Analytical Methods to Estimate Dietary Intake during Pregnancy

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Daniela Sotres-Alvarez

Department of Biostatistics

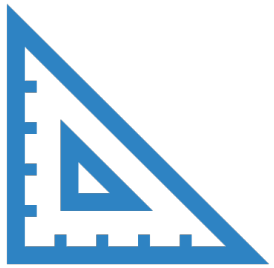
UNC Gillings School of Global Public Health

The National Academies of Sciences, Engineering and Medicine

WEBINAR 1. Methods for Dietary Assessments during Pregnancy

May 6, 2021

Outline



Measurement Error

Usual Intake Foods & Beverages

Usual Intake Including Supplement Use

DISTRIBUTION

Biomarkers Regression Calibration

ASSOCIATION

Best Practices Future Directions Resources

Questions & Answers

Measurement Error in Usual Intake

Types of measurement error:

- Random error
- Systematic
  - General Bias
  - Person-specific bias
  - Intake-related bias

Additional information needed to account for measurement error:

- Several dietary instruments
- Repeated measures (at least in a subset)
- Covariates
- Biomarkers

Impact of random error in Estimating Usual Intake Distribution

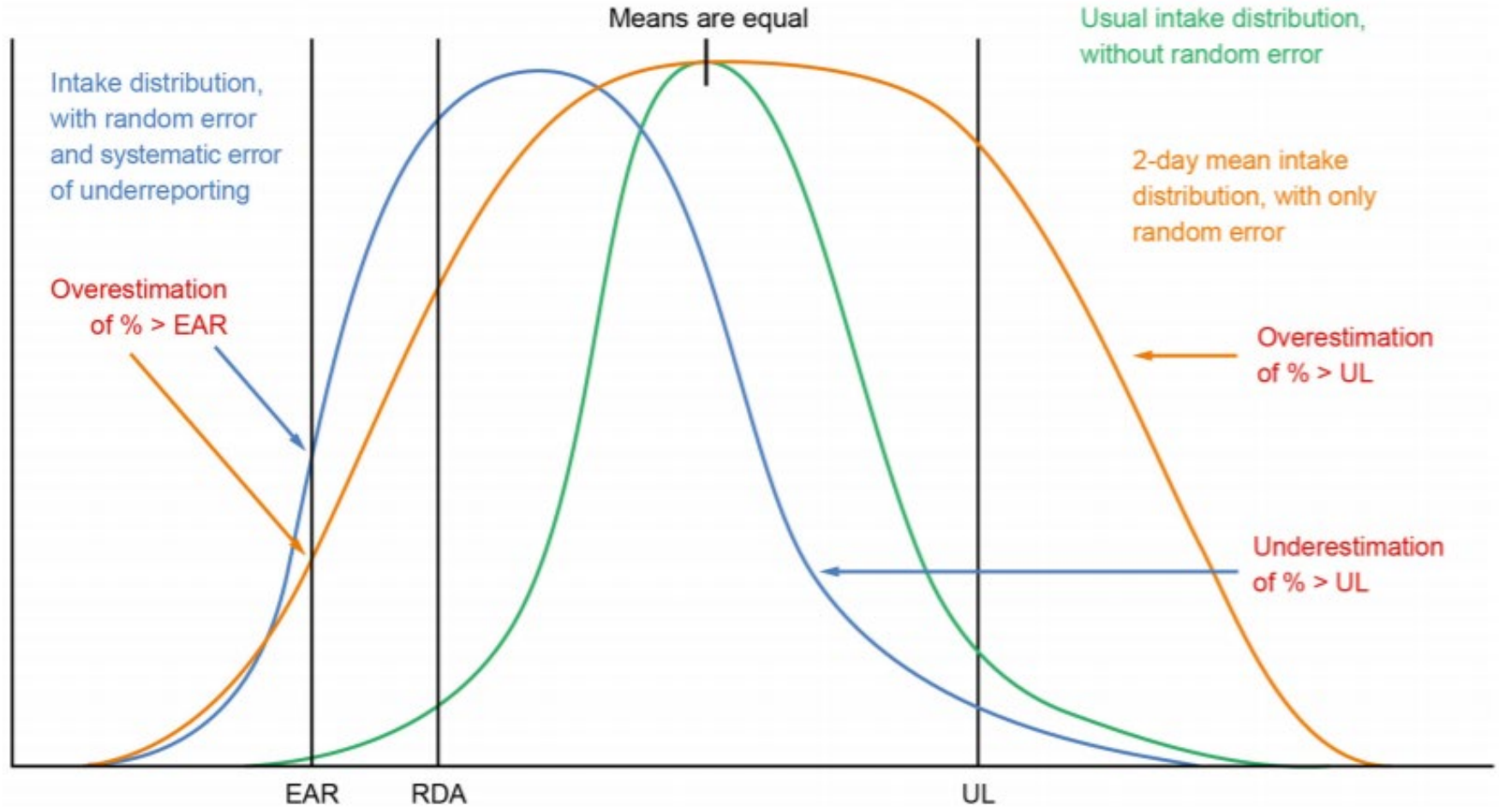


Figure 1 from Bailey et al, *J Nutr* 2019

Usual Intake from foods and beverages (multiple 24hr recalls)

Methods to Estimate Usual Intake (several 24hr recalls or food records)

- **NRC** (National Research Council)
- **ISU** (Iowa State University) (Nusser et al, 1996a)
- **Best Power Method** (Nusser et al, 1996b)
- **NCI Method (Tooze et al, 2006, 2010)**
- **SPADE** (Statistical Program to Assess habitual Dietary Exposure) (Waijers et al, 2006)
- **MSM** (Multiple Source Method) (Haubrock et al, 2011)

References comparing methods:

- Dodd et al, *J Am Diet Assoc* 2006
- Souverein et al, *Eur J Clin Nutr* 2011
