Estimating Dietary Intake: What Are the Implications for DRI Development?

Amy F Subar, PhD, MPH, RD
Applied Research Program
Risk Factor Monitoring and Methods Branch
Uses of Dietary Intake Estimates in the DRI Process

• Focus 1: Dietary exposure assessment
  – Used to estimate current intakes of US (and Canadian) populations: national surveys
  – Used to characterize risk of inadequate or excessive intake
  – Basis for study committees to place DRI values in context

• Focus 2: Estimated intake data have strengths and weaknesses
  – Important to understand when DRI committees compare DRI values to population distributions
Additional Uses of Dietary Intake Data Relevant to DRI Development

• Intake measured as part of clinical feeding studies to study dose-response relationship:
  – Truth is known and not estimated

• Intake measured as part of population-based epidemiological or clinical studies
  – Intake is estimated: from a variety of instruments
  – Generate insight for dose-response relationships

• Use of observed intakes to develop AIs
  – Intake is estimated: NHANES
How Dietary Data Inform DRI Development

- Dietary data provide information
  - For descriptive purposes
  - Usual intake distributions
  - To relate to health outcomes
How Dietary Intake Data Are Used in the Application of the DRIs

- Estimate proportion of population not meeting requirements or exceeding upper limits
  - Based on DRI standards
Goal for All Applications: Usual Intake

- Theoretical long-run average daily intake of a dietary component
- Common operational definition: average daily intake over past year
Self-Report Instruments Used in Estimating Usual Intake

- 24-Hour dietary recalls
- Food records or diaries
- Food frequency questionnaires (FFQs)
24-Hour Dietary Recalls

• Variations in approach
  – Training of interviewers
  – Standardization of probing questions
  – Multiple passes through the day
  – Computer vs. paper/pencil administration
  – In-person vs. telephone
  – Portion size models or measurement aids
  – Development of self-administered automated systems
24-Hour Dietary Recall: Strengths

- Intake data are quantified, detailed
- Does not affect eating behavior
- Lower sample selection bias than other methods
  - Literacy not required (if interviewer administered)
  - Respondent burden relatively low
- Most trusted of methods: used in national dietary surveillance
- Population usual intake distributions can be estimated from two recalls
24-Hour Dietary Recall: Weaknesses

- Relies on memory
- Imperfect knowledge
- Use of defaults
- Costly to develop and administer
  - Highly trained interviewers
- Underreporting is typical
  - Worse with overweight/obese
- Multiple days/statistical modeling required to estimate usual intake
Food Diaries or Records

- Variations in approach
  - Less standardized than recalls
  - Trained or untrained respondents
  - Detailed review or not
  - Highly standardized coding rules or not
  - Development of electronic methods: PDA, cell phones
Food Diaries or Records: Strengths

- Intake can be quantified, detailed
- Could be relatively accurate
- Real-time data collection relies less on memory
Food Records/Diaries: Weaknesses

- Recording influences diet (reactive tool): biased
- Requires literacy
- High respondent and investigator burden
- Sample selection bias
- Completion worse over time
- Often not completed in real-time
- Underreporting is typical
  - Worse with overweight/obese
- Multiple days/statistical modeling required to estimate usual intake
Food Frequency Questionnaire

Over the past 12 months...

28. How often did you eat coleslaw?
   - NEVER (GO TO QUESTION 29)
   - 1–6 times per year
   - 7–11 times per year
   - 1 time per month
   - 2–3 times per month
   - 1 time per week
   - 2 or more times per day

28a. Each time you ate coleslaw, how much did you usually eat?
   - Less than 1/4 cup
   - 1/4 to 3/4 cup
   - More than 3/4 cup

29. How often did you eat sauerkraut or cabbage (other than coleslaw)?
   - NEVER (GO TO QUESTION 30)
   - 1–6 times per year
   - 7–11 times per year
   - 1 time per month
   - 2–3 times per month
   - 1 time per week
   - 2 or more times per day

29a. Each time you ate cabbage or sauerkraut, how much did you usually eat?
   - Less than 1/4 cup
   - 1/4 to 1 cup
   - More than 1 cup

31. How often did you eat string beans or green beans (fresh, canned, or frozen)?
   - NEVER (GO TO QUESTION 32)
   - 1–6 times per year
   - 7–11 times per year
   - 1 time per month
   - 2–3 times per month
   - 1 time per week
   - 2 or more times per day

31a. Each time you ate string beans or green beans, how much did you usually eat?
   - Less than 1/2 cup
   - 1/2 to 1 cup
   - More than 1 cup

