Data Science Initiative for Africa (DSI-Africa)

Climate Change, Food Systems and Planetary Health

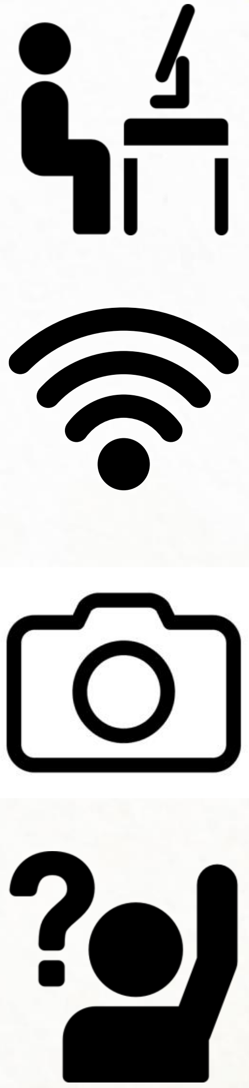
24 July 2024

Ina Danquah

Optimal learning atmosphere

For the online course, …

- Be seated in a quiet working environment
- Ensure stable internet access
- Keep on your cameras whenever possible
- Raise your (digital) hand when you have a question



Learning objectives

Week 1:

- Familiarizing with the course program and getting to know each other
- **Statistical approaches to identifying climate change impacts** on agriculture, **diet and nutrition**, including basic constructs of food system metrics
- Adaptive planning using data science and technology

Week 2:

- Refreshing epidemiology with a focus on food systems
- Operationalize sustainable nutrition using anthropometry, dietary patterns, and yield estimates
- Calculate constructs of sustainable nutrition and agriculture, incl. remote sensing

WASHA TAKWIMU
WORKING ON APPLICATIONS FOR DATA SCIENCE AND HEALTH IN AFRICA

Outline

Day	Week 1, 22 – 26 July (online)	Facilitator
Mon	Exploratory spatial analysis and model evaluation Reading: Rainfall patterns related to dietary habits	G Kallah-Dagadu Students
Tue	Hackathon: Climate Change solutions in your country Theoretical concepts: Climate change impacts on nutrition and diets Practical: Calculate rainfall pattern related to dietary habits Theoretical concepts: Nutrition and food systems	G Kallah-Dagadu I Danquah I Danquah I Madzorera
Wed	Hackathon: Climate change solutions in your country Theoretical concepts: Dietary pattern construction Calculation of food system metrics	G Kallah-Dagadu I Danquah I Madzorera
Thu	Technological innovations for sustainable agriculture Trends, scenarios and resilience planning	S Barteit S Barteit
Fri	Hackathon presentations Heat-2-Harvest project	Students S Barteit

Concepts of dietary pattern construction

- Recap rainfall pattern derivation
- Why dietary pattern construction?
- Types of dietary pattern construction
  - Exploratory (a posteriori)
  - Hypothesis-based (a priori)
  - Hybrid methods
- Summary
- Practical exercise: Calcuation of GDQS → Prof. Madzorera

Optional reading

- Ocké M. Evaluation of methodologies for assessing the overall diet: dietary quality scores and dietary pattern analysis. Proc Nutr Soc. 2013;72(2):191-199.
- Burggraf C, Teuber R, Brosig S, Meier T. Review of a priori dietary quality indices in relation to their construction criteria. Nutr Rev. 2018;76(10):747-764.
- Mank I et al. Dietary habits associated with growth development of children aged < 5 years in the Nouna Health and Demographic Surveillance System, Burkina Faso. Nutr J. 2020;19(1):81.
- Tanaka J, Yoshizawa K, Hirayama K, Karama M, Wanjihia V, Changoma MS, Kaneko S. Relationship between dietary patterns and stunting in preschool children: a cohort analysis from Kwale, Kenya. Public Health. 2019;173:58-68.

Practical exercise

Dimension reduction technique:

Identification of rainfall patterns explaining variations in dietary patterns among young children living in north-western Burkina Faso

(Reduced Rank Regression, RRR)

Practical exercise – Ingredients

- Literature by Mank et al. 2021

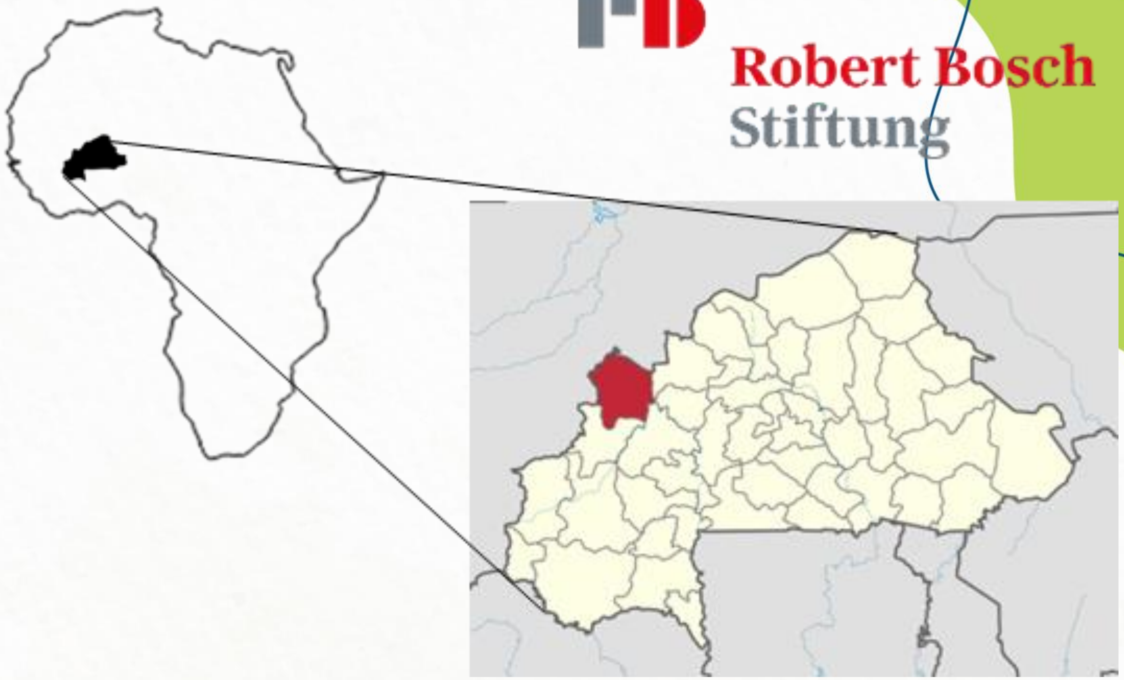
The Impact of Rainfall Variability on Diets and Undernutrition of Young Children in Rural Burkina Faso

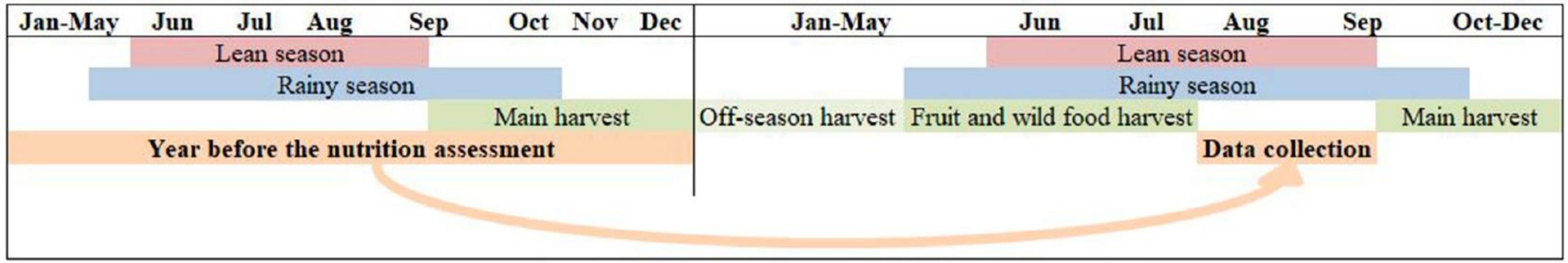
Isabel Mank[1], Kristine Belesova[2], Jan Bliefernicht[3], Issouf Traoré[4,5], Paul Wilkinson[2], Ina Danquah[1†] and Rainer Sauerborn[1†]*

- Dataset NutriClim
- Codebook NutriClim
- R code for Reduced Rank Regression

Practical exercise – Study design

- Subsistence farming
- Income per capita : 670 USD/year
- 1 rainy season
- 514 children aged <5 years
- 2 x 12 rainfall indicators
- 3 dietary pattern scores





Practical exercise – Code book

Suffixes:

- 1ybb – 1 year before birth
- yb – year of birth
- 1ybs – 1 year before survey
- ys – year of survey

Rainfall indicators: →

ID (unit)	Indicator name	Definitions
PRCPTOT (mm)	Annual total wet-day precipitation	Annual total PRCP in wet days (RR>=1mm)
PRCPano (SD)	Total precipitation anomalies	Yearly total prec. difference from the mean value
SDII (mm/day^{-1})	Simple daily intensity index	Annual total precipitation by number of wet days (PRCP>=10mm)
R10 (days)	Number of heavy precipitation days	Annual count of days when PRCP>=10mm
R20 (days)	Number of very heavy precipitation days	Annual count of days when PRCP>=20mm
R25 (days)	Number of very heavy precipitation days	Annual count of days when PRCP>=25mm
CDD (days)	Consecutive dry days	Maximum number of consecutive days with RR<1mm
CWD (days)	Consecutive wet days	Maximum number of consecutive days with RR>=1mm
R95p (mm)	Very wet days	Annual total PRCP when RR>95th percentile
R99p (mm)	Extremely wet days	Annual total PRCP when RR>99th percentile
RS_Length (Lws, days)	Duration wet season	Length of the wet season
CDD_ws (days)	Mini-drought	Max. number of consecutive dry days (RR<1 mm) during wet season

Practical exercise – Code book

Dietary pattern scores:

- DP1_diet_score – Dietary pattern score 1 (market-based diet)
- DP2_diet_score – Dietary pattern score 2 (legume-based diet)
- DP3_diet_score – Dietary pattern score 3 (vegetable-based diet)

TABLE 2 | Rotated factor loadings of food items for the three dietary patterns among 1,439 children aged <5 years in the Nouna HDSS area.

