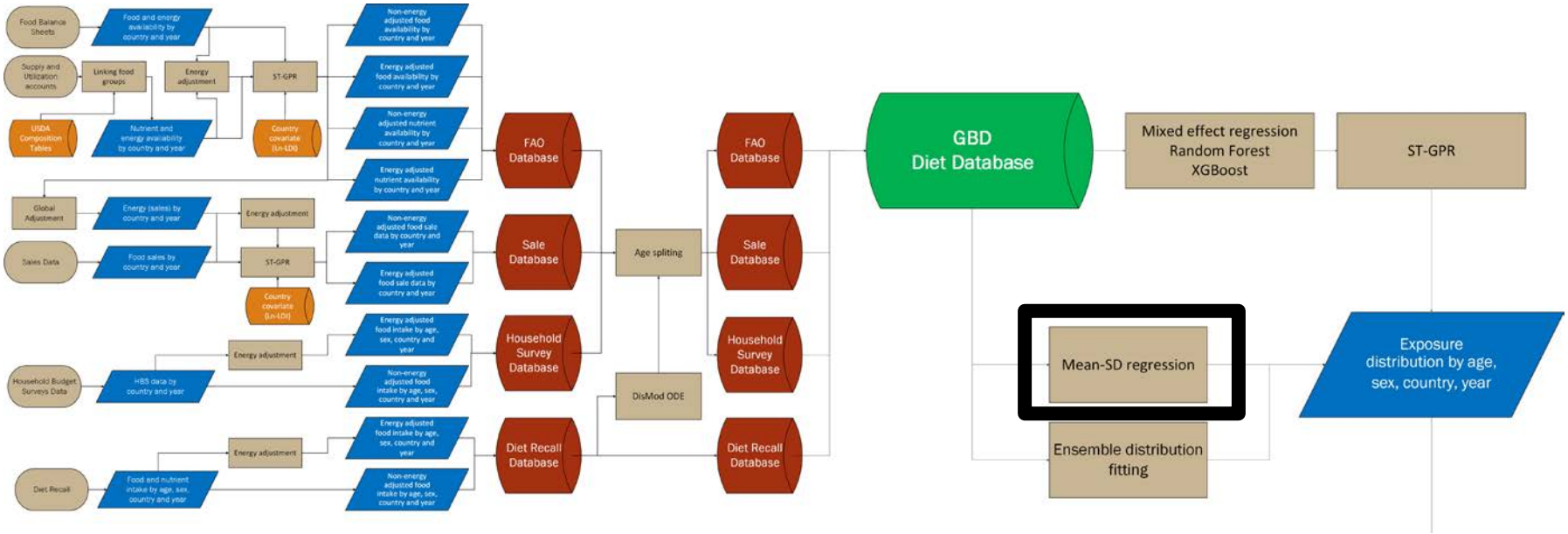
Legumes



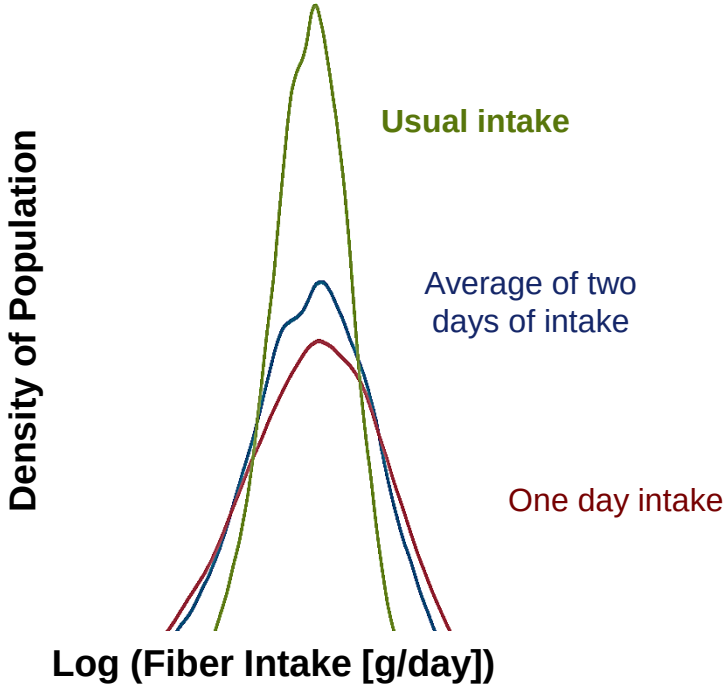
Vegetables



Dietary risk factor exposure estimation

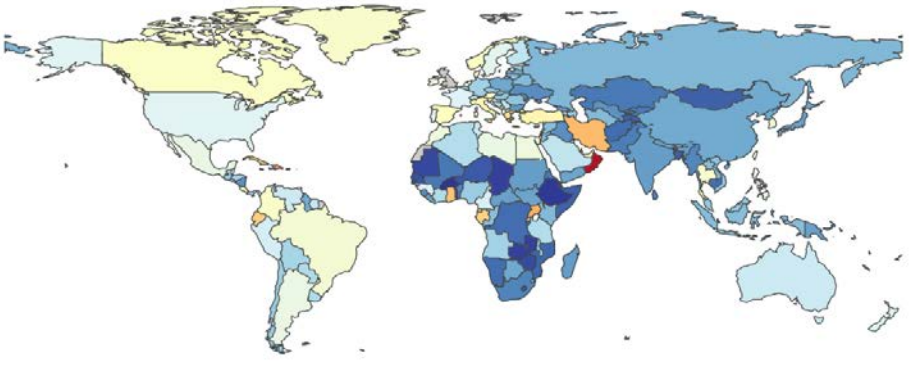


