Applying recovery biomarkers to calibrate self-report measures of energy, protein, sodium & potassium in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)

Women's Health Initiative Scientific Interest Group
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Study Design for Parent Study

- Multi-center, community based cohort study
  - Households selected via two-stage area probability sample in communities surrounding field centers
- Enrolled 16,415 US Hispanic/Latino adults (18-74 yrs)
  - 4,000+ per field center who self-identify as Hispanic/Latino
- Sufficient subgroup sample sizes to support comparisons by Hispanic/Latino background
  - Cubans
  - Central Americans
  - South Americans
  - Mexicans
  - Puerto Ricans
  - Dominicans
Why Study of Latinos- Nutrition & Physical Activity Assessment Study (SOLNAS)?

- Ability to detect diet-disease relationships diminished due to self-report bias
- Biomarker-corrected energy consumption in the Women’s Health Initiative reflects positive relationship between energy intake, total cancers, diabetes, whereas uncorrected data do not reflect these associations (Prentice 2009; Tinker 2011). What about HCHS/SOL participants?


Aims

• Compare self-reported energy & protein (24 HR recall) to objective recovery biomarkers (Doubly Labeled Water, urinary nitrogen)
  – Urinary sodium & potassium were also collected

• Fit measurement error model to produce calibrated intake and physical activity measures on the full cohort for use in analyses of clinical outcomes

• Collect blood concentration biomarkers (folate, carotenoids, tocopherols, vitamin B12, retinol) for future analyses
**Study Of Latinos: Nutrition & Physical Activity Assessment Study (SOLNAS)**

**Study Design**

**HCHS/SOL Baseline Visit**
- Day 1:
  - Informed consent
  - Anthropometry
  - Physical activity
  - Questionnaires
  - In-person 24-hr diet recall
- Days 1-7: Actical
- Days 5-90: 2nd 24-hr dietary recall by telephone

**Visit 1** *(n = 485)*
- In-person 24-hr diet recall
- Pre-DLW spot urine samples
- DLW dosing
- 2 post DLW spot urines
- Sedentary behavior and body image questionnaires
- 24-hour urine collection instructions

**Visit 2** *(n = 478)*
- 12 days after SOLNAS Visit 1
- Bring 24 hour urine to visit
- Weight
- Fasting blood draw
- Fasting urine
- One spot urine
- Indirect calorimetry

**Visit 3** *(n = 98)*
- 5-7 months post SOLNAS Visit 1
- Repeat procedures as in SOLNAS visit 1 plus instructions for Actical
- 2nd 24-hour dietary recall by telephone (5-90 days after visit 3)

**Visit 4** *(n = 96)*
- 12 days after SOLNAS Visit 3
- Repeat procedures as in SOLNAS Visit 2
- Collect Actical (7 days of wear) from participants

**SOLNAS Reliability Study**

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**If Eligible and Willing to Enroll in SOLNAS**

**Not Eligible**

**Within 7 Months after baseline visit**
- Invitation letter and telephone screening for SOLNAS
SOLNAS* Demographics (n=485)

- Mean age: 46.2 (y), SD 13.0
- Mean BMI at SOLNAS visit: 29.8 (kg/m²), SD 6.1
- 61% female; 76.5% prefer Spanish
- 31.5% < high school education
- 45.6 % not employed and not retired
## SOLNAS vs. HCHS/SOL

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>SOLNAS (n=485)</th>
<th>HCHS/SOL (n=16,415)</th>
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<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>18-44 yr</td>
<td>38.6</td>
<td>40.8</td>
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<tr>
<td>45+ yr</td>
<td>61.4</td>
<td>59.2</td>
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<tr>
<td>Male</td>
<td>39.2</td>
<td>40.1</td>
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<tr>
<td>Female</td>
<td>60.8</td>
<td>59.9</td>
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<tr>
<td>Not employed</td>
<td>54.0</td>
<td>49.4</td>
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<tr>
<td>Income:</td>
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<tr>
<td>&lt; $30K</td>
<td>67.0</td>
<td>64.1</td>
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<tr>
<td>≥ $30K</td>
<td>25.8</td>
<td>29.7</td>
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<td>Education:</td>
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<tr>
<td>&lt; high school</td>
<td>32.4</td>
<td>38.0</td>
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<tr>
<td>≥ high school</td>
<td>66.8</td>
<td>62.0</td>
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<td>BMI distribution:</td>
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<td>underweight</td>
<td>0.8</td>
<td>0.8</td>
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<tr>
<td>normal</td>
<td>18.8</td>
<td>20.3</td>
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<tr>
<td>overweight</td>
<td>40.0</td>
<td>37.3</td>
</tr>
<tr>
<td>obese</td>
<td>40.4</td>
<td>41.6</td>
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## Measurements: SOL & SOLNAS