Food groups	DP1 Market-based diet	DP2 Legume-based diet	DP3 Vegetable-based diet
Pasta	**0.57***	0.24	0.10
Eggs	**0.56***	−0.07	0.05
Poultry	**0.55***	−0.03	0.09
Sweets	**0.52***	0.19	0.25
Bread	**0.49***	0.07	0.06
Beverages	**0.46***	−0.11	0.01
Rice	**0.45***	0.40	0.03
Cassava	**0.41***	0.06	−0.09
Soumbala	0.05	**0.60***	0.09
Oils and fats	−0.01	**0.57***	**0.42***
Dark green leaves	0.26	**0.46***	0.03
Peanuts	0.35	**0.41***	−0.06
Millet	−0.09	**0.41***	−0.03
Tea	0.10	**0.41***	0.02
Okra	−0.05	0.05	**0.70***
Tomatoes	0.08	−0.02	**0.66***
Eggplant	0.07	0.14	**0.64***
Maize	0.09	−0.17	**0.46***
Coffee	0.21	0.04	**0.43***
Fish	0.16	0.29	**0.42***
Meat	0.38	0.37	−0.03
Cabbage	0.37	0.13	−0.08
Cowpea beans	0.27	0.02	0.28
Animal milk	0.26	0.30	0.12
Onions	0.25	0.39	−0.09
Fruits	0.25	0.11	0.19
Couscous	0.20	0.24	0.02
Groundnuts	0.18	0.13	−0.13
Mother's milk	0.02	−0.36	−0.03
Sorghum	−0.08	0.27	0.01
Explained variance	**9.88%**	**8.28%**	**7.87%**

Food groups with factor loadings of ≥|0.40| indicate relevant contributions to the DPS.

Practical exercise – Procedures

- Read in your dataset
- Check the rainfall indicators → 2 x 12 indicators
- Check the dietary pattern scores → 3 dietary pattern scores
- Apply the RRR code to the rainfall indicators as predictor variables and dietary pattern scores as response variables

Practical exercise – Procedures

```
proc pls data=DSI_RRR method=rrr varss details;
model  DP1_diet_score DP2_diet_score DP3_diet_score
       /*3 dietary pattern scores*/=
       PRCPTOT_1ybs PRCPano_1ybs SDII_1ybs R10_1ybs R20_1ybs
R25_1ybs CDD_1ybs CWD_1ybs R95p_1ybs R99p_1ybs RS_Length_1ybs
CDD_ws_1ybs
       /*12 rainfall indicators from the year before the survey*/
       PRCPTOT_ys PRCPano_ys SDII_ys R10_ys R20_ys R25_ys CDD_ys
CWD_ys R95p_ys R99p_ys RS_Length_ys CDD_ws_ys;
       /*12 rainfall indicators from the year of the survey*/

/*response variables=predictor variables*/
output out=pattern xscore=scorex /*factor score*/
yscore=scorey /*response score*/;
run;
```

Practical exercise – Results

Table 1. Explained variation of dietary pattern scores

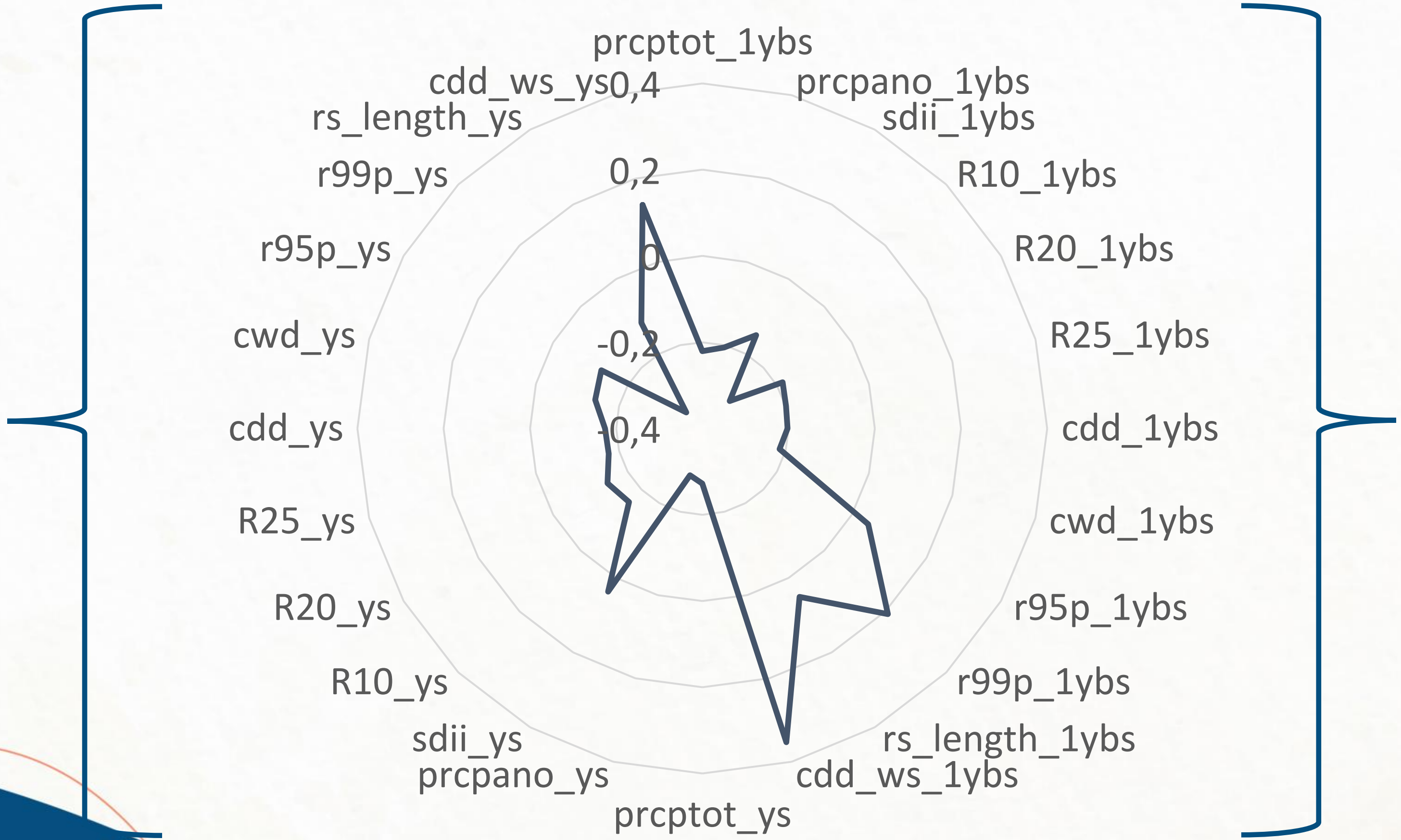
Explained variation	Dietary pattern 1	Dietary pattern 2	Dietary pattern 3
Rainfall pattern	10.62%	7.62%	24.32%

Practical exercise – Results

Table 2/Figure 1. Factor loadings of rainfall indicators

Year of

the survey



Year before

the survey

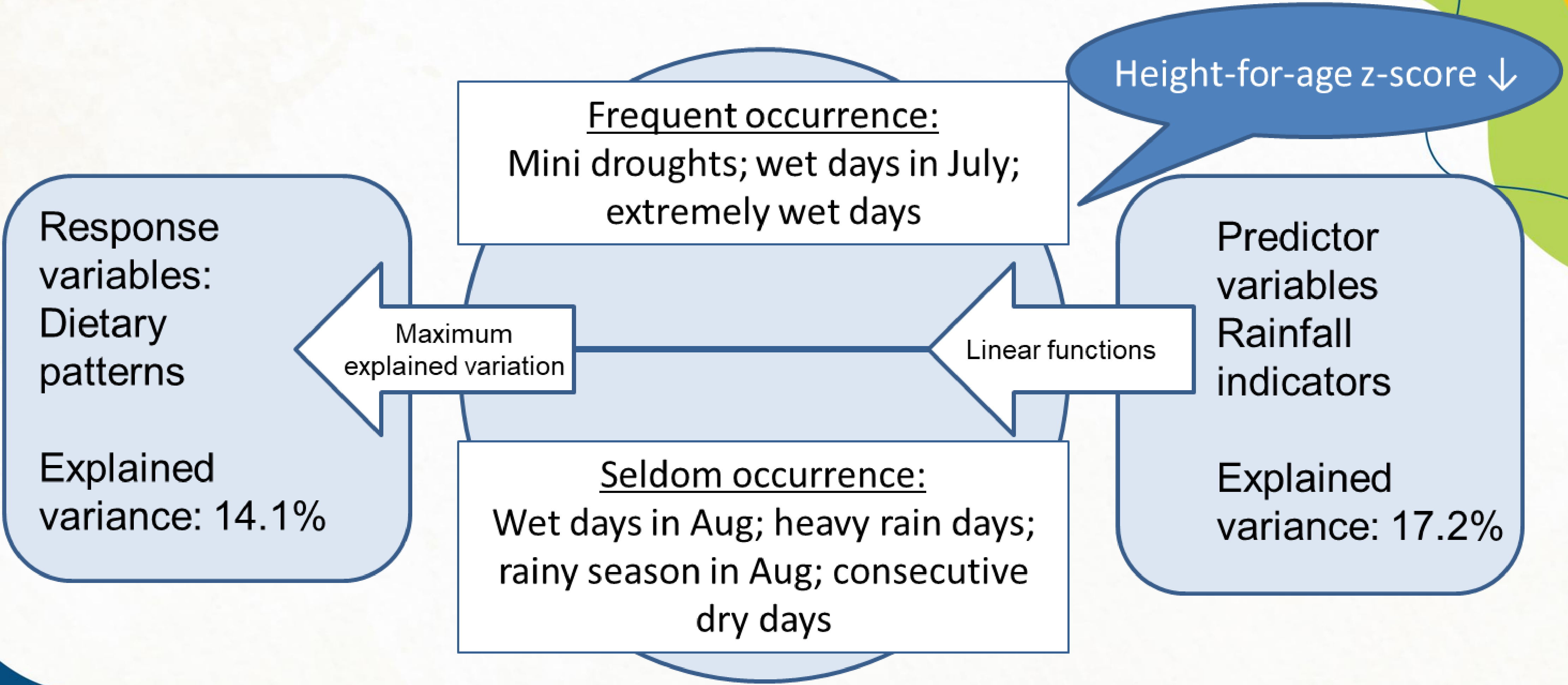
Practical exercise – Results

- Sort by factor loadings
- Flag loadings > | 0.25 |
- Characterize the precipitation/rainfall pattern

… frequent occurrence of SDII_ys and seldom occurrence of R99p_ys.

Indicator	Factor loading
r99p_ys	**-0,347597**
R10_1ybs	**-0,310293**
prcpano_ys	**-0,287625**
prcptot_ys	**-0,272661**
sdii_ys	**0,036712**
r95p_1ybs	**0,044126**
cdd_ws_1ybs	**0,353444**
prcptot_1ybs	-0,220792
cwd_1ybs	-0,214899
prcpano_1ybs	-0,205416
cdd_1ybs	-0,202145
rs_length_1ybs	0,050885
r99p_1ybs	0,208321
R25_1ybs	-0,199284
R20_1ybs	-0,185316
R25_ys	-0,174966
cdd_ys	-0,173855
R10_ys	-0,159114
sdii_1ybs	-0,150141
R20_ys	-0,145778
cwd_ys	-0,142441
r95p_ys	-0,129521
rs_length_ys	-0,117318
cdd_ws_ys	0,137093

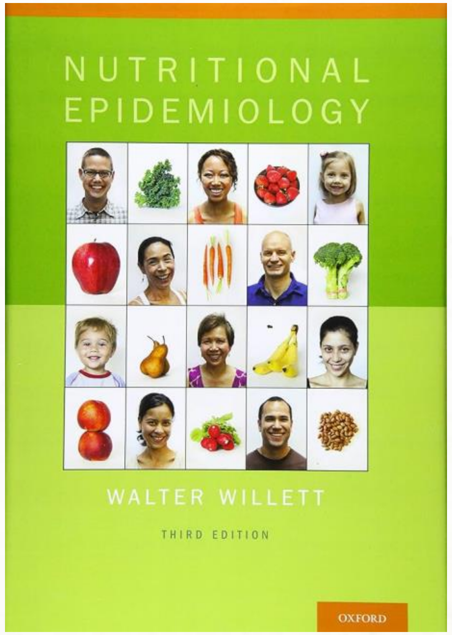
Practical exercise – Results summary



Source: Mank et al. Front Public Health 2021

Why dietary pattern analysis?