Characterizing the usual dietary intake at the population level



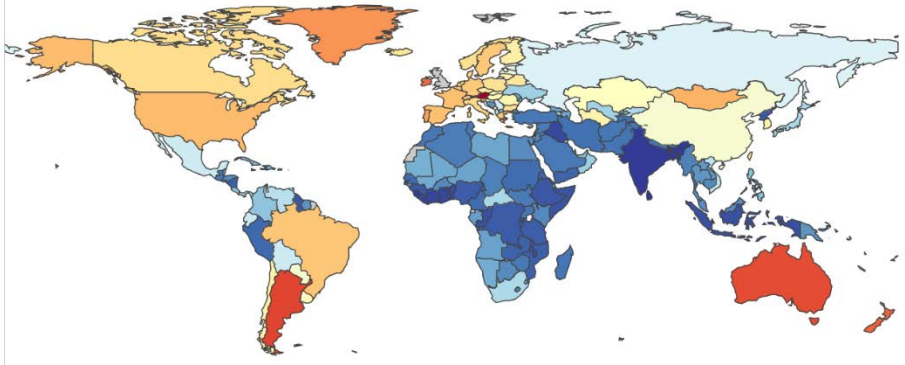
Current intake vs. recommended intake

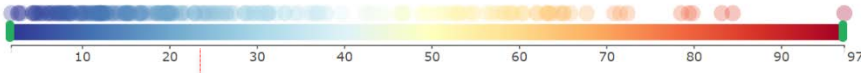
Fruit intake (g/d) in 2017
Male (45-49y)