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<th>DIET</th>
<th>PHYSICAL ACTIVITY</th>
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<tbody>
<tr>
<td><strong>Subjective Measurements</strong></td>
<td>24 hr Dietary Recall</td>
<td>Questionnaires:</td>
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<tr>
<td></td>
<td>Food Propensity Questionnaire</td>
<td>Modified 16-item</td>
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<tr>
<td></td>
<td>Multi-cultural Food Frequency Questionnaire* (*Bronx only)</td>
<td>Global Physical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Activity (GPAQ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sedentary Behavior</td>
</tr>
<tr>
<td><strong>Objective Measurements</strong></td>
<td>Doubly Labeled Water</td>
<td>Actical</td>
</tr>
<tr>
<td></td>
<td>Urinary nitrogen, potassium, sodium, fructose, sucrose, polyphenols</td>
<td>Indirect Calorimetry</td>
</tr>
<tr>
<td></td>
<td>Serum levels of folate, carotenoids, tocopherols, retinol, vitamin B12</td>
<td></td>
</tr>
</tbody>
</table>
Doubly Labeled Water
24 hr Urine collection
Psycho-social & other unique covariates

From parent study SOL:
- SF-12 Health Survey, Socio-Cultural, Social Network Index, Well-Being

From SOLNAS:
- Body Image, Acculturation
Approach

Primary study: n= 471*  
Reliability Study: n= 96*

We regressed the biomarker on self-reported intake and participant characteristics to develop prediction equations for usual short-term intake of energy, protein, sodium and potassium.

- Linear regression model, with intakes on log-scale and stepwise backwards selection for keeping characteristics significant at level $p<0.1$

*n=450 for protein analyses, n=447 for sodium/potassium analyses in primary study; n=90 for protein analyses, n=85 for sodium and potassium analyses in reliability study with 24-hr urinary potassium/sodium and reliable 24 HR dietary recall that are >500 kcal.
Energy (kcal/d): Self-report vs Biomarker by sex and Hispanic/Latino background (age-adjusted)

Underestimation
Overall: 25.3%
Men: 21.8%
Women: 27.3%
Protein: Self-report vs Biomarker by sex and Hispanic/Latino background (age-adjusted)
Protein Density: Self-report vs Biomarker by sex and Hispanic/Latino background (age-adjusted)
Example: Calibration Energy Equation
Referent group: male, Mexican non-smoker

- Calibrated log energy = 7.92 +0.050*(log Q - 7.49) + 0.015*(BMI - 29.6) – 0.002* (Age - 46)
  - Self-reported 1790 kcal, BMI 29.6, Age 46 yrs has predicted median energy intake = 2752 kcal
  - 25% increase in self-reported intake associated with a 1% increase in predicted median intake
  - Being South American associated with a 7% decrease in predicted median intake
  - Being female associated with a 19.5% decrease in predicted median intake
  - 5 kg/m² increase in BMI associated with a 8% increase in predicted median intake
Correlates of energy/protein underestimation

- Energy intake was underestimated on average by 25.3% (men 21.8%; women 27.3%)
- Protein intake underestimated on average by 18.5% (men 14.7%; women 20.7%)
- Participant characteristics associated with underestimation of energy included higher BMI and Hispanic heritage*
- For protein, these characteristics included higher BMI, older age, being a non-smoker, Spanish speaking and Hispanic heritage*

