Dietary Assessment: Understanding and Addressing the Concerns

Susan M Krebs-Smith, PhD, MPH
US National Cancer Institute
Risk Factor Assessment Branch
Framework for presentation

- Concerns
- Resource
- Tool
Concerns

AF Subar, LS Freedman, JA Tooze, SI Kirkpatrick, C Boushey, ML Neuhouser, FE Thompson, N Potischman, PM Guenther, V Tarasuk, J Reedy, and SM Krebs-Smith
Concerns: Outline

- Recent criticisms of self-report dietary data
- Overview of measurement error
- Accuracy of absolute energy intake based on self-report
- Magnitude of underreporting: energy vs. other nutrients
- Implications of measurement error
- Recommendations regarding data collection, analysis, and interpretation
Criticisms of self-report dietary data

- Based on energy “underreporting,” dietary self-report data have no value
Opinion: A Wolf in Sheep’s Clothing

Nutrition research must overcome pseudoscientific measures and self-interest to make progress in the fight against obesity.

By Edward Archer | October 22, 2013

So what is going on? Is such research mere pseudoscience? And if so, how can the federal government continue to spend billions of taxpayer dollars on studies that are making no demonstrable progress in our nation’s fight against obesity and diabetes?

... implies that the field has been perpetrating fraud against the US taxpayers for more than 40 years—far greater than any fraud perpetrated in the private sector (e.g., the Enron and Madoff scandals).

“... the equivalent of saying the Titanic had a floatation problem or a buoyancy problem. These data should not be used,” says Edward Archer, an obesity researcher, who authored a scientific takedown of the NHANES data in the Journal PLOS One.
What is measurement error?

- **Random error**
- **Bias**

Difference between the measured value and the true value
Measurement error is pervasive
Sources of measurement error in self-report data

- Within-person variation
  - Easily adjusted with repeat applications and modeling
- Memory, depending on method
- Food and nutrient databases
- Default recipes and portion sizes
- Systematic bias: Misreporting based on individual characteristics
Energy intake is inaccurately estimated by self-report

- This major criticism is TRUE
  - Based on DLW and estimated energy requirements compared to self-report
- Must be widely acknowledged
- This systematic error varies by:
  - Instrument
  - Population characteristics
Potential sources of energy misreporting

- Never intended to measure energy
- Finite list of foods and beverages
- Limited specificity
- Food database represents composites
Potential sources of energy misreporting

- Memory issues
- Difficulty in estimating quantity
Potential sources of energy misreporting

- Reactivity
- Difficulty in estimating quantity (depends on methods)
- Memory, if not completed in real time
Why we have energy misreporting

- Limitations of each instrument
- Social desirability
- Social environment that stigmatizes obesity
- Energy is in nearly every food
  - Small and large errors add up
  - Energy intake errors likely larger in magnitude than for other nutrients and food groups

Data have flaws which require thoughtful analysis and interpretation.
Nutrition community acknowledges measurement error

- Ongoing research since the 1970s
- Acknowledgement of limitations of self-report
- Progress to mitigate it:
  - Appropriate study design
  - Selection of number and types of instruments
  - Statistical methods to reduce error
  - Recommendations regarding interpretation of findings
Magnitude of underreporting

- Validation Studies Pooling Project (VSPP)
  - Combined data from four of the largest recovery biomarker studies ever conducted in the US
  - All had DLW, multiple 24-urines
  - Energy, protein, potassium, sodium
  - FFQs and 24HRs

Magnitude of underreporting

- Energy underreporting:
  - FFQs: 24-33%
  - 24HRs:
    - 6-16% for young and middle aged adults
    - 25% for elderly women

- Underreporting of other nutrients
  - 24HRs:
    - 5% protein
    - 3% potassium

- Controlled feeding study
  - Reported vs. known intakes not different for foods and nutrients

Kirkpatrick et al.. *Am J Clin Nutr* 2014;100:233-40
Energy: *not* the only important aspect of dietary intake

- Energy is clearly important
  - How much precision is needed?
  - Weight is the best measure of energy balance
- There are other critically important dietary factors:
  - Food intakes
  - Diet quality
  - Social and physical environment related to consumption
  - Nutrient intakes
- Self-report data guide education and policy
Surveillance implications

- Energy collected from 24HRs
  - Energy distributions shifted left
  - Persons above or below cut points affected
  - Correction for bias must consider population subgroups (BMI, education, etc.)
  - Biased and difficult to interpret
  - DLW would be optimal but often impractical
Surveillance implications

- Assessment of energy balance
  - Intake and expenditure both difficult to measure from self-report or even monitors
  - Weight and waist circumference over time or controlled feeding studies are better measures
Surveillance implications