Recommended intake

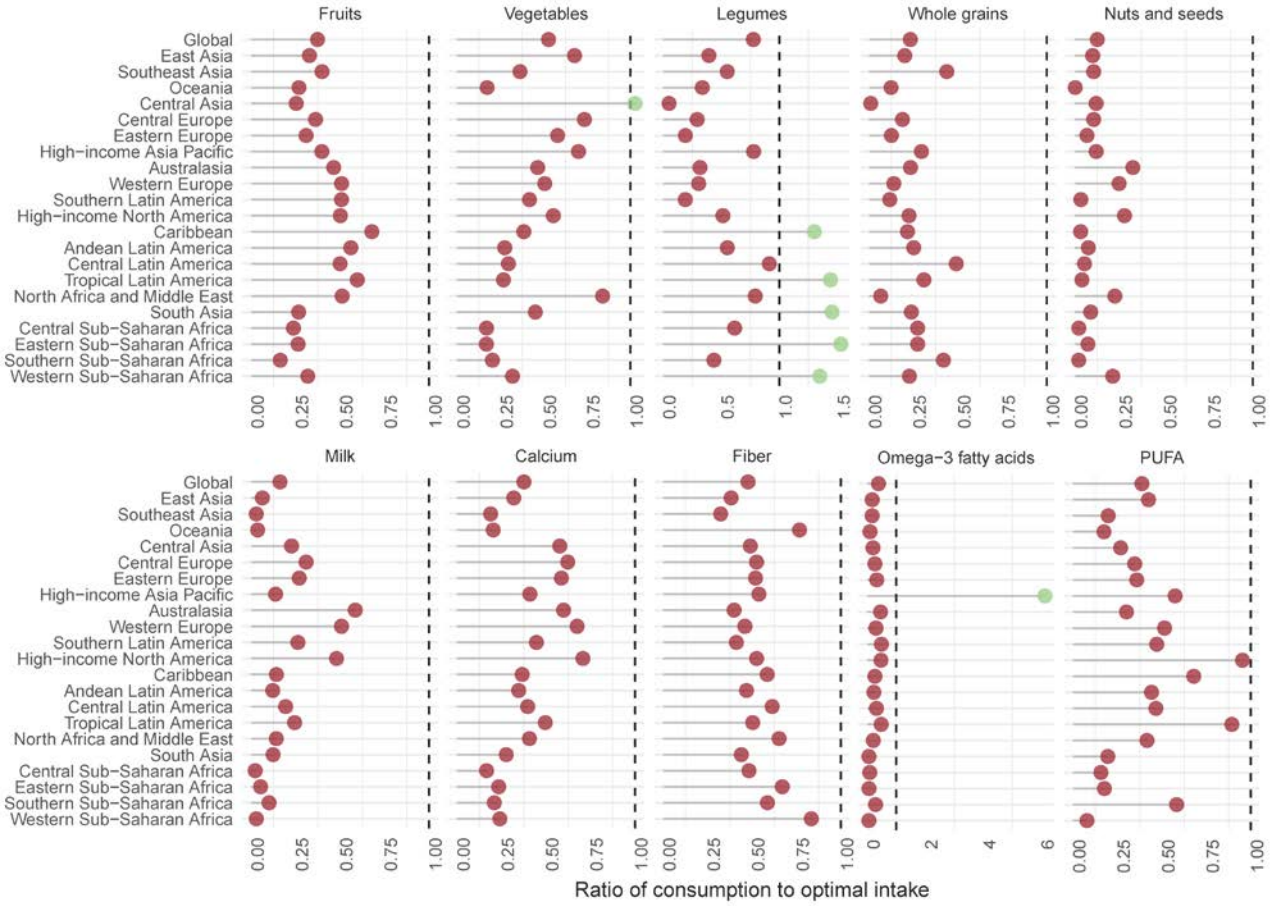
Red meat intake (g/d) in 2017
Male (45-49y)