- Laureano et al, Nutrients 2016

NCI Method to model usual intake using multiple 24hr dietary recalls

- **Nutrients or food groups**
- **Consumed every day** (amount) **or episodically** (2-part model)
- Accounts for **day-day variability**
- Accommodates **highly skewed variables**
- **Relates covariates to usual intake**, which helps improving the estimates by explaining some of the variability
- **Estimates distribution** for a population or subpopulations
- **Corrects (at least partially) bias** caused by measurement error in estimated **associations** between usual dietary intakes and health outcomes
- **Assumes reference (24hr recall) is unbiased of the true usual intake**

SAS macros available

https://epi.grants.cancer.gov/diet/usualintakes/method.html

The NCI Method

SAS macros currently available to facilitate modeling:	Examples
Single dietary component whether consumed daily or episodically;	- Usual sodium intake - Usual F&V intake
Ratios of two dietary components that are consumed nearly every day	- Usual sodium intake per 1000 kcal - % energy from fat
Multiple dietary components, whether consumed daily or episodically	- AHEI - HEI - DASH

SAS macros available

https://epi.grants.cancer.gov/diet/usualintakes/method.html

Usual intake from foods and beverages (multiple 24hr recalls) and dietary supplements

Challenges to Estimation of Usual and Total (Foods & Supplements) Nutrient Intakes

- Measurement error
- Skewness
- Spikes and possible multimodal distribution
- Supplements collected typically via a questionnaire
- Correlation between supplement use and dietary intake

Bailey et al, *J Nutr* 2019

Methods to Estimate Total Usual Intake (Foods & Supplements)