- We eat foods that deliver energy and nutrients.
- We do not eat foods in isolation.
- Nutrients interact in our body.
- Most dietary recommendations are food-based.



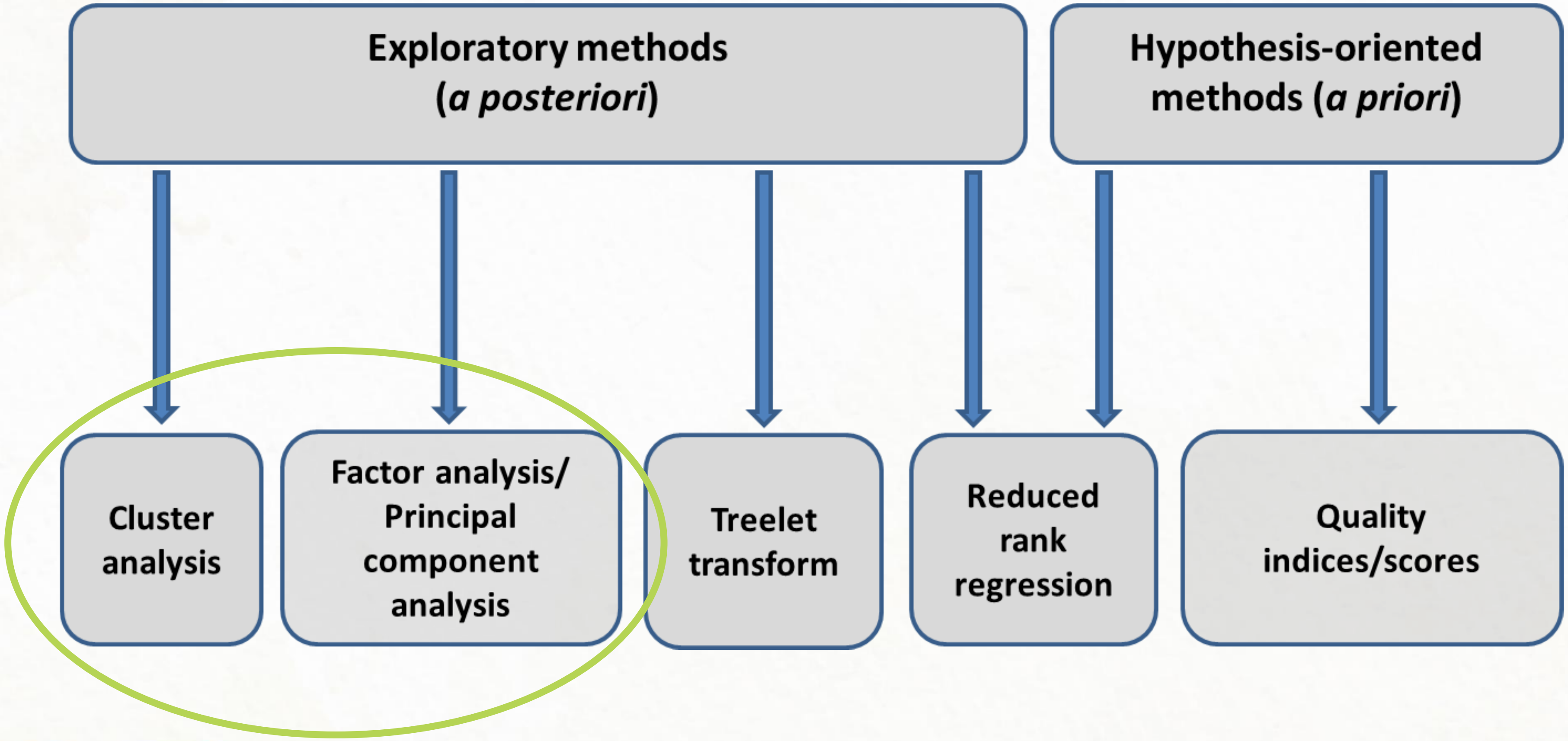
Source: Willett W. Nutritional Epidemiology. 3rd ed. 2013

Why dietary pattern analysis?

- ✓ Capture complexity
- ✓ Account for synergistic effects of nutrients
- ✓ Uncover etiologic pathways
- ✓ Transmit public health messages

Source: Willett W. Nutritional Epidemiology. 3rd ed. 2013

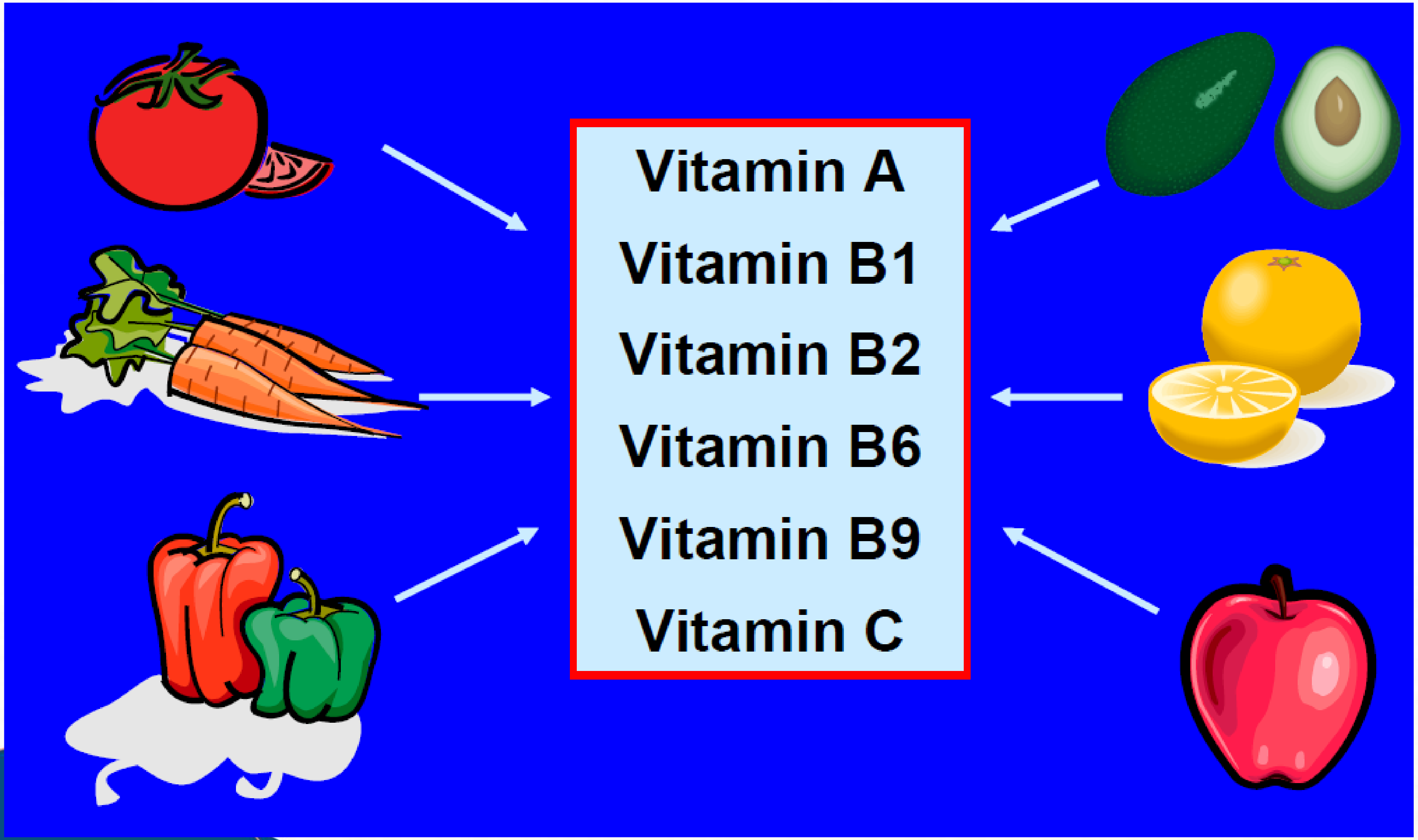
Types of dietary pattern construction



Source: Ocké. Proc Nutr Soc 2013; Schulze & Hoffmann. Br J Nutr 2006

Exploratory (a posteriori) methods

Observed variation (food groups) vs. variation of interest (nutrients)