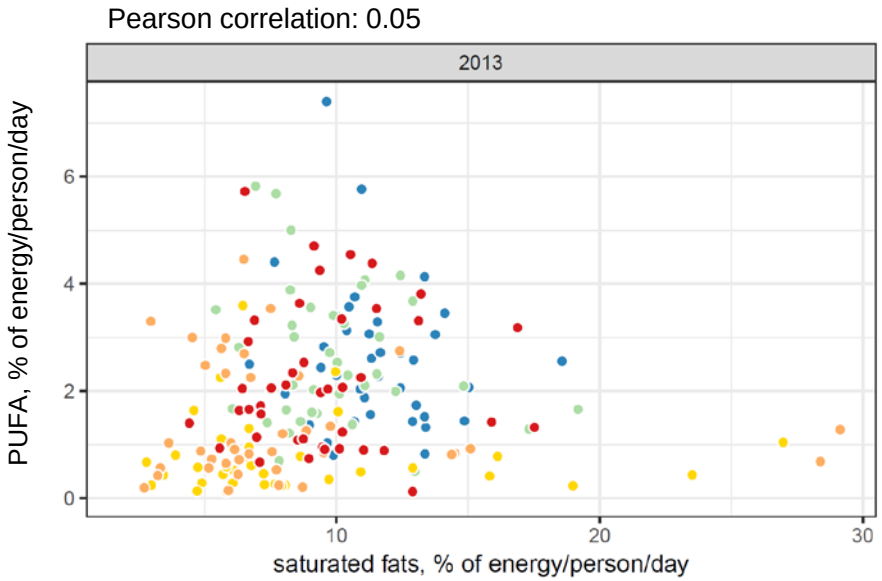


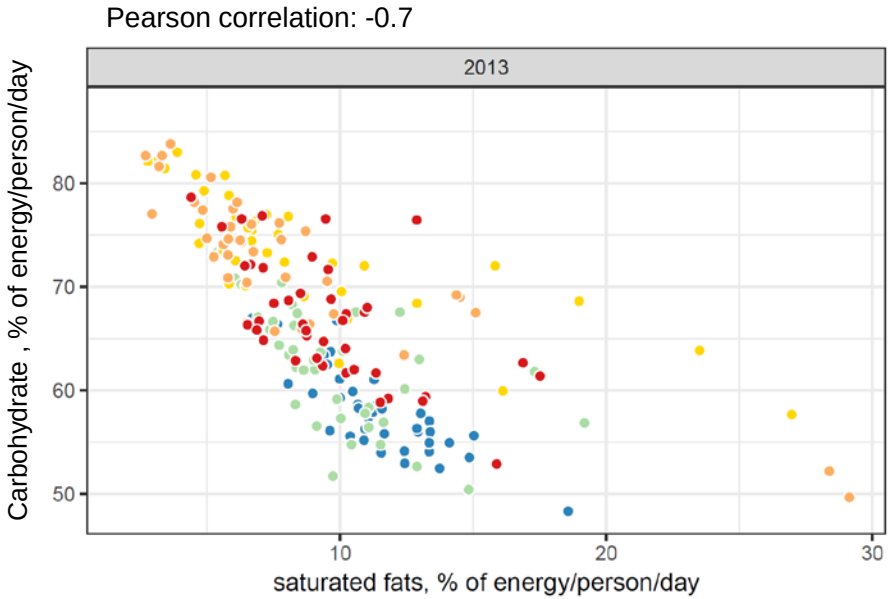
Recommended intake

Current intake vs. recommended intake



Macronutrient replacement





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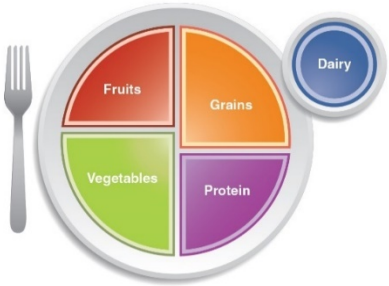
Other challenges in measuring human diet

Defining diet

Nutrients	Foods	Dietary patterns
		
Biological mechanism	No biological knowledge	Intercorrelations not a problem
Statistical Power	No food composition data needed	Between-food interactions
Supplementation	Use in dietary advice	