32. How often did you eat peas (fresh, canned, or frozen)?
   - NEVER (GO TO QUESTION 33)
   - 1–6 times per year
   - 7–11 times per year
   - 1 time per month
   - 2–3 times per month
   - 1 time per week
   - 2 or more times per day

32a. Each time you ate peas, how much did you usually eat?
   - Less than 1/4 cup
   - 1/4 to 3/4 cup
   - More than 3/4 cup
Food Frequency Questionnaire (FFQ)

- Variations in approach
  - Number of foods, clarity of questions
  - Portion size questions: pictures vs. text description
  - Time frame
  - Development of food list, nutrient database
  - Type of administration: computer vs. paper
  - Specificity to population of interest
  - Food preparation
FFQ: Strengths

- Low respondent burden: one administration
- Frame of reference: usual individual intake
- Information on total diet queried
- Does not affect eating behavior
- Low cost of administering/processing
  - Computer-generated data
FFQ: Weaknesses

- Lacks detail
  - Finite food list; details not collected
- Cognitively complex
- Requires literacy
- Different FFQs can behave quite differently
- Different populations respond differently
- Severe measurement error for absolute intake: bias
  - Ranking individuals
  - Energy adjustment used to reduce error
  - Outcome findings attenuated by error
Biomarkers to Assess Intake

- **Recovery**: represent 1:1 relationship between intake and biomarker value
  - Very few available
- **Concentration**: reflect biological response
  - Correlate to amount consumed
  - Cannot be used to assess amount consumed
  - May reflect short or long term intakes
  - Not usually appropriate for evaluating DRIs
- **Homeostatically controlled**: no relationship to intake
Underreporting in Free-Living Populations

- Problem for all self-report methods
- % energy underreported based on review of DLW studies for energy:
  - Food records: up to 58%
  - 24-hour dietary recalls: up to 26%
  - FFQs: up to 38%
- % protein underreporting based on UN tracks with energy; tends to be slightly lower
- Underreporting can differ by gender, age, BMI, etc.
Results from OPEN*: Energy Intake Underestimation

*OPEN: NCI’s Observing Protein and Energy Nutrition Study
Results from OPEN: Energy Intake Underreporting by Weight Category

Energy Underreporting by Category of BMI

- Normal Weight
- Overweight
- Obese

* Trend test: $p < .05$
Dietary Supplements

- May or may not be collected
- Often episodically consumed
- Not accounting for supplement intake:
  - Substantial underestimation of total nutrient intake
- Including supplement intake:
  - Skewed distributions
  - By itself and combined with diet: usual intake estimation is difficult
- Measurement error is present
Nutrient Database

- Another source of error in all self-report dietary data
- Methods of analysis change and improve
- Content of foods constantly changing
  - Database needs to match time period of study
Goal for All Applications: Usual Intake

- Theoretical long-run average daily intake of a dietary component
- Common operational definition: average daily intake over past year
- But we may only have a few dietary recalls…
• Impossible to observe long term intakes
• Best estimates based on statistical modeling using short term, self-reported data
Evolution in Estimating Usual Intake Distributions from Recalls or Records

- Single day of intake for recalls
- Average of a few single-day measurements
- Statistical modeling
  - National Research Council method
  - Iowa State University method
  - NCI method
Statistical Modeling

- Removes day-to-day variability from 24-HRs
- Involves assumptions
- Approach well-established for
  - Most nutrients
1-day vs Usual Intake (UI) Distributions

![Graph showing 1-day vs Usual Intake Distributions.](image)
New NCI Method to Estimate Usual Intake

- Builds on NRC/ISU methods
- Estimates usual nutrient intake distributions
- Handles episodically consumed dietary constituents
  - Nutrients such as vitamin A
  - Can be applied to foods and dietary supplements
- Provides greater power to conduct subgroup analyses
Using Dietary Intake Data in DRI Process

• Dietary exposure assessment
  – Ideally: usual intake distributions estimated from multiple days of intake and statistical modeling
  – Sometimes: intake data from observational studies

• Consistency check on DRI values
Limitations and Benefits of Dietary Exposure Assessment Data

- A gold standard for self-reported intake does not exist
- Methods vary in quality
- Measurement error always present
- Need to acknowledge and understand limitations
- But …statistical methods can compensate
- Best dietary exposure data are those modeled to estimate usual intake for purposes of:
  - Estimating intake distributions for populations
  - Determining relationships between intake and health outcomes for individuals
Overall Conclusions

- Usual intake cannot be observed but it can be modeled.
- Good estimates of usual intake are necessary to assess population level dietary exposure.
- Using observational data to set DRIs must be done understanding limitations.
GOOD LUCK TO US ALL!