Source: Schulze & Hoffmann. Br J Nutr 2006

Exploratory (a posteriori) methods

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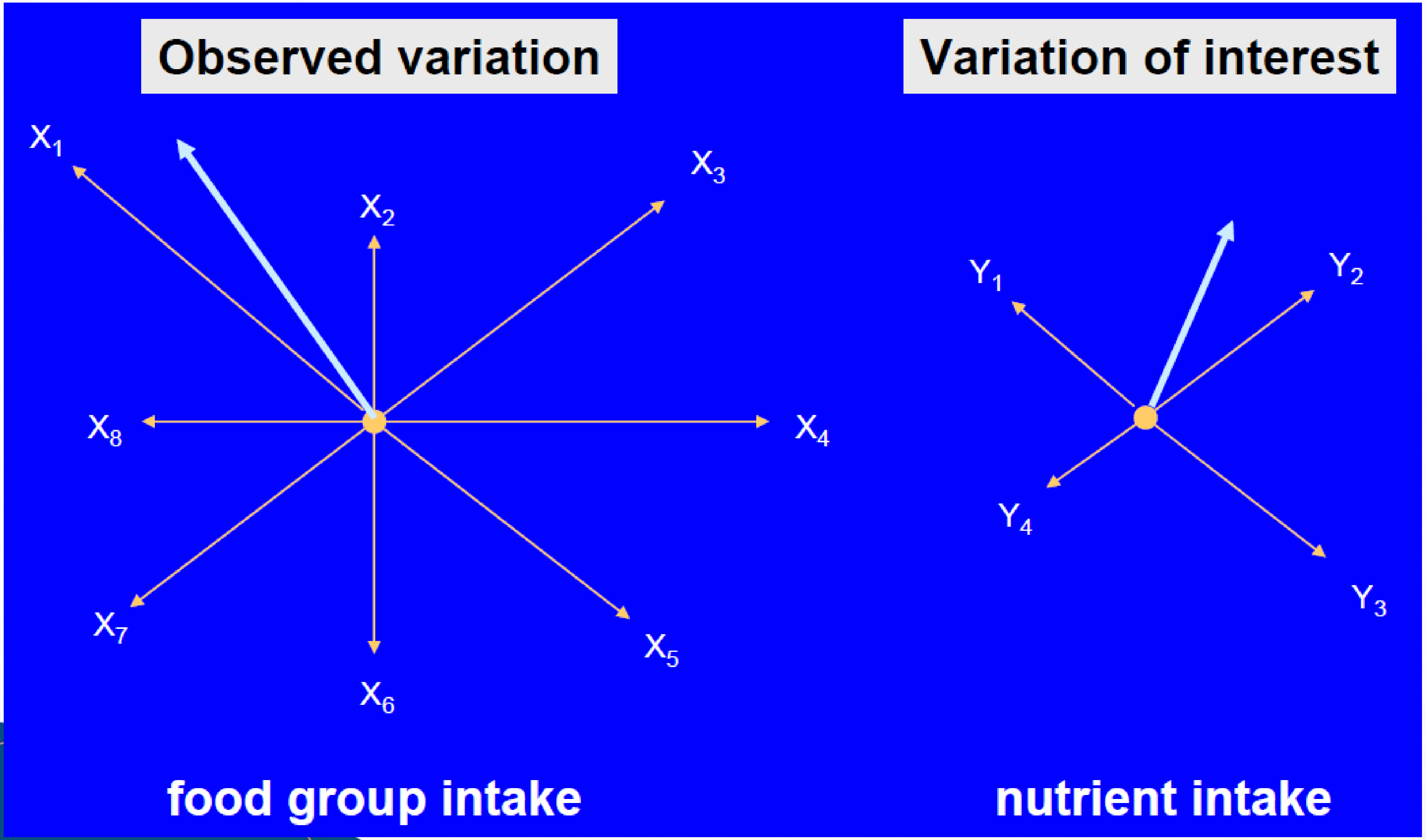
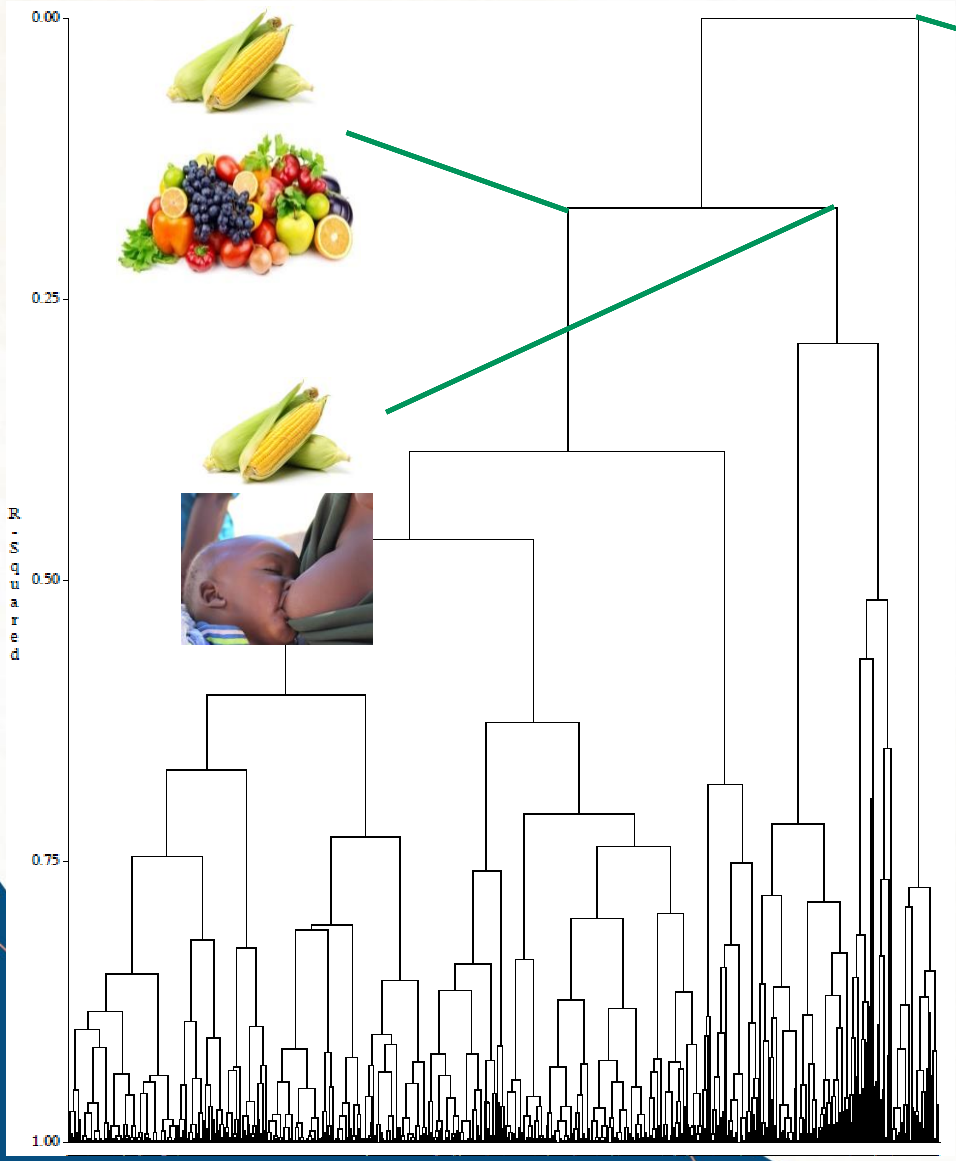


Source: Schulze & Hoffmann. Br J Nutr 2006

Cluster analysis – people who eat similarly

- Uses standardized variables for scalability
- Creation of non-overlapping subgroups
- Participants in each subgroup eat similar
- Most common: k-means
- Extraction criteria:
  - Smallest sum of squares difference between cluster solutions
  - Amount of explained variation
  - Size and interpretability of the clusters
  - Stability of clusters

Cluster analysis – people who eat similarly



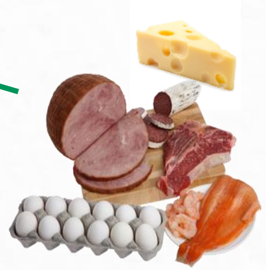


Table 3 – Mean dietary intake (g/day) for the three dietary patterns among Kenyan preschool children aged 6–59 months.

Food group	Total (n = 402)		Dietary pattern					
			Protein rich (n = 79)		Traditional (n = 221)		Traditional complemented by breast milk (n = 102)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Maize foods	307.0	191.0	280.4	137.1	369.3	206.0	192.5	124.7
Cereals	33.2	63.6	101.8	108.8	18.3	27.0	12.3	27.1
Beans	18.6	31.8	44.9	57.5	14.6	17.0	7.1	10.6
Fish	16.0	39.2	42.8	75.0	12.7	20.9	2.5	5.4
Meats	4.3	7.6	9.5	12.1	4.1	6.0	0.5	1.6
Potatoes	18.8	45.1	47.2	79.0	16.4	32.6	2.1	4.9
Fried foods	49.0	46.6	72.2	51.3	52.3	46.1	23.9	29.5
Eggs	6.4	22.2	17.1	43.3	5.2	13.1	0.8	2.2
Leafy vegetables	29.9	47.2	52.4	63.9	31.1	46.5	9.7	13.7
Other vegetables	23.3	93.3	60.2	185.1	19.9	54.4	2.1	11.3
Fruits	341.0	328.1	352.0	226.2	432.5	371.4	134.1	160.8
Nuts	0.7	3.4	2.7	7.1	0.3	1.1	0.0	0.1
Snacks	16.1	27.0	24.9	25.2	18.2	31.3	4.6	8.5
Tea	104.8	82.1	113.2	68.8	125.6	88.1	53.2	50.5
Juice	18.3	46.3	55.9	86.4	9.5	20.0	8.3	22.8
Soda	2.4	9.4	9.5	18.8	0.9	3.4	0.2	1.2
Dairy products	61.4	125.8	167.6	224.1	37.7	61.1	30.4	70.4
Average age (months)	24.1	15.3	30.1	14.8	26.1	14.2	15.2	14.2

SD, standard deviation.

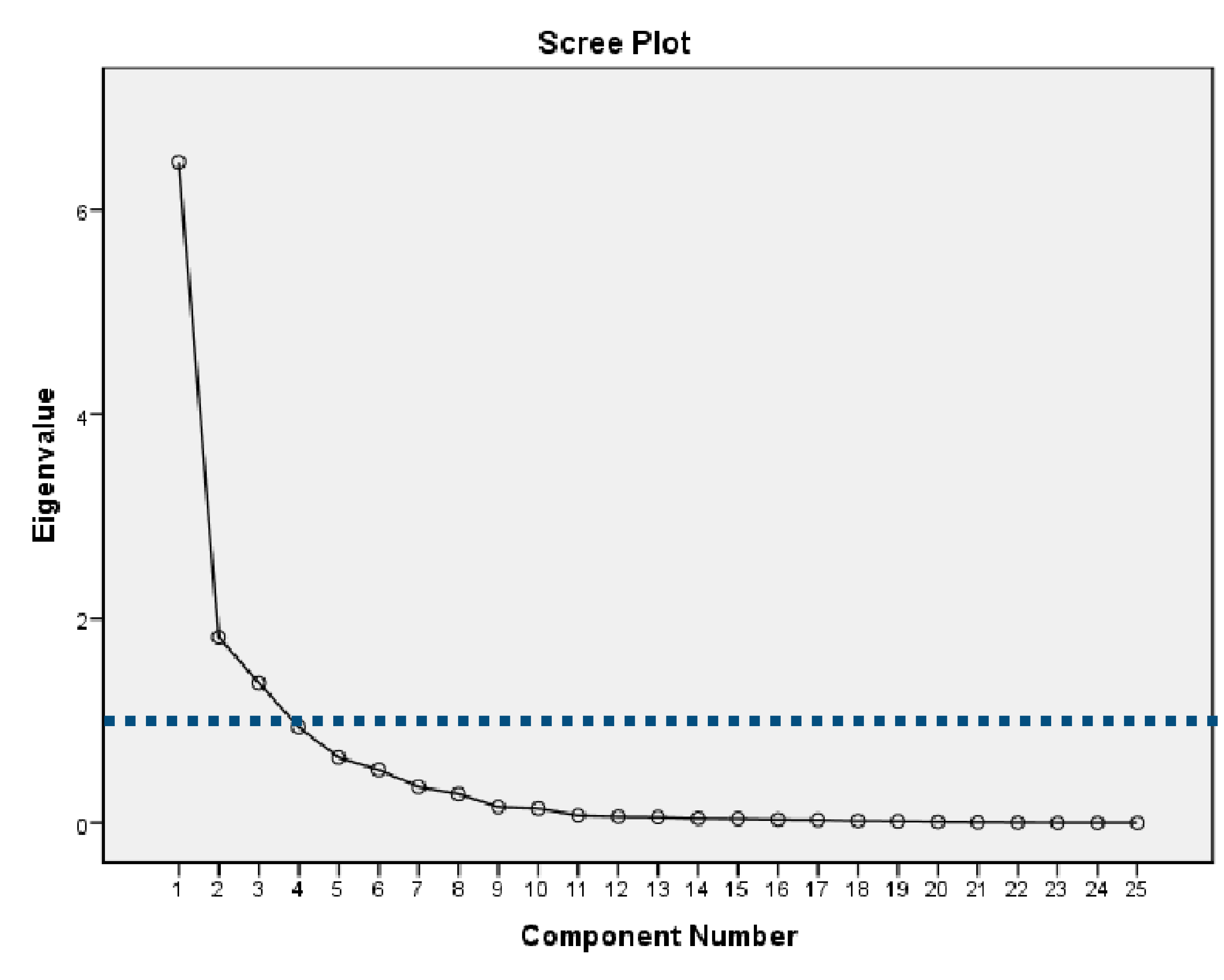
Source: Tanaka et al. Pub Health 2019

Factor analysis – foods eaten together

- Explain as much predictor variation as possible
- Creation of pattern scores reflecting food group combinations
- Each participant is assigned each pattern score
- Most common: principal component analysis (PCA)
- Extraction criteria:
    - Eigenvalue >1
    - Scree plot
    - Explained variation and interpretability of the patterns