Users

Non-Users

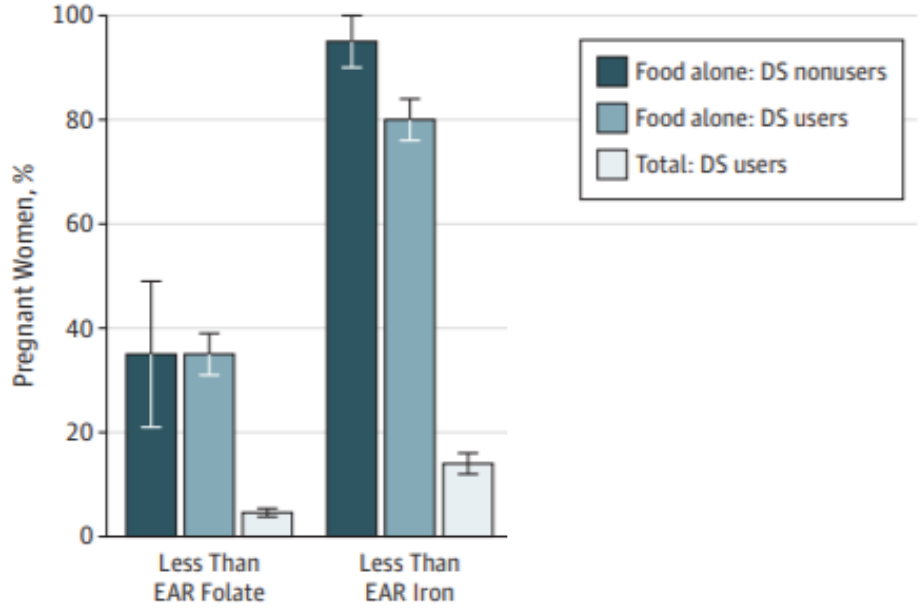
The Journal of Nutrition
Critical Review

Best Practices for Dietary Supplement Assessment and Estimation of Total Usual Nutrient Intakes in Population-Level Research and Monitoring

Regan L Bailey,[1] Kevin W Dodd,[3] Jaime J Gahche,[4] Johanna T Dwyer,[4] Alexandra E Cowan,[1] Shinyoung Jun,[1] Heather A Eicher-Miller,[1] Patricia M Guenther,[5] Anindya Bhadra,[2] Paul R Thomas,[4] Nancy Potischman,[4] Raymond J Carroll,[6] and Janet A Tooze[7]

- Combined Methods (users and non-users):
  - **“shrink then add” (preferred)**
  - “add then shrink”
- Stratified
- Hybrid (three-part model)

Figure. Prevalence of Usual Nutrient Intake Distributions From Food Alone and Total Intake Below the Estimated Average Requirement (EAR) for Folate and Iron for Nonlactating Pregnant Women Aged 20 to 40 Years



Data are from 1003 women participating in the National Health and Nutrition Examination Survey, 2001-2014. The EAR is set based on the dietary folate equivalent that includes natural and synthetic forms; the UL is set based on synthetic folic acid form only in fortified foods and dietary supplements (DS). The prevalence of exceeding the UL from food sources alone is 0 for folate and iron among users and nonusers of dietary supplements. The error bars indicate the SEs.

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Estimation of Total Usual Dietary Intakes of Pregnant Women in the United States

Regan L. Bailey, PhD, MPH, RD; Susan G. Pac, MS, RD; Victor L. Fulgoni III, PhD; Kathleen C. Reidy, DrPH, RD; Patrick M. Catalano, MD

Recovery Biomarkers and Regression Calibration

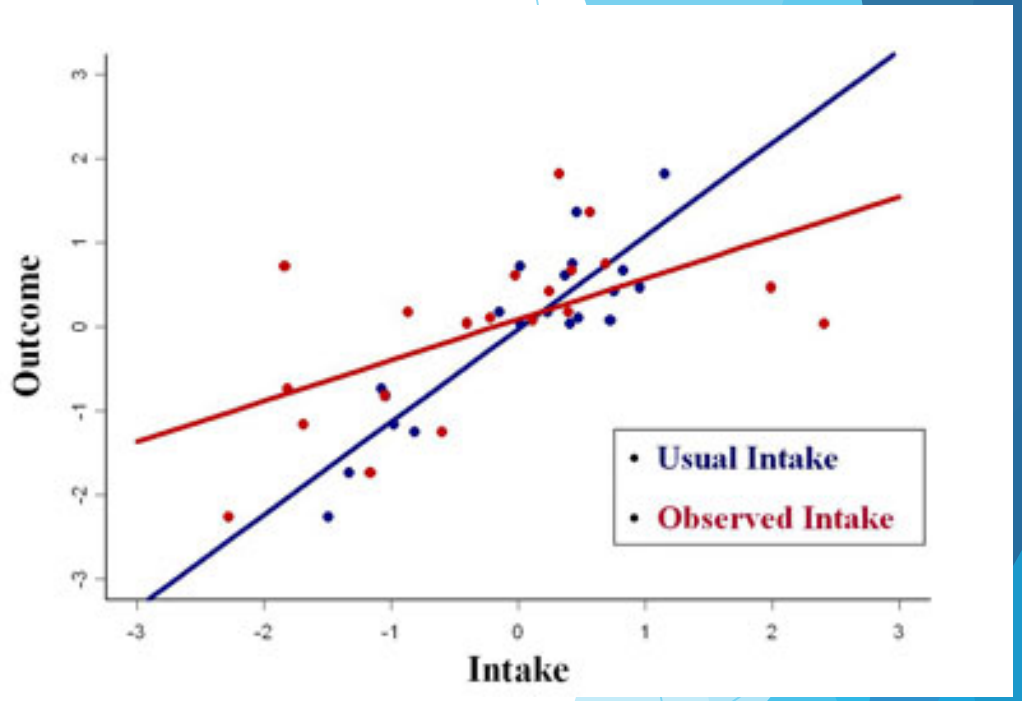
Diet-Disease Model with calibrated intake