- Valuable data for obesity related questions
  - Types of foods consumed
  - Contextual factors (when and with whom eaten)
  - Assessment of nutrient adequacy
  - Assessment of nutrient or food group quality
    - e.g. intake/1000 kcal as in the Healthy Eating Index
Quality of children’s diets as measured by HEI-2010

NHANES 2007-08, children ages 2-17
Major sources of sodium in diets of US population

NHANES 2005-06, ages 2 and older
Percentage of persons eating less than recommended intake of fruits

- Consuming less than recommendation: 76%
- Consuming recommended amount: 12%
- Consuming more than recommended amount: 12%

Surveillance implications

- Valuable insights from surveillance data
  - Added sugar consumption far exceeds recommendations
  - Overall diet quality not consistent with Dietary Guidelines
- To the extent that bias exists
  - Less underreporting of fruits
  - More underreporting of sugar
  - So, it is likely worse than what we are measuring
- Data are valuable
  - Corrective action
  - Nutrition policy
Epidemiology implications

- Collect recovery biomarker when possible (in at least a subset) to do measurement error adjustment
- Do not use absolute energy as an exposure variable
- Collect DLW to correct for energy in self-report
- Do not use DLW to energy adjust other nutrients and food groups -- use self-reported energy
- In multivariate models of disease risk: control for self-reported energy
  - Reduces bias
  - Do not use energy coefficients to make inferences
Epidemiology implications

- If an association is found:
  - Error likely means associations are underestimated
  - Residual confounding can occur -- does not usually lead to spurious findings
  - Strong signal across studies likely to be true
  - FFQs most likely to fail to detect important associations, especially if small
Carcinogenicity of consumption of red and processed meat

Véronique Bouvard, Dana Loomis, Kathryn Z Guyton, Yann Grosse, Fatiha El Ghissassi, Lamia Benbrahim-Tallaa, Neela Guha, Heidi Mattock, Kurt Straif

The Lancet Oncology
Volume 16, Issue 16, Pages 1599-1600 (December 2015)
DOI: 10.1016/S1470-2045(15)00444-1
“The Working Group assessed more than 800 epidemiological studies that investigated the association of cancer with consumption of red meat or processed meat in many countries, from several continents, with diverse ethnicities and diets. For the evaluation, the greatest weight was given to prospective cohort studies done in the general population. High quality population-based case-control studies provided additional evidence…”
HRs of all-cause mortality across cohorts (women)

* Models adjusted for age, race, education, BMI, physical activity, smoking, energy, diabetes, alcohol (HEI/DASH), HRT (women); Comparing Q5 vs. Q1: HEI = Healthy Eating Index-2010, AHEI = Alternate Healthy Eating Index-2010; aMED = Fung’s Mediterranean Diet Score; DASH = Fung’s Dietary Approaches to Stop Hypertension Score
HRs of CVD mortality across cohorts (women)

* Models adjusted for age, race, education, BMI, physical activity, smoking, energy, diabetes, alcohol (HEI/DASH), HRT (women); Comparing Q5 vs. Q1: HEI = Healthy Eating Index-2010, AHEI = Alternate Healthy Eating Index-2010; aMED = Fung’s Mediterranean Diet Score; DASH = Fung’s Dietary Approaches to Stop Hypertension Score
HRs of cancer mortality across cohorts (women)


* Models adjusted for age, race, education, BMI, physical activity, smoking, energy, diabetes, alcohol (HEI/DASH), HRT (women); Comparing Q5 vs. Q1: HEI = Healthy Eating Index-2010, AHEI = Alternate Healthy Eating Index-2010; aMED = Fung’s Mediterranean Diet Score; DASH = Fung’s Dietary Approaches to Stop Hypertension Score
Recommendations for data collection, analysis and interpretation

- Improve tools
  - Technology may help
- Combine dietary assessment methods if possible
- For energy, consider administering DLW
- Research more affordable methods to accurately measure energy intake and expenditure
  - Self-report still useful for patterns, diet quality, etc.
- Thoughtfully interpret data

Recommendations for data collection, analysis and interpretation

- To improve estimates of mean intakes and distributions of energy for surveillance:
  - Collect DLW in at least a subset to adjust for error in energy intake estimates
- Continue to collect 24-hour recalls
Recommendations for data collection, analysis and interpretation

- Begin using recalls or record as primary tool vs. food frequency questionnaires
  - Technology makes this feasible
  - Recalls and records less biased and culturally neutral
- Combining methods: use FFQ data for covariate information
- If FFQ is primary instrument:
  - Include calibration/validation substudies and do measurement error adjustment
DIETARY ASSESSMENT PRIMER

SM Krebs-Smith, SI Kirkpatrick, AF Subar, AB Rodgers, TE Schap, J Reedy, MM Wilson, FE Thompson
Background

- Importance of appropriate assessment
- Multiple approaches to dietary assessment
- Identifying the best method for a particular purpose can be challenging
WHAT WOULD YOU LIKE TO DO?
Learn about self-report dietary assessment instruments