Source: Schulze & Hoffmann. Br J Nutr 2006

Factor analysis – foods eaten together



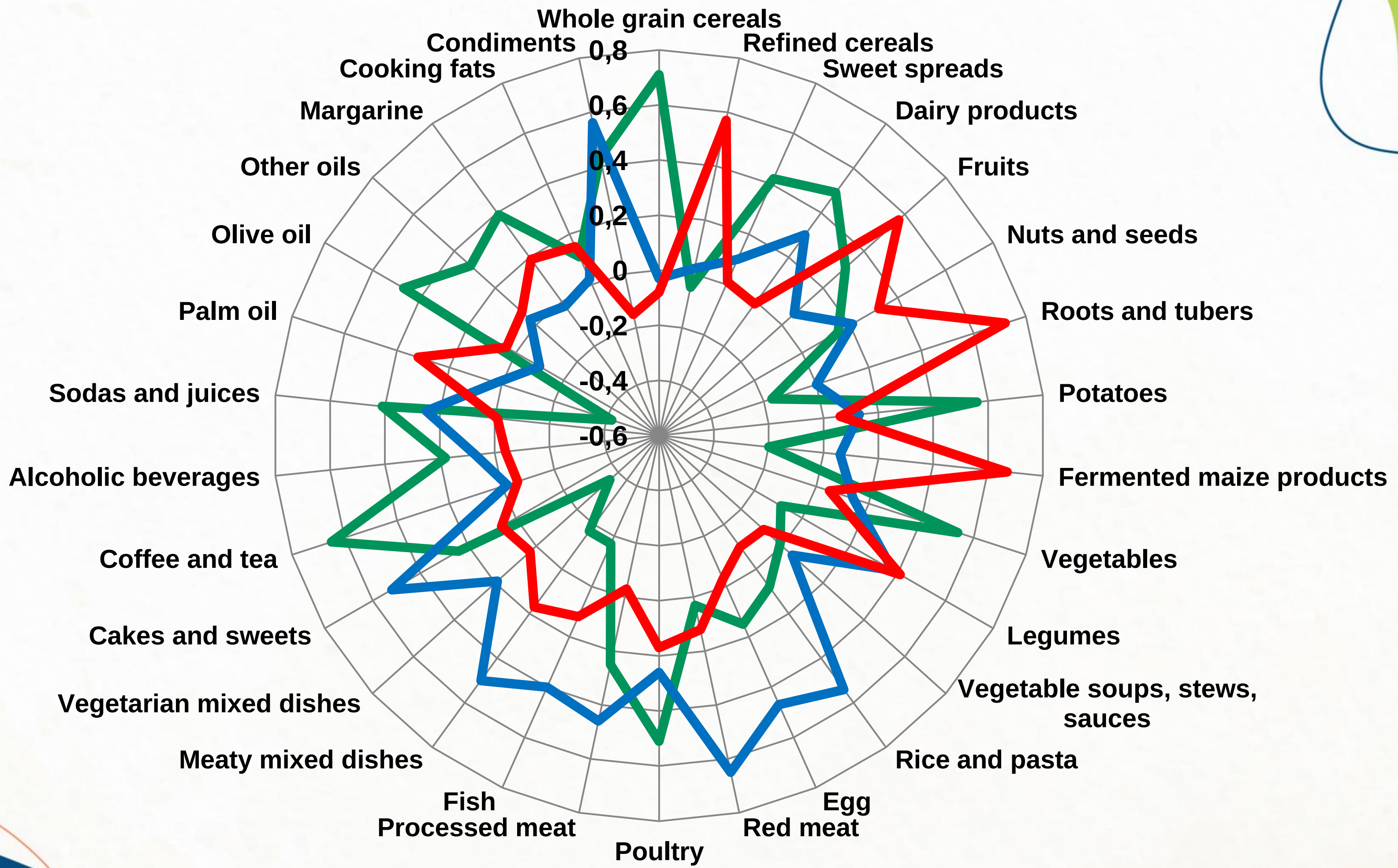
Eigenvalue >1

Factor analysis – foods eaten together

Mixed pattern: 14%

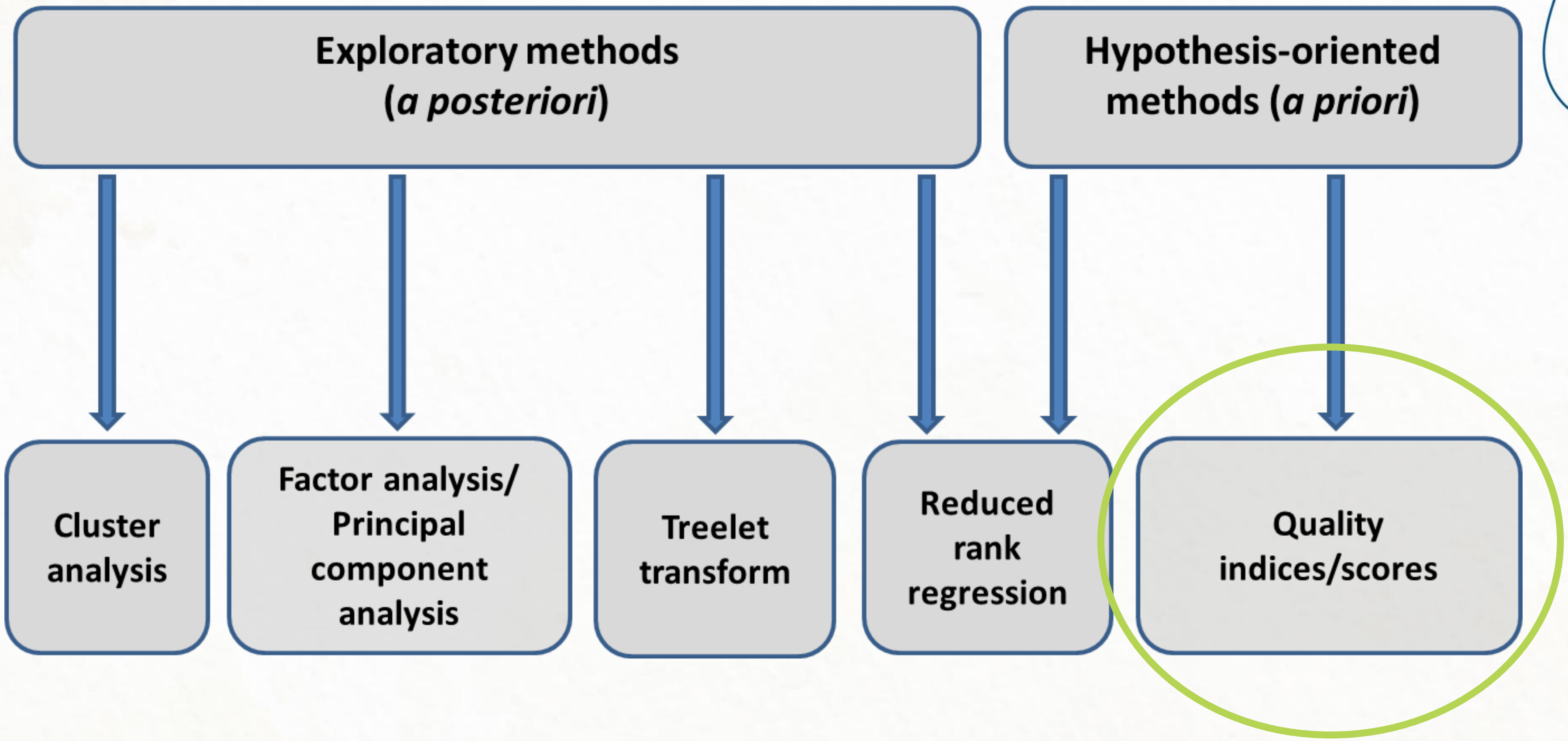
Rice, pasta, meat and fish pattern: 9%

Roots, tubers and plantain pattern: 6%



Source: Galbete C et al. Food Nutr Res 2017

Types of dietary pattern construction



Source: Ocké. Proc Nutr Soc 2013; Schulze & Hoffmann. Br J Nutr 2006

Hypothesis-based (a priori) methods

- Adherence to dietary guidelines and recommendations
- Composite scores of food items and/or nutrients
- Dichotomized, ordinal or continuous variables to define scoring criteria
- Popular examples:
  - Healthy Eating Index
  - DASH Diet
  - Mediterranean Diet Score