Y Outcome

R Recovery Biomarker (only subsample)

Q Diet intake measured with error (e.g., 24hr recall)

Z Covariates measured WITHOUT error



1. Calibration Model (subsample)

$$ln\,(R) = ln(Q) + Z + \varepsilon$$

E(ε)=0

ε is uncorrelated to Q, R and Z

2. Diet-Disease Model (full sample)

$$\text{Logit}\{\Pr[Y = 1|Q^*, \boldsymbol{Z}]\} = \alpha_0^* + \alpha_1^* Q^* + \boldsymbol{\alpha}_z^* \boldsymbol{Z}$$

Best Practices

- Additional information to account for the measurement error
  - ✓ Validation studies (biomarkers)
  - ✓ Several dietary instruments
  - ✓ Repeated measures (at least in a subset)
  - ✓ Covariates
- Use statistical methods to mitigate the effect of measurement error
- Research question should guide which instruments and which analytical methods are better to measure and estimate dietary intake

Adv Nutr. 2021 Feb 19;nmaa183. doi: 10.1093/advances/nmaa183. Online ahead of print.

Perspective: Big Data and Machine Learning Could Help Advance Nutritional Epidemiology

Jason D Morgenstern,[1] Laura C Rosella,[2,3] Andrew P Costa,[1] Russell J de Souza,[1,4] and Laura N Anderson[1]

[1]Department of Health Research Methods, Evidence, and Impact, McMaster University, Hamilton, Ontario, Canada; [2]Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada; [3]Vector Institute, Toronto, Ontario, Canada; and [4]Population Health Research Institute, Hamilton Health Sciences, Hamilton, Ontario, Canada

BIG DATA

- New methods of dietary data collecting (larger samples and more repeated measures)
- Novel big data sources could help avoid unmeasured confounding by offering more covariates