Absolute Intake



Diet Composition

Epidemiologic evidence supporting causality between dietary risk-outcome pairs

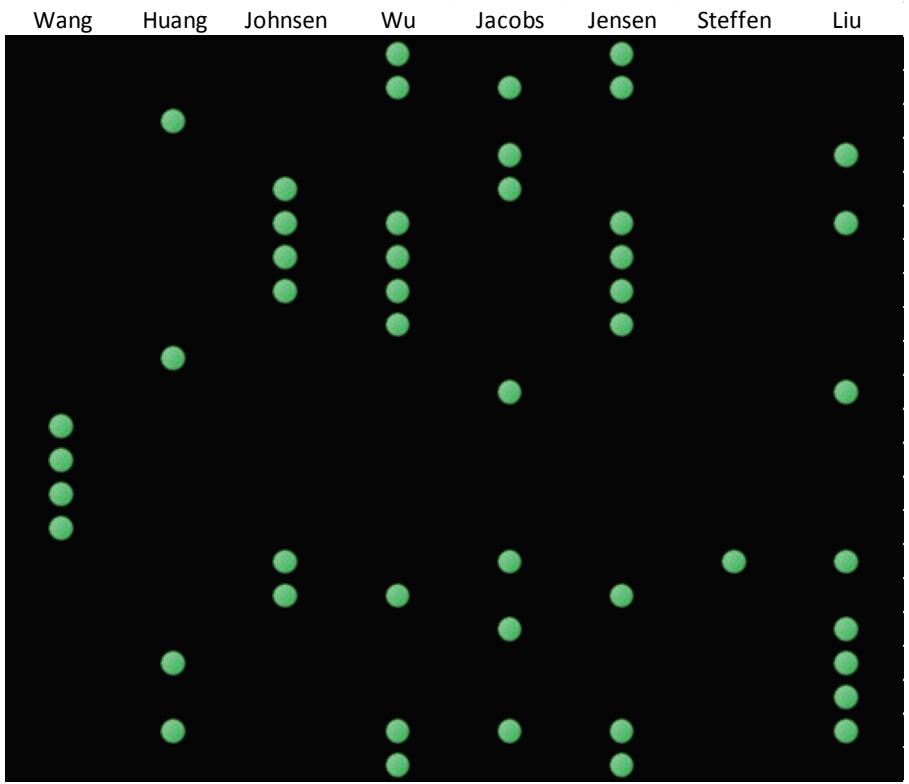
Risk	Outcome	RCTs (Number)	RCTs with significant effect in the opposite direction (%)	RCTs with null findings (%)	Prospective observational studies (Number)	Prospective observational studies with significant	Lower limit of RR > 1.5	Dose-response relationship	Biologic plausibility	Analogy
Diet low in fruits	Lip and oral cavity cancer	0	-	-	2	0	🔴	🟢	🟢	🟢
Diet low in fruits	Nasopharynx cancer	0	-	-	2	0	🔴	🟢	🟢	🟢
Diet low in fruits	Other pharynx cancer	0	-	-	2	0	🔴	🟢	🟢	🟢
Diet low in fruits	Larynx cancer	0	-	-	2	0	🔴	🟢	🟢	🟢
Diet low in fruits	Oesophageal cancer	0	-	-	5	0	🔴	🟢	🟢	🟢
Diet low in fruits	Tracheal, bronchus, and lung cancer	0	-	-	22	0	🔴	🟢	🟢	🟢
Diet low in fruits	Ischaemic heart disease	0	-	-	9	0	🔴	🟢	🟢	🟢
Diet low in fruits	Ischaemic stroke	0	-	-	9	0	🔴	🟢	🟢	🟢
Diet low in fruits	Hemorrhagic stroke	0	-	-	5	0	🔴	🟢	🟢	🟢
Diet low in fruits	Diabetes mellitus	0	-	-	9	0	🔴	🟢	🟢	🔴
Diet low in vegetables	Oesophageal cancer	0	-	-	5	0	🔴	🟢	🟢	🔴
Diet low in vegetables	Ischaemic heart disease	0	-	-	9	0	🔴	🟢	🟢	🟢
Diet low in vegetables	Ischaemic stroke	0	-	-	8	0	🔴	🟢	🟢	🟢
Diet low in vegetables	Hemorrhagic stroke	0	-	-	5	0	🔴	🟢	🟢	🟢
Diet low in whole grains	Ischaemic heart disease	0	-	-	7	0	🔴	🟢	🟢	🟢
Diet low in whole grains	Ischemic stroke	0	-	-	6	0	🔴	🟢	🟢	🟢
Diet low in whole grains	Hemorrhagic stroke	0	-	-	6	0	🔴	🟢	🟢	🟢
Diet low in whole grains	Diabetes mellitus	0	-	-	10	0	🔴	🟢	🟢	🔴
Diet low in nuts and seeds	Ischaemic heart disease	1	0	100	6	0	🔴	🟢	🟢	🔴
Diet low in nuts and seeds	Diabetes mellitus	1	0	100	5	0	🔴	🟢	🟢	🔴