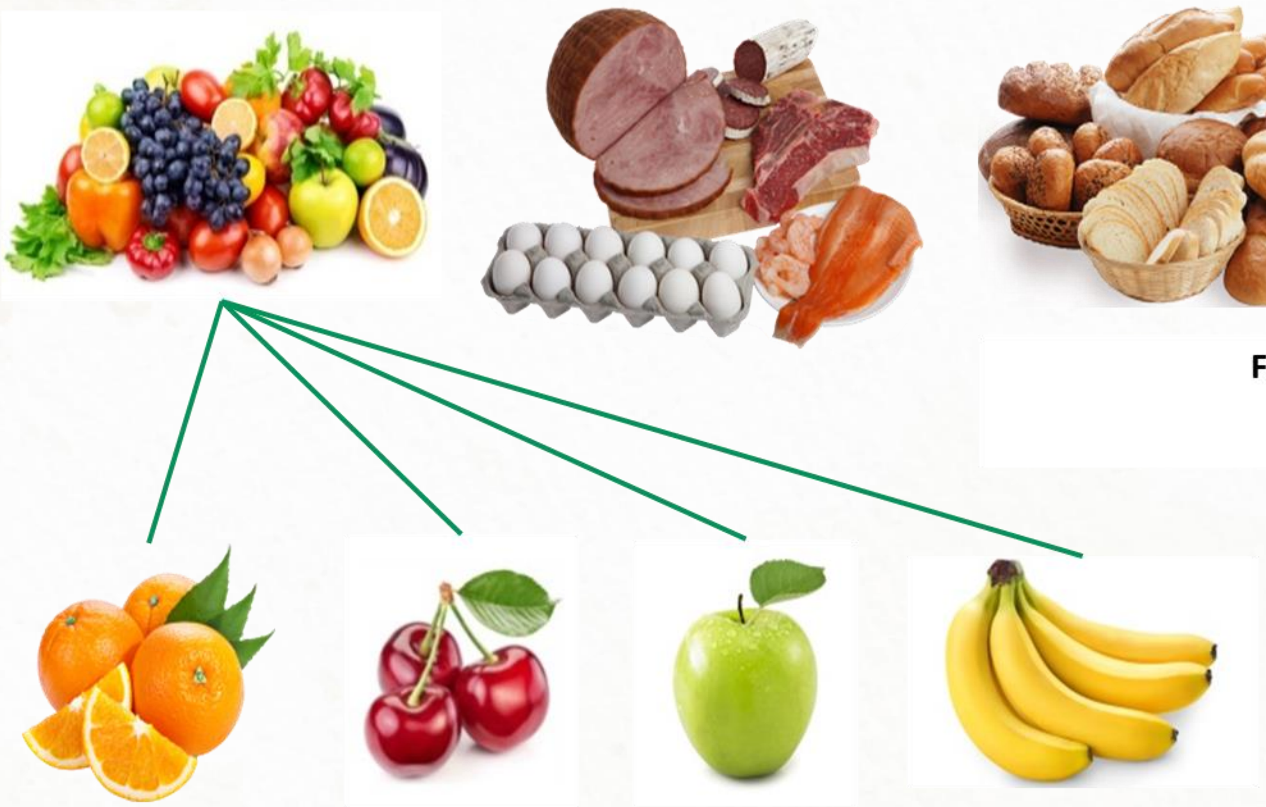
Components of Healthy Eating Index

Food Group	Range of Scores	Perfect Score of 10[1]
1. Grains	0 to 10	6 - 11 servings
2. Vegetables	0 to 10	3 - 5 servings
3. Fruits	0 to 10	2 - 4 servings
4. Milk	0 to 10	2 - 3 servings
5. Meat	0 to 10	2 - 3 servings
Dietary Guidelines		
6. Total fat	0 to 10	30% or less energy from fat
7. Saturated fat	0 to 10	Less than 10% energy from saturated fat
8. Cholesterol	0 to 10	300 mg. or less
9. Sodium	0 to 10	2400 mg. or less
10. Variety	0 to 10	16 different food items over 3-day period

[1]Depends on recommended Energy Intake - See Table 1; all amounts listed are based on a per day basis with the exception of food variety.

Source: Ocké. Proc Nutr Soc 2013; Schulze & Hoffmann. Br J Nutr 2006

Hypothesis-based (a priori) methods – simple



Food Variety Score

Dietary Diversity Score

Source: Danquah et al. Eur J Nutr 2017

Hypothesis-based (a priori) methods – complex

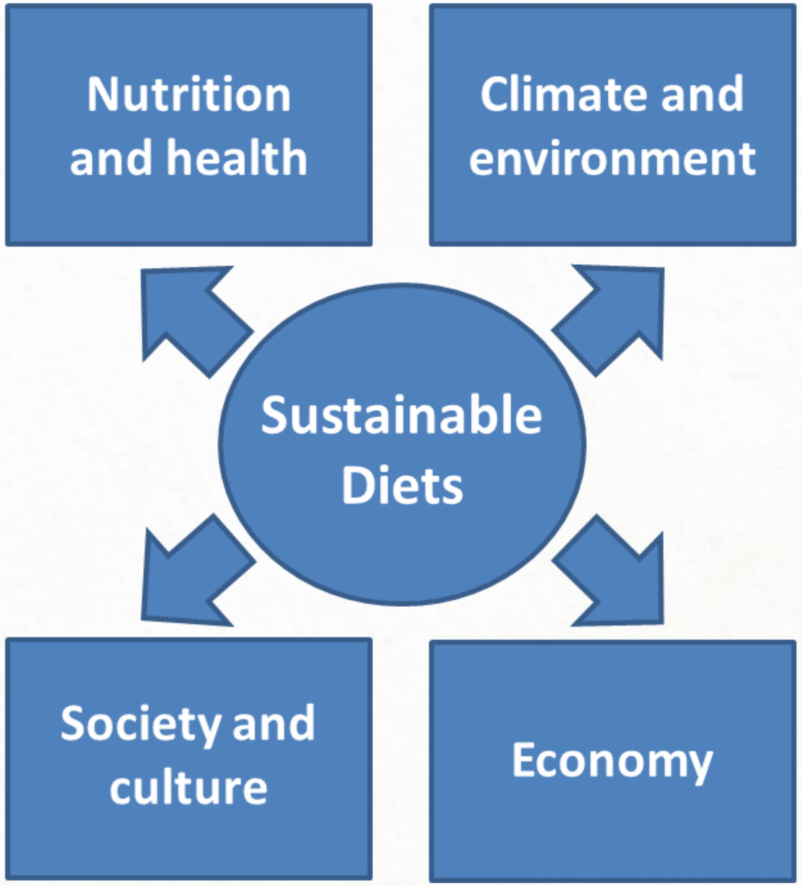
Components	Score	Scoring criteria	(n = 110)
DQI-I, total	0–100		68.9 ± 8.2
Variety	0–20		16.5 ± 2.6
Overall food group variety	0–15	≥1 serving from each food group/d = 15	11.9 ± 2.3
		Any 1 food group missing/d = 12	
		Any 2 food groups missing/d = 9	
		Any 3 food groups missing/d = 6	
		≥4 food groups missing/d = 3; None = 0	
Within-group variety for protein source	0–5	≥3 different sources/d = 5; 2 different sources/d = 3; From 1 source/d = 1; None = 0	4.6 ± 1.0
Adequacy*	0–40		32.5 ± 4.7
Vegetable group	0–5	≥3-5 servings/d = 5; 0 serving/d = 0	4.5 ± 1.0
Fruit group	0–5	≥2-4 servings/d = 5; 0 serving/d = 0	2.3 ± 1.9
Grain group	0–5	≥6-11 servings/d = 5; 0 serving/d = 0	4.9 ± 0.4
Fiber	0–5	≥20-30 g/d = 5; 0 g/d = 0	3.2 ± 1.6
Protein	0–5	≥10% of energy/d = 5; 0% of energy/d = 0	5.0 ± 0.1
Iron	0–5	≥100% of RDA(AI)/d = 5; 0% of RDA(AI)/d = 0	4.8 ± 0.6
Calcium	0–5	≥10% of AI/d = 5; 0% of AI/d = 0	3.9 ± 1.2
Vitamin C	0–5	≥100% of RDA(RNI)/d = 5; 0% of RDA(RNI)/d = 0	4.1 ± 1.2
Moderation	0–30		17.4 ± 5.6
Total fat	0–6	≤20% of total energy (TE)/d = 6; >20-30% of TE/d = 3; >30% of TE/d = 0	3.7 ± 2.1
Saturated fat	0–6	≤7% of TE/d = 6; >7-10% of TE/d = 3; >10% of TE/d = 0	5.6 ± 1.3
Cholesterol	0–6	≤300 mg/d = 6; >300-400 mg/d = 3; >400 mg/d = 0	4.0 ± 2.6
Sodium	0–6	≤2,400 mg/d = 6; >2,400-3,400 mg/d = 3; >3,400 mg/d = 0	0.9 ± 1.9
Empty calorie foods	0–6	≤3% of TE/d = 6; >3-10% of TE/d = 3; >10% of TE/d = 0	3.2 ± 2.2
Overall balance	0–10		2.4 ± 2.6
Macronutrient ratio	0–6	55-65:10-15:15-25 = 6; 52-68:9-16:13-27 = 4; 50-70:8-17:12-30 = 2; Otherwise = 0	1.4 ± 2.1
Fatty acid ratio	0–4	P/S = 1-1.5 and M/S = 1-1.5 = 4;Else if P/S = 0.8-1.7 and M/S = 0.8-1.7 = 2; Otherwise = 0	1.1 ± 1.5

Source: Kim et al. J Nutr 2003

Hypothesis-based (a priori) methods – complex

Diet Quality Index-International

GHG emission per food
Land occupation
Energy consumption
Organic food



→ **Next week**

Place of food purchase
Ready-made products

Proportion of income devoted to diet

Source: FAO 2012; Seconda et al. Br J Nutr 2019

Hypothesis-based (a priori) methods – complex

TABLE 3 GDQS and GDQS submetric food groups and scoring[1]

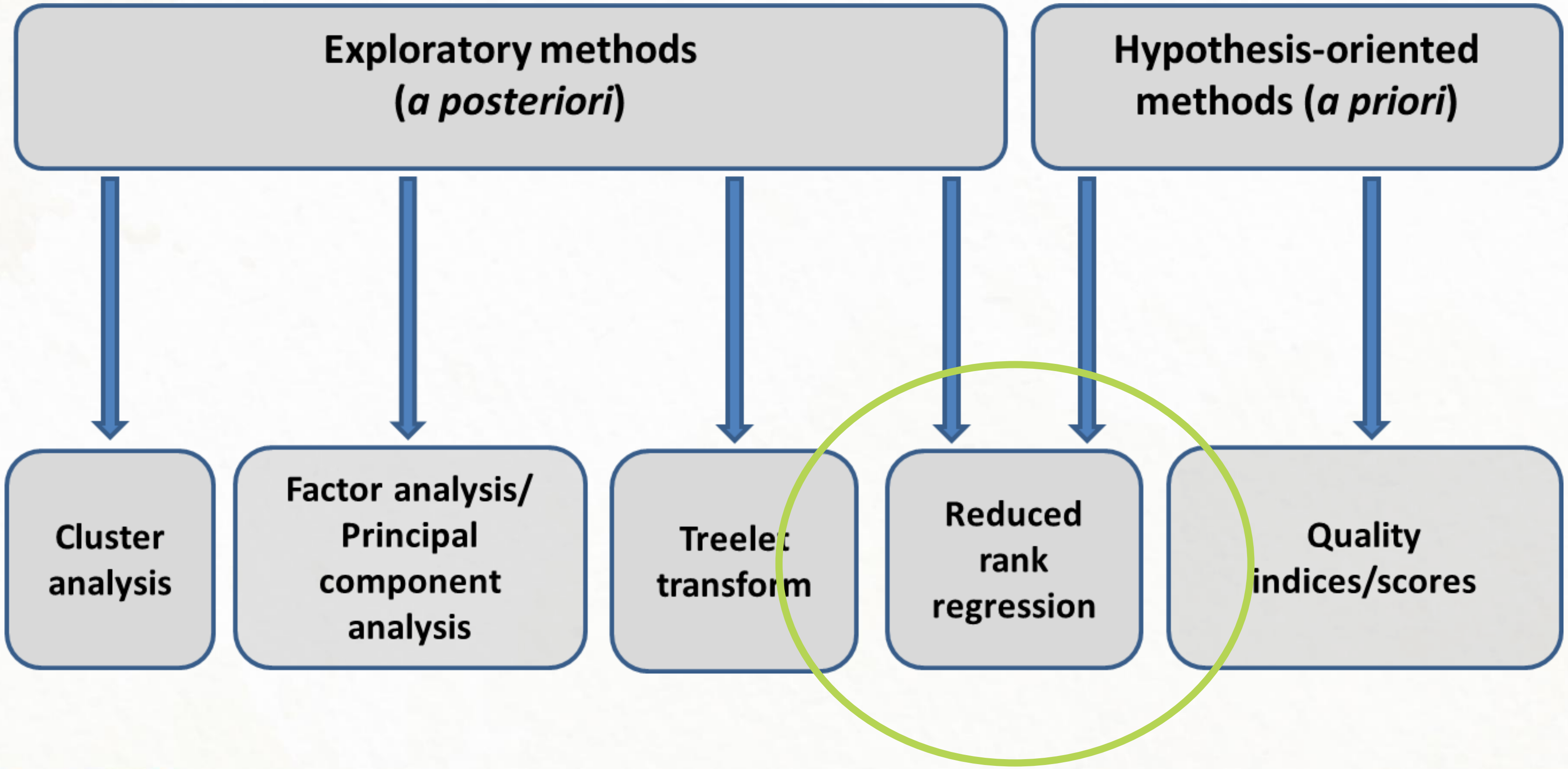
Food group	Categories of consumed amounts (g/d)				Point values			
	1	2	3	4	1	2	3	4
Food groups included in the GDQS and GDQS+								
Healthy								
Citrus fruits	<24	24–69	>69		0	1	2	
Deep orange fruits	<25	25–123	>123		0	1	2	
Other fruits	<27	27–107	>107		0	1	2	
Dark green leafy vegetables	<13	13–37	>37		0	2	4	
Cruciferous vegetables	<13	13–36	>36		0	0.25	0.5	
Deep orange vegetables	<9	9–45	>45		0	0.25	0.5	
Other vegetables	<23	23–114	>114		0	0.25	0.5	
Legumes	<9	9–42	>42		0	2	4	
Deep orange tubers	<12	12–63	>63		0	0.25	0.5	
Nuts and seeds	<7	7–13	>13		0	2	4	
Whole grains	<8	8–13	>13		0	1	2	
Liquid oils	<2	2–7.5	>7.5		0	1	2	
Fish and shellfish	<14	14–71	>71		0	1	2	
Poultry and game meat	<16	16–44	>44		0	1	2	
Low fat dairy	<33	33–132	>132		0	1	2	
Eggs	<6	6–32	>32		0	1	2	
Food groups included in the GDQS and GDQS-								
Unhealthy in excessive amounts								
High fat dairy (in milk equivalents)[2]	<35	35–142	>142–734	>734	0	1	2	0
Red meat	<9	9–46	>46		0	1	0	
Unhealthy								
Processed meat	<9	9–30	>30		2	1	0	
Refined grains and baked goods	<7	7–33	>33		2	1	0	
Sweets and ice cream	<13	13–37	>37		2	1	0	
Sugar-sweetened beverages	<57	57–180	>180		2	1	0	
Juice	<36	36–144	>144		2	1	0	
White roots and tubers	<27	27–107	>107		2	1	0	
Purchased deep fried foods	<9	9–45	>45		2	1	0	

