Causal analysis in multidimensional dietary data to assess effect on all-cause mortality

Yohannes Adama Melaku

Flinders University, Adelaide, Australia

27 September 2024

Funding

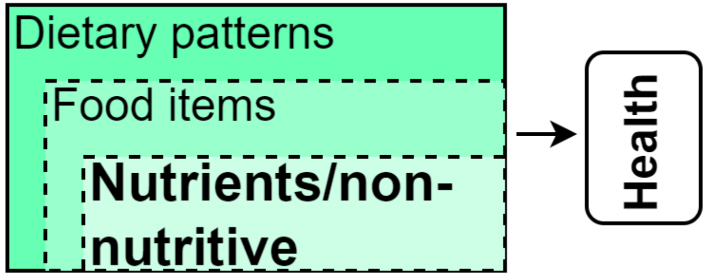
- This work was supported by the National Health and Medical Research Council through the Emerging Leadership Fellowship (2009776).

Background

- Estimating the causal effect of dietary exposure on health outcomes is challenging
  - Background diet — lifelong exposure (prevalent user)
  - Diet is multidimensional and dynamic — it has subcomponents (nutrients) and changes over time and across geographic areas
  - Diet is compositional — multiple dietary components
    - Full substitution, partial substitution, or addition

Stern D, et al (2024)

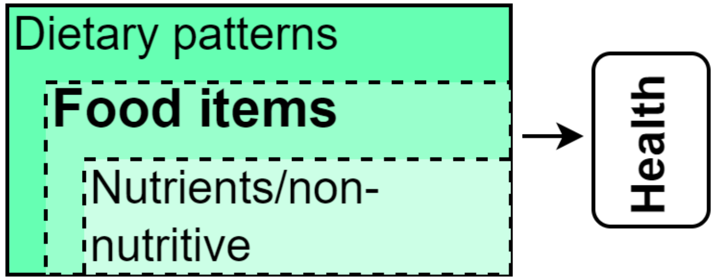
Background



Nutrients

- Ill-defined exposure (particularly if from dietary sources)
- Difficult to design interventions based on nutrients (if from dietary sources)

Background



Food items

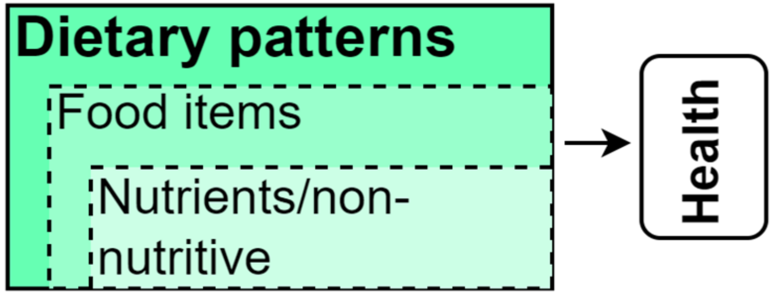
- Causal effect estimation can be determined based on adherence to:
  - Individual food items, or
  - Two or more food items (joint interventions)

- What if we wanted to estimate the effect of each dietary component on health simultaneously (concurrent exposure)?
  - Adjusting for each component → overadjustment, model misspecification, etc

Chiu YH, et al (2021)

Background

- Dietary exposures can be defined in three levels



Dietary patters

- Constructs (*a priori, a posteriori* and *hybrid methods*)
- Dimension reduction vs pre-determined dietary components
- Determining a clear intervention strategy is challenging (poorly defined exposure)
- A hypothetical clinical trial where assigning dietary scores to participants is not feasible

Background

- Estimating the causal effect of concurrent dietary exposures on health outcomes requires:
  - Accounting for the co-occurrence of multiple dietary constituents, which exist as complex mixtures in real-world settings
  - Balancing covariates across different levels of dietary exposure

Method

- Multivariate generalized propensity score (mvGPS)
  - A novel extension of the generalized propensity score for multiple simultaneous continuous exposures
  - Has two main advantages
    - Creates covariate balance for multiple exposures
    - Helps to identify dietary components that have a stronger causal effect within the same statistical framework
  - Has been applied in environmental epidemiology but not in nutrition
  - R package – *mvGPS*