Epidemiologic evidence supporting causality between dietary risk-outcome pairs

Risk	Outcome	RCTs (Number)	RCTs with significant effect in the opposite direction (%)	RCTs with null findings (%)	Prospective observational studies (Number)	Prospective observational studies with significant	Lower limit of RR > 1.5	Dose-response relationship	Biologic plausibility	Analogy
Diet low in milk	Colon and rectum cancer cancer	0	-	-	7	0	🔴	🟢	🟢	🔴
Diet high in red meats	Colon and rectum cancer cancer	0	-	-	8	0	🔴	🟢	🟢	🔴
Diet high in red meats	Diabetes mellitus	0	-	-	9	11	🔴	🟢	🟢	🔴
Diet high in processed meats	Colon and rectum cancer cancer	0	-	-	9	11	🔴	🟢	🟢	🔴
Diet high in processed meats	Ischaemic heart disease	0	-	-	5	0	🔴	🟢	🟢	🔴
Diet high in processed meats	Diabetes mellitus	0	-	-	8	0	🔴	🟢	🟢	🔴
Diet high in sugar sweetened beverages	Body mass index	10	0	60	22	0	-	🟢	🟢	-
Diet low in fibre	Colon and rectum cancer cancer	0	-	-	15	0	🔴	🟢	🟢	🔴
Diet low in fibre	Ischaemic heart disease	0	-	-	12	0	🔴	🟢	🟢	🔴
Diet low in calcium	Colon and rectum cancer cancer	0	-	-	13	0	🔴	🟢	🟢	🔴
Diet low in seafood omega-3 fatty acids	Ischaemic heart disease	17	0	94	16	0	🔴	🟢	🟢	🔴
Diet low in polyunsaturated fatty acids	Ischaemic heart disease	8	0	75	11	0	🔴	🟢	🟢	🔴
Diet high in trans fatty acids	Ischaemic heart disease	0	-	-	4	0	🔴	🟢	🟢	🔴
Diet high in sodium	Systolic blood pressure	45	0	73	-	-	-	🟢	🟢	-
Diet high in sodium	Stomach cancer	0	-	-	3	0	🔴	🟢	🟢	🔴

Definition of dietary factors

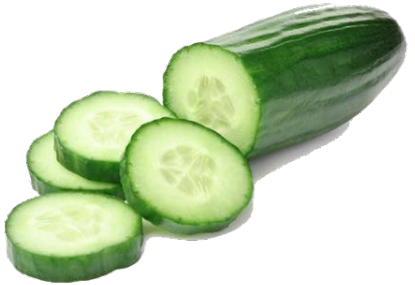
added bran
added wheat germ
bagels
bran
breakfast cereals
brown rice
brown rice flour
buckwheat
bulgur
cooked cereal
cooked oatmeal
corn meal dumplings
corn meal flat cakes
corn meal porridge
corn meal steamed bread
non-white bread
oats
other grains
pancakes
pizza
popcorn
psyllium



Classification of food groups

Fruits

?