[1] GDQS, Global Diet Quality Score; GDQS-, GDQS Negative Submetric; GDQS+, GDQS Positive Submetric.
[2] Due to the importance of cheese in many food cultures and the significantly different nutrient density of hard cheeses in comparison with other dairy products, we recommend converting consumed masses of hard cheeses to milk equivalents when calculating total consumption of high fat dairy for the purpose of assigning a GDQS consumption category [using cheddar cheese as a typical example, a conversion factor of 6.1 can be computed as the mass of 1 serving of milk (237 mL × 0.95 g/mL = 225 g) divided by an isocaloric mass of cheddar cheese (37 g)] (38).

→ **Afternoon**

Source: Bromage et al. J Nutr 2021

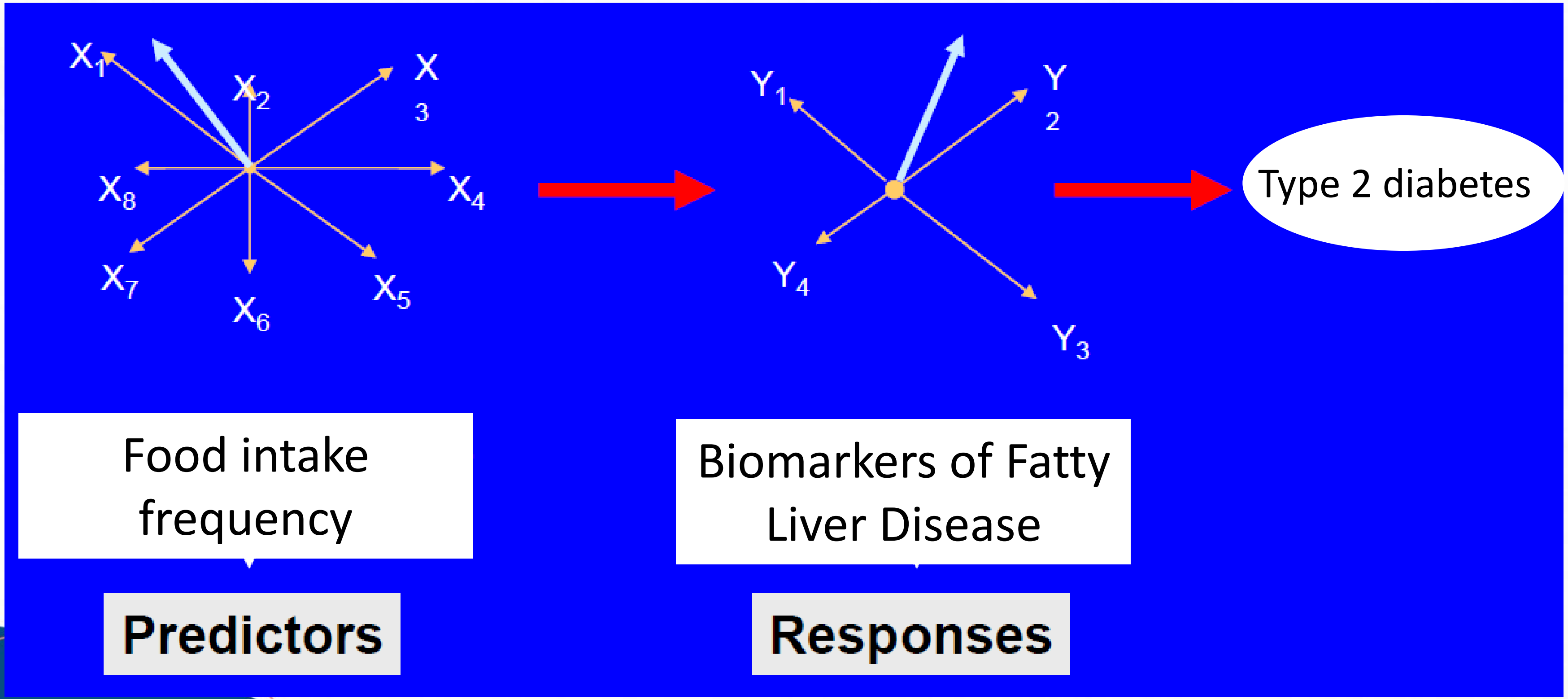
Types of dietary pattern construction



Source: Ocké. Proc Nutr Soc 2013; Schulze & Hoffmann. Br J Nutr 2006

Hybrid methods – Reduced Rank Regression (RRR)

- Explain as much response variation as possible
- Pathway from exposure to disease



Source: Ocké. Proc Nutr Soc 2013; Schulze & Hoffmann. Br J Nutr 2006

Hybrid methods – Reduced Rank Regression (RRR)

RRR-derived dietary pattern for markers of Non-Alcoholic Fatty Liver Disease (NAFLD)

Table 4. Percentage of explained variation in food intake and factor loadings of 30 food groups of the RRR-derived dietary pattern scores related to NAFLD biomarkers among males and females [1].

Food Group	Men (n = 1366)		Women (n = 2321)	
	Explained Variation (%)	Factor Loading	Explained Variation (%)	Factor Loading
Whole-grain cereals	**36.5**	**0.33**	**25.3**	**−0.26**
Poultry	**26.6**	**0.28**	**35.1**	**−0.31**
Dairy products	**25.8**	**0.28**	13.4	−0.19
Coffee and tea	**23.8**	**0.27**	**44.9**	**−0.35**
Condiments	**21.4**	**0.25**	**33.0**	**−0.30**
Potatoes	**19.0**	**0.24**	**28.7**	**−0.28**
Margarine	**12.8**	**0.20**	**14.6**	**−0.20**
Olive oil	**13.6**	**0.20**	**18.3**	**−0.22**
Sodas and juices	7.9	0.15	6.1	−0.13
Sweet spreads	7.8	0.15	6.6	−0.13
Rice and pasta	7.5	0.15	0.7	−0.05
Processed meat	5.5	0.13	5.7	−0.13
Palm oil	**32.7**	**−0.31**	**27.1**	**0.27**
Roots, tubers and plantains	**30.6**	**−0.30**	12.4	0.18
Fermented maize products	**23.5**	**−0.26**	6.1	0.13
Vegetarian mixed dishes	10.5	−0.18	**27.3**	**0.27**
Refined cereals	5.6	−0.13	7.4	0.14
Cakes and sweets	4.0	0.11	7.5	−0.14
Vegetables	3.9	0.11	9.2	−0.16
Meaty mixed dishes	4.1	−0.11	0.9	0.05
Legumes	3.9	−0.11	0.5	−0.04
Other oils	2.8	0.09	4.2	−0.11
Cooking fats	1.5	0.07	0.1	−0.01
Fish	1.6	−0.07	13.1	0.19
Fruits	1.4	−0.06	1.7	−0.07
Eggs	0.9	0.05	5.9	−0.13
Vegetable soups, stews and sauces	0.3	0.03	0.1	0.01
Red meat	0.3	−0.03	1.1	−0.05
Nuts and seeds	0.4	−0.03	0.0	−0.01
Alcoholic beverages	0.1	−0.02	6.3	−0.13
Total	**11.2**		**12.1**	

[1] Factor loadings are correlations between food groups and the dietary pattern score. Figures in bold represent food groups with relevant contributions to the dietary pattern score (≥0.20% explained variation in the factor loading for either males or females).

Table 5. Percentage of explained variation in the NALFD biomarkers and response weights of the RRR-derived dietary pattern scores among males and females [1].