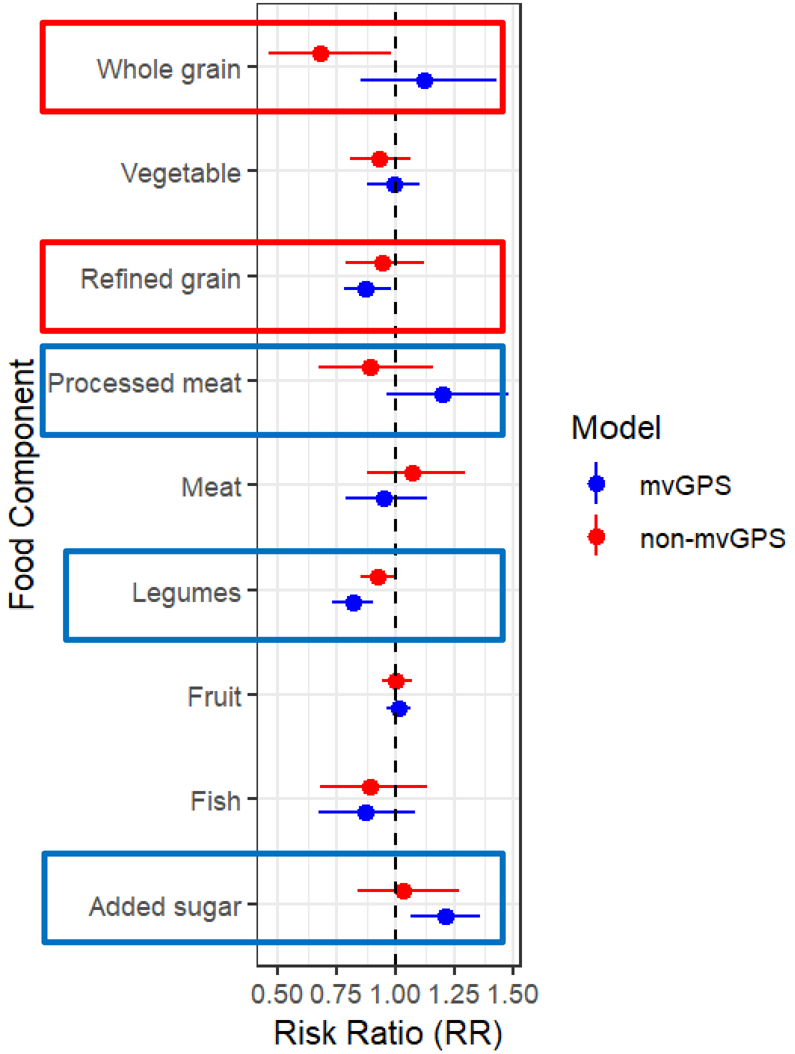
Williams JR et al (2020)

Method

- 9 dietary exposures (fruits, vegetables, whole grains, legumes, fish, meat, processed meat, refined grains, and added sugar) – per 100 gr/day increase
    - Two approaches used – mvGPS and mutual adjustment using GLM
- Data source
    - National Health and Nutrition Examination Survey (NHANES)
    - 12,635 ‘healthy’ participants
    - In 15 years, 400 deaths were recorded

Williams JR et al (2020)

Results

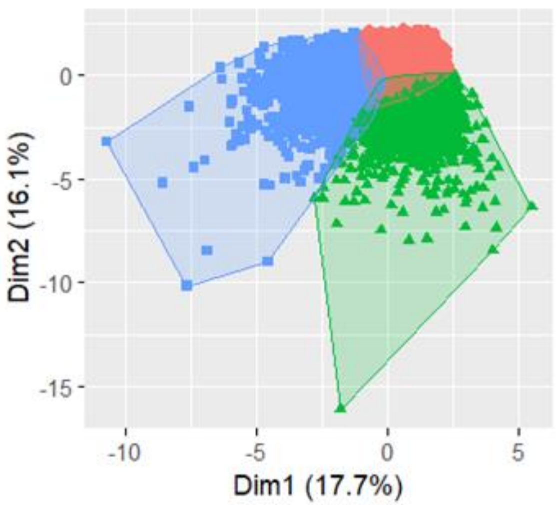


- Euclidean distance (covariate balance)
  - mvGPS – 0.98
  - Non-mvGPS – 1.21-1.32
- Average correlation (between covariates and treatment assignment)
  - mvGPS – 0.04
  - Non-mvGPS – 0.05-0.06
- Although covariates are successfully balanced using mvGPS, effect estimates for some of the dietary components are not consistent with existing evidence

*All models were adjusted for race, sex, marital status, income, education, physical activity, smoking, alcohol intake, depression, health insurance, BMI, hypertension, total energy intake, follow up*age*

Results

- K-means to create clusters



	RR (95% CI)
Non-IPW model	
Balanced	1.00
Healthy	0.96 (0.67, 1.37)
Unhealthy	0.79 (0.56, 1.11)
IPW model	
Balanced	1.00
Healthy	0.75 (0.55, 1.04)
Unhealthy	0.92 (0.63, 1.36)

Conclusion

- mvGPS can be used to balance covariates to estimate the causal effect of simultaneous exposure to dietary components
  - In this specific study, we were able to demonstrate balanced covariate distribution
- However,
  - Simulation studies are required to demonstrate that mvGPS can provide unbiased causal effect estimates in cases of dietary exposure
  - The use of this approach in the target trial framework should also be further explored

Thank you

- Prof Zumin Shi
- A/Prof Amy Reynolds
- Dr Sarah Appleton
- Prof Danny Eckert
- Prof Robert Adams

Flinders University | FHMRI

WCE
WORLD CONGRESS OF EPIDEMIOLOGY 2024