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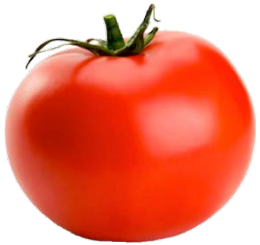

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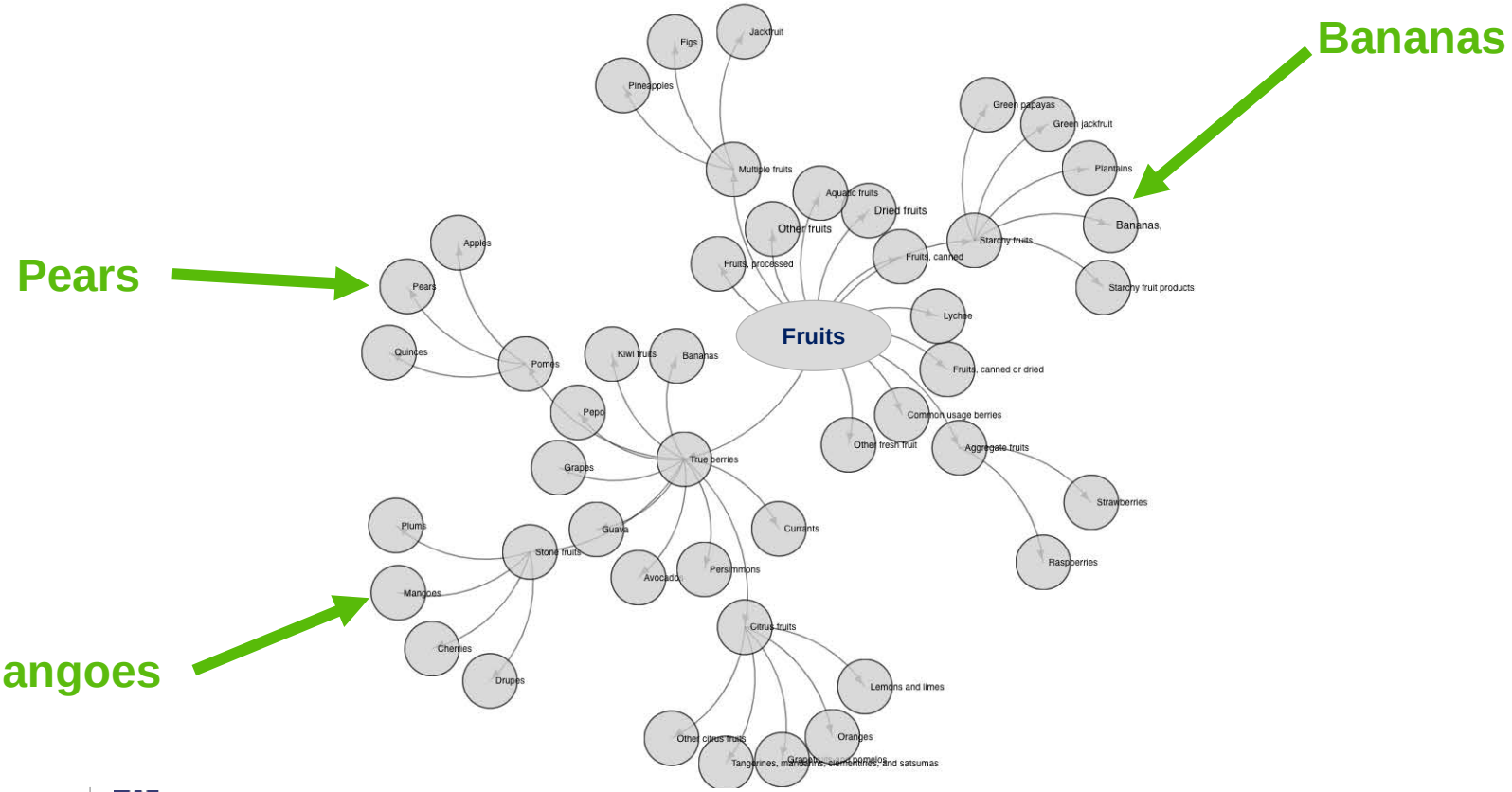
Classification of food groups