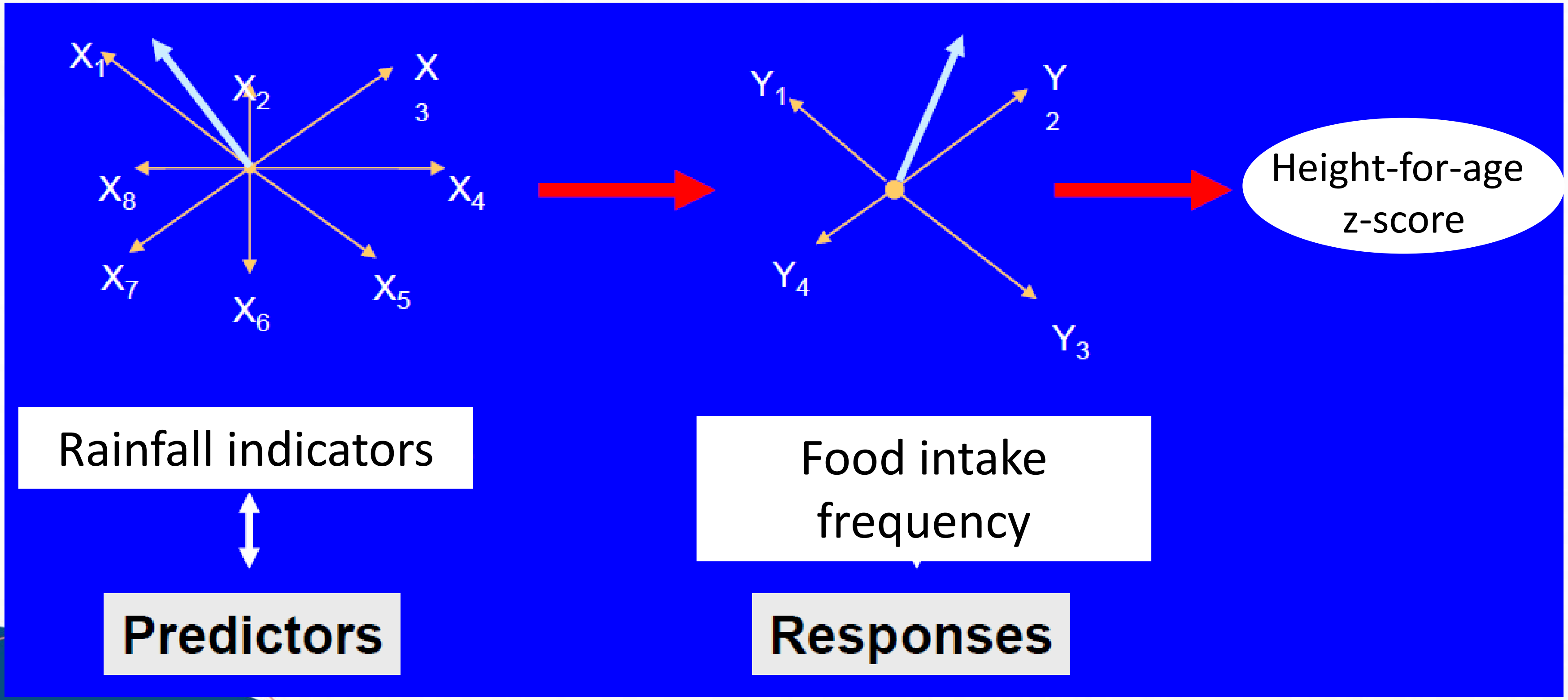
Biomarker	Men (n = 1366)		Women (n = 2321)	
	Explained Variation (%)	Response Weight	Explained Variation (%)	Response Weight
Cholesterol	**4.5**	**0.45**	0.3	0.09
LDL-cholesterol	**4.2**	**0.44**	1.0	0.16
HDL-cholesterol	2.9	0.36	**8.6**	**−0.49**
AST	**7.4**	**−0.58**	**12.3**	**0.58**
GGT	1.5	−0.26	0.3	0.09
Triglycerides	1.3	−0.24	**11.1**	**0.55**
C-reactive protein	0.3	−0.12	0.4	0.11
ALT	0.2	0.08	2.2	0.25
Total	**2.80**		**4.50**	

[1] Figures in bold represent biomarkers with relevant relationships with the dietary pattern scores (response weight > |0.35|).

Source: Bonsu Osei et al. Nutrients 2021

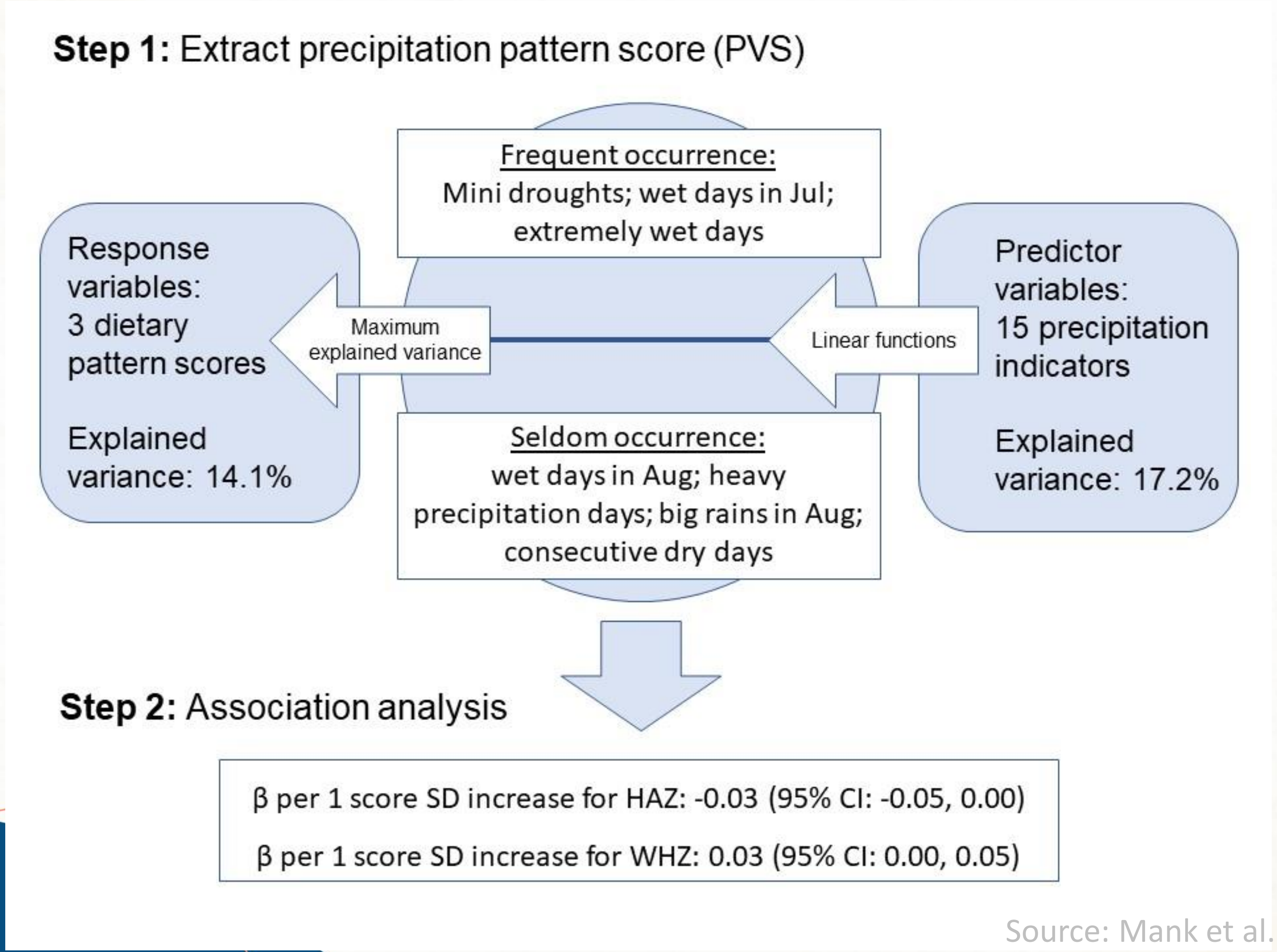
Hybrid methods – Reduced Rank Regression (RRR)

- Utility in climate change and health research
- Pathway from climate change to intermediate risk factors



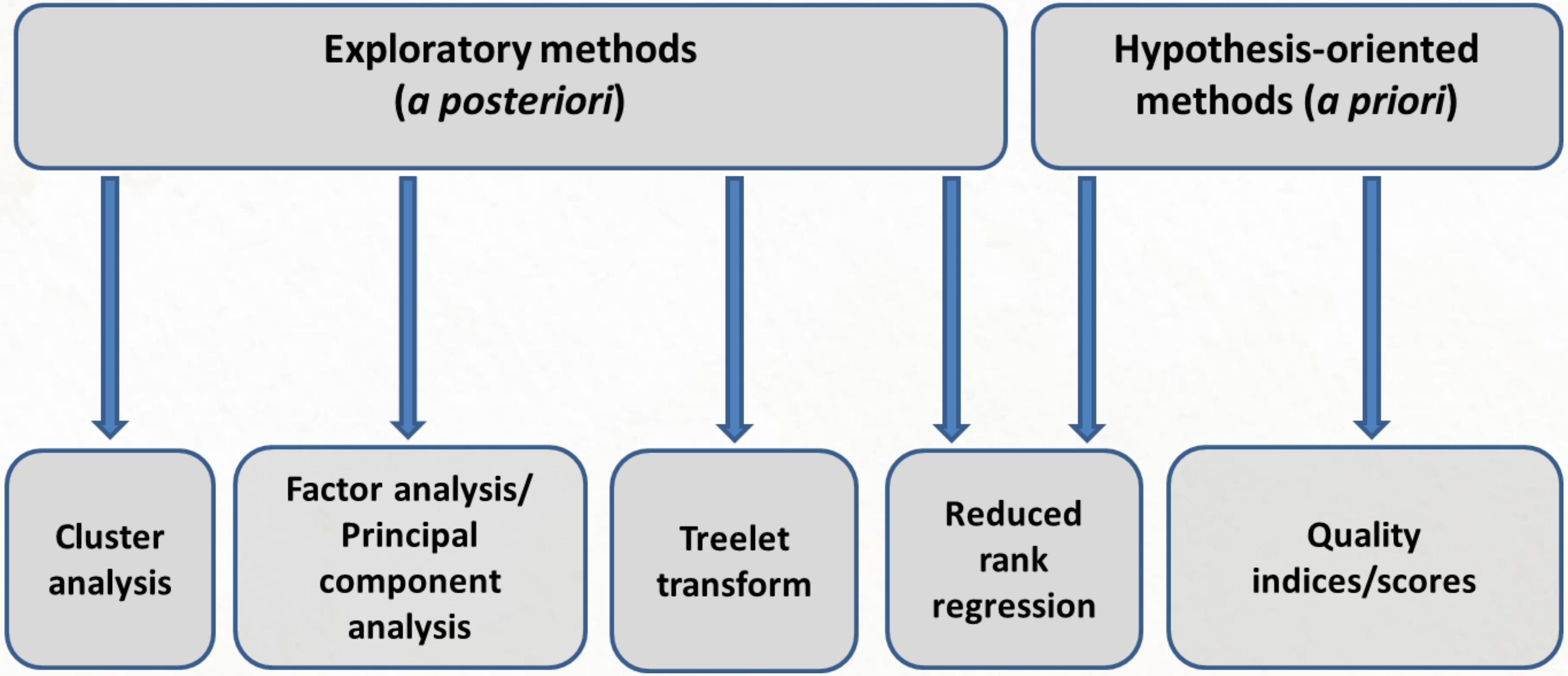
Source: Mank et al. Front PH 2021

Hybrid methods – Reduced Rank Regression (RRR)



Source: Mank et al. Front PH 2021

Dietary pattern construction – Tools for climate change and health research



Source: Ocké. Proc Nutr Soc 2013; Schulze & Hoffmann. Br J Nutr 2006