- **Instrument Profiles**
  - 24-Hour Recall (24HR)
  - Food Record (FR)
  - Food Frequency Questionnaire (FFQ)
  - Screeners

- **Comparing Dietary Assessment Instruments**
24-hour Dietary Recall (24HR) At a Glance

Purpose

Description

Utility of Data

Limitations of Data

Salient Features Compared to Other Self-Report Instruments
Validation

Evaluating Validity

Understanding Misreporting

Considering Measurement Error
Data Capture

Mode of Administration

Population Considerations

Resource Requirements

Study Design Considerations
Data Processing and Data Analysis

Data Processing Requirements

Data Analysis Considerations

General

Guidance for Specific Research Objectives
References and Resources

Cited References

Additional References

Resources
### Dietary Assessment Primer

<table>
<thead>
<tr>
<th>Study design</th>
<th>24-Hour Recall (24HR)</th>
<th>Food Record (FR)</th>
<th>Food Frequency Questionnaire (FFQ)</th>
<th>Screener</th>
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<th>Food Record (FR)</th>
<th>Food Frequency Questionnaire (FFQ)</th>
<th>Screener</th>
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<td>Total diet</td>
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<td>One or a few components</td>
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<th>Food Frequency Questionnaire (FFQ)</th>
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<td>X</td>
<td>X</td>
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<tr>
<td>No</td>
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Learn about key concepts in dietary assessment

- **Key Concepts**
  - Measurement Error
    - Types of Measurement Error
    - Effects of Measurement Error
    - Evaluating the Measurement Error Structure of Self-Report Dietary Assessment Instruments
  - Validation
    - Validation Using Unbiased Reference Instruments
    - Validation Using Imperfect Reference Instruments (Comparative or Relative Validation)
    - Interpretation of Validation Studies
Learn how to use self-report instruments to address different research questions

- **Choosing an Approach for Dietary Assessment**
  - Principles Underlying Recommendations
  - Details of Recommendations & Further Considerations
    - Describing Dietary Intake
    - Examining the Association between Diet as an Independent Variable and a Dependent Variable
    - Examining the Association between an Independent Variable and Diet as a Dependent Variable
    - Evaluating the Effect of the Intervention

- **Choosing an Approach for Dietary Assessment Table**
## Approach

**More:**
- Information provided
- Flexibility for analyses
- Investigator and respondent burden cost

**Less:**
- Information provided
- Flexibility for analyses
- Investigator and respondent burden cost

## Describing dietary intake

<table>
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<tr>
<th>x(24HR) + FFQ</th>
<th>x(24HR) + x(24HR)</th>
<th>FFQ/SCR + x(24HR)</th>
<th>24HR Single administration of 24HR on whole sample</th>
<th>FFQ</th>
<th>SCR</th>
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<tbody>
<tr>
<td>Multiple administration of 24HR plus FFQ on whole sample</td>
<td>Single administration of 24HR on whole sample plus repeat(s) on subsample</td>
<td>FFQ/SCR on whole sample plus multiple administrations of 24HR on subsample</td>
<td>FFQ on whole sample</td>
<td>Screener on whole sample</td>
<td></td>
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</tbody>
</table>

### 1. Mean ($\mu$) usual intake

| More than necessary $d$ | More than necessary $d$ | More than necessary $d$ | Acceptable, if calibrated to 24HR $e$ | Recommended | Possible $f$ | Possible $f$ |

### 2. Difference between two groups in mean usual intake ($\mu_A - \mu_B$)

<table>
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<th>Acceptable, if</th>
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</table>
Learn more about specific aspects of dietary assessment research

• Learn More
  • Biomarkers
  • Calibration
  • Combining Instruments
  • Day-of-Week Effect
  • Diet History
  • Dietary Supplements and Estimating Total Nutrient Intakes
  • Deriving Group-level Estimates from Individual-level Intakes
  • Energy Adjustment
  • Food Composition Databases for 24-hour Dietary Recalls and Food Records
  • Food Composition Databases for Food Frequency Questionnaires and Screeners
  • Misreporting
  • Normal Distribution
  • Observation and Feeding Studies
  • Outliers
  • Ratios and Proportions
  • Reactivity
  • Regression Calibration
  • Scoring Algorithms for Screeners
  • Season Effect
  • Social Desirability
  • Software for 24-Hour Dietary Recalls (24HR) and Food Records
  • Software for Food Frequency Questionnaires and Screeners
  • Statistical Modeling
  • Surrogate Reporting
  • Technology in Dietary Assessment
  • Usual Dietary Intake
Learn more about specific aspects of dietary assessment research

A second class of validity studies relies on independent and unobtrusive observation of the eating behaviors being recorded in the food record (Learn More about Observation and Feeding Studies).