MACHINE LEARNING

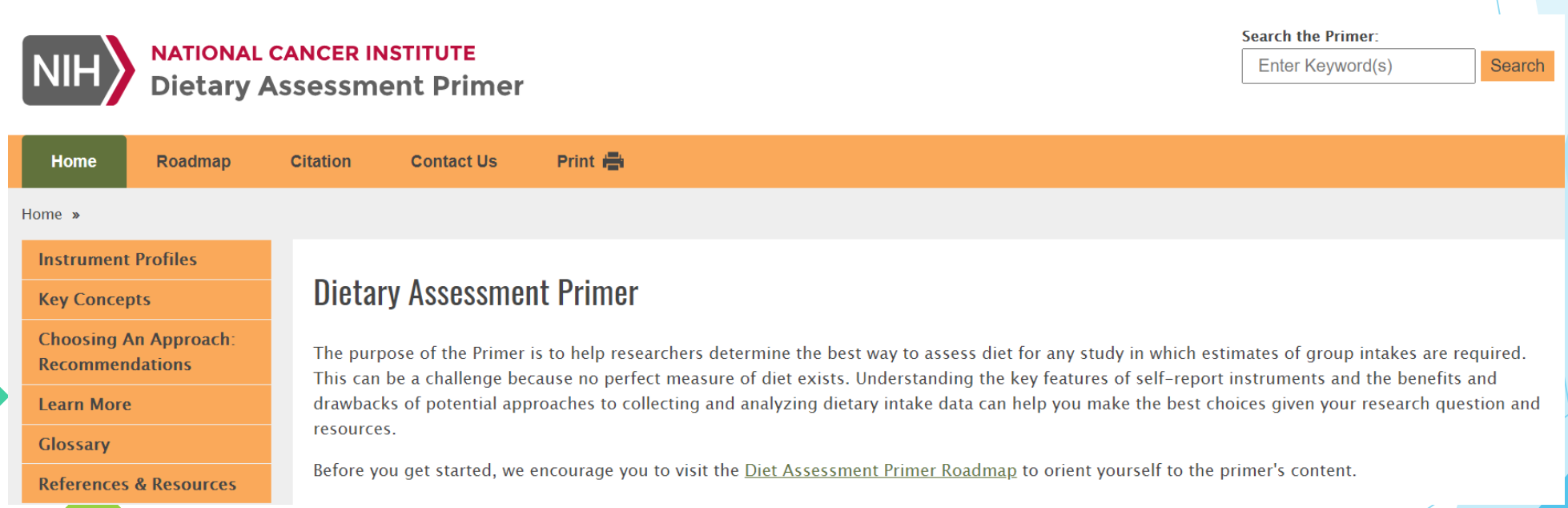
- Automatically classify pictures of food could become a useful complimentary
- Could help better model diet as a complex exposure with nonadditive and nonlinear associations

These opportunities must be approached cautiously to ensure quality of dietary measurements, avoid overfitting, and confirm accurate interpretations.

Resources

measurement ERROR webinar series

https://epi.grants.cancer.gov/events/measurement-error/



measurement ERROR webinar series

https://epi.grants.cancer.gov/events/measurement-error/

1. **Introduction to Measurement Error in Dietary Intake Data**, S. Kirkpatrick
2. **Estimate Usual Intake Distribution (daily)**, K. Dodd
3. **Estimate Usual Intake Distribution (episodically)**, J. Tooze
4. **Account for Complex Survey Design**, K. Dodd
5. **Estimate Usual Intake Distribution from Supplements**, R. Bailey
6. **Measurement Error When Examining Diet-Health Relationships**, L. Freedman
7. **Assessing Diet-Health Relationships with FFQ (daily)**, D. Midthune
8. **Assessing Diet-Health Relationships with FFQ (episodically)**, V. Kipnis
9. **Estimating Usual Intake Distributions for Multivariate Dietary Variables**, R. Carroll
10. **Combining Self-Report Dietary Assessment Instruments**, D. Midthune
11. **Combine Self-Report Dietary Intake & Biomarker, L. Freedman**
12. **Asses Diet-health Relationships Using a Short-term Unbiased Dietary Instrument**, V. Kipnis

Thanks

“There will always be error in dietary assessments. The challenge is to understand, estimate, and make use of the error structure during analyses.”
[George Beaton, 1997]

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- Tooze, JA; Kipnis, V; Buckman, DW, et al. A mixed-effects model approach for estimating the distribution of usual intake of **nutrients**: The NCI method. *Statistics in Medicine*. 2010; 29: 2857-2868.

- Tooze, JA; Midthune, D; Dodd, KW, et al. A new statistical method for estimating the usual intake of **episodically consumed foods** with application to their distribution. *J Am Diet Assoc.* 2006; 106:1575-1587.

- For a comprehensive list please see:

  http://epi.grants.cancer.gov/diet/usualintakes/information.html

  http://appliedresearch.cancer.gov/measurementerror/

Other Methods to Estimate Usual Intake

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- Waijers PM, Dekkers AL, Boer JM, Boshuizen HC, van Rossum CT. The potential of AGE MODE, **an age-dependent model, to estimate usual intakes and prevalences** of inadequate intakes in a population. J Nutr. 2006 Nov;136(11):2916-20.
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References on Dietary Supplements

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