Tree nuts

Peanuts (legumes)

Nutrient Profile (100g)			
Nutrients	**Peanut butter**	**Peanuts**	**Walnuts**
Energy(kcal)	590	570	654
Protein(g)	24	26	15
Total fat(g)	50	50	65
Carbohydrate(g)	22	16	14
Fiber(g)	7	10	7
Magnesium(mg)	159	388	158

GBD food hierarchy and classification



Serving size: a special consideration for FFQs

- A unique challenge presented by food frequency questionnaires is the presentation in the form of servings consumed by the individual

Response Categories:			
	>6 per day (A)	1 per day (D)	1 per week (G)
	4-6 per day (B)	5-6 per week (E)	1-3 per month (H)
	2-3 per day (C)	2-4 per week (F)	Almost Never (I)

B. [RC 1] FRUITS

"In the past year, how often on average did you consume..."

9. Fresh apples or pears; 1 ..... ☐

10. Oranges; 1 ..... ☐

11. Orange or grapefruit juice; small glass ..... ☐

12. Peaches, apricots or plums; 1 fresh or 1/2 c. canned or dried ..... ☐

13. Bananas; 1 ..... ☐

14. Other fruits; 1 fresh or 1/2 c. canned, including fruit cocktail ..... ☐

C. [RC 1] VEGETABLES -- Portion is 1/2 c.

"In the past year, how often on average did you consume..."

15. String beans or green beans; 1/2 c. ..... ☐

16. Broccoli; 1/2 c. ..... ☐

Dietary unit conversion

- In order to make this data usable in our analyses, a method is needed to convert from **servings** → **grams**
  - Servings can be reported as an item amount, mass, volume, or arbitrary units

- **1 apple = ??**

Easy

Unit conversion database

- Have to start somewhere… 

Dietary unit conversion

- In order to make this data usable in our analyses, a method is needed to convert from **servings** → **grams**
  - Servings can be reported as an item amount, mass, volume, or arbitrary units

- **1 apple = 182 grams?** **Easy**

Dietary unit conversion

- In order to make this data usable in our analyses, a method is needed to convert from **servings** → **grams**
  - Servings can be reported as an item amount, mass, volume, or arbitrary units

- **1 apple = 182 grams?** **Easy**
- **0.5 cup broccoli = 45 grams?** **A bit harder**

Dietary unit conversion

- In order to make this data usable in our analyses, a method is needed to convert from **servings** → **grams**
  - Servings can be reported as an item amount, mass, volume, or arbitrary units

- **1 apple = 182 grams?** **Easy**
- **0.5 cup broccoli = 45 grams?** **A bit harder**
- **1 pat of butter = ??** **Arbitrary**

Dietary unit conversion

- In order to make this data usable in our analyses, a method is needed to convert from **servings** → **grams**
  - Servings can be reported as an item amount, mass, volume, or arbitrary units

- **1 apple = 182 grams?** **Easy**
- **0.5 cup broccoli = 45 grams?** **A bit harder**
- **1 pat of butter = 6 grams?** **Arbitrary**

Our expanded unit conversion database

- USDA Food Composition Database contains data on ~8,800 food items
  - **Is this a fair assumption for serving sizes of food across populations?**

Our expanded unit conversion database

- USDA Food Composition Database contains data on ~8,800 food items
  - We are continually extracting all information on serving size as it provided with questionnaires.

Salmon

Serving	Weight	Source
3-4 oz	98 grams	USDA
1 can	140 grams	Framingham
0.5 fillet	154 grams	ARIC

Summary

1. Dietary data are far from being optimal
2. Multiple lines of evidence show that diet is an important risk factor for the health of people and planet
3. We cannot wait for perfect data in order to make decision about diet. Decisions have to be made now.
4. Methods have been developed the make the best use of current dietary data in order to characterize the human diet and inform decision making
5. New data sources and new data processing methods should be harnessed as they become available to improve and update existing dietary estimates

Acknowledgment

3000+ GBD Collaborators