Learn More about Direct Observation and Feeding Studies

By design, both observation studies and feeding studies occur in specific settings. Institutional meal settings, such as in schools, cafeterias or nursing homes, provide the optimal opportunities for unobtrusively observing study participants in natural eating environments. Trained research staff observe individuals during a meal, noting all foods and portions consumed. The observer may have access to a planned menu, weighed portions given to participants, and/or plate waste. Feeding studies are typically conducted in more controlled research environments and always include unobtrusive recording of pre- and post-meal weights of known foods. In many studies, two research staff are assigned to monitor participants’ intakes. Quality control procedures for individual observers and across observers should be developed and followed. For both direct observation and controlled feeding studies, standardized recording forms should be used.
Understand the terminology

- Glossary of Key Terms
Understand the terminology

• Glossary of Key Terms

Usual portion size can be asked separately for each food and beverage. Alternatively, portion size can be combined with frequency information by asking respondents to translate usual consumption amount to number of specified units (e.g., How often do you eat a ½ cup of rice?). Some questionnaires include portion size images in an attempt to enhance reporting accuracy.
Understand the terminology

- Glossary of Key Terms

Usual portion size can be asked separately for each food and beverage. Alternatively, portion size can be combined with frequency information by asking respondents to translate usual consumption amount to number of specified units (e.g., How often do you eat a ½ cup of rice?). Some questionnaires include portion size images in an attempt to enhance reporting accuracy.

Accuracy

The degree of closeness of measurements of a quantity to that quantity’s true value.
Find articles cited in the Primer and become familiar with related resources

- References
- Resources
  - Dietary Assessment Primers, Toolkits and Tutorials
  - Dietary Assessment Instruments
  - Calibration and Validation Registers
  - Scoring Algorithms for Screeners
  - Food Composition Databases
  - Dietary Analysis Software
  - Diet Quality Indexes
https://dietassessmentprimer.cancer.gov
Web stats (Jan-April, 2016)

- More than 6,500 visits
- More than 5,300 unique visitors
- About 16,000 page visits
- Most visits from:
  - US
  - Australia
  - Germany
  - Canada
  - Great Britain
  - France
  - Sweden
  - Japan
  - Netherlands
Tool

Amy F. Subar, PhD, MPH, RD
What is ASA24?

- Fully automated, web-based, self-administered 24-hour recall
- Complete system for probing, coding, and calculation of intakes
- Format based on the Automated Multiple-Pass Method (AMPM) used in NHANES
- Freely available
Latest version

- Released in March, 2016
- Runs on all mobile devices!
- Can be used to collect food records as well as recalls
- Nutrient, food group, supplement databases updated to those used in NHANES 2011-12
- Available in English and Spanish
• Freely available web-based tool

Number of studies registered and number of recalls collected from June 2009 to March 2016.

Researchers register a study  
Respondents complete dietary recalls or records  
Researchers monitor responses and obtain data analysis
Options

ASA24-2016 contains many options and optional modules for research studies:

- supplements
- food source
- with whom meals were eaten
- use of electronic devices during meals
- location of meals

For dietary recalls:

- midnight-to-midnight vs. past 24 hours
- multiple vs. single logins
- completion time restricted to 24 hours

For food records (food diaries):

- single vs. multiple days
- consecutive vs. non-consecutive days
Time to complete

Average time to complete a 24-hour recall

Time in Minutes - No Supplements

Time in Minutes - With Supplements
Available versions

- ASA24-2016
- ASA24-Kids-2014
  - Shorter food list and probes regarding food preparation
- ASA24-Canada-2014
  - Food list Canadianized
  - Nutrient database adapted for Canada
Coming soon

- ASA24-Kids-2016
- ASA24-Canada-2016
  - In English and French Canadian
- ASA24-Australia-2016
  - Food list and nutrient databases adapted for Australian population
- Option for all 2016 versions to provide customized nutrient and food group intake reports
For more information

epi.grants.gov/asa24
Conclusions

- Concerns
- Resource
- Tool
Concerns

1) Continue to collect self-report dietary intake data for surveillance and epidemiology

2) Do not use self-reported energy intake as a measure of energy intake

3) Do use self-reported energy intake for energy adjustment of other self-reported dietary constituents to improve risk estimation

4) Acknowledge the limitations of self-report dietary data; analyze and interpret them appropriately
Concerns

5) Design studies and conduct analyses that allow adjustment for measurement error

6) Design new epidemiological studies to collect data from both short- and long-term instruments on everyone

7) Continue to develop, evaluate, and further expand methods including biomarkers and new technologies
Concerns
Resource and Tool

- Visit:

Dietary Assessment Primer

dietassessmentprimer.cancer.gov

ASA24

Automated Self-Administered 24-hour Recall

epi.grants.gov/asa24
Questions?

- Concerns
- Resource
- Tool