*P<0.05
Comparison of the logarithm (log) of visit 1 and visit 3 measures (n = 96 and n = 90 for energy and protein, respectively), Study of Latinos: Nutrition and Physical Activity Assessment Study, 2010–2012. A) Biomarker energy (kcal), correlation = 0.81; B) 24-HR energy intake (kcal), correlation = 0.58; C) biomarker protein (g/day), correlation = 0.66; D) 24-HR protein intake (g/day), correlation = 0.51; E) biomarker protein density (percentage of energy derived from protein), correlation = 0.59; F) 24-HR protein density (percentage of energy derived from protein), correlation = 0.24. DLW, doubly labeled water; 24 HR, 24-hour dietary recall; UN, urinary nitrogen.
**Background**

- 90.7% of US adults consumed more sodium than recommended (2300 mg/day); <2% of US adults consumed the recommended intake for potassium (≥4700 mg/day)

- Among US adults mean sodium intake is 3569 mg/day; mean potassium intake is 2745 mg/day

- Mexican-Americans consume median of 3251 mg of sodium and 2586 mg of potassium per day

- Limited information exists for Other Hispanics: 19-50 yr mean: 3599 mg/day for sodium (vs 19-50 yr mean of 3558 mg/day of sodium for Mexican-Americans)

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1. To assess in SOLNAS, a sub-study of HCHS/SOL, the measurement error properties of the study diet assessment instrument-- using 24-HR dietary recalls for potassium and sodium by comparison with 24-HR urinary potassium and sodium biomarkers.*

2. To fit measurement error models to produce calibrated intake on the full cohort for use in analyses of clinical outcomes.

*Approximately 80% of potassium intake and 86% of sodium intake recovered in the urine.¹

Variables Considered

Demographic: age, sex, ethnicity, income, education, employment, language

Behaviors:
• % of meals at home
• Type of food (Hispanic vs American)
• Eating at fast food outlets
• Restaurant score (range: 0 to 36)
• Supplement use (last 30 days)
• Alcohol level (no current use, low level, high level)
• Smoking status (current or not)
• Self-reported physical activity (min/day of total activity)

Medications:
• Anti-hypertensives
• Diuretics
• Corticosteroids
• Beta blockers
• Calcium channel blockers
Age-adjusted geometric mean (95% CI) for SODIUM (mg): Biomarker vs. Self-reported by Hispanic/Latino background and sex

Overall
Dominican
Central American
Cuban
Mexican
Puerto Rican
South American

Male: Biomarker • Male: Self-Report
Female: Biomarker • Female: Self-Report
Age-adjusted geometric mean (95% CI) for POTASSIUM (mg): Biomarker vs. Self-reported by Hispanic/Latino background and sex
Selected variables from backward selection

Regression Calibration

### SODIUM

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td>Log (self-report sodium)</td>
<td>1</td>
<td>0.019</td>
</tr>
<tr>
<td>BMI group</td>
<td>2</td>
<td>&lt;.001</td>
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<tr>
<td>Age group</td>
<td>3</td>
<td>0.035</td>
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<tr>
<td>Female</td>
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<td>&lt;.001</td>
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<td>English</td>
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<td>0.058</td>
</tr>
<tr>
<td>Supplement Use</td>
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</tr>
<tr>
<td>Physical Activity</td>
<td>1</td>
<td>0.017</td>
</tr>
<tr>
<td>Restaurant score</td>
<td>1</td>
<td>0.070</td>
</tr>
<tr>
<td>Fast food</td>
<td>1</td>
<td>0.070</td>
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Total R-squared = 0.21  
Adjusted R-squared = 0.76

### POTASSIUM

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<tr>
<td>Log (self-report potassium)</td>
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<td>0.001</td>
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<tr>
<td>BMI group</td>
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<tr>
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<tr>
<td>Female</td>
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<td>&lt;.001</td>
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<tr>
<td>Ethnicity</td>
<td>5</td>
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<tr>
<td>Employment status</td>
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<td>0.095</td>
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<tr>
<td>Supplement Use</td>
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<td>0.001</td>
</tr>
<tr>
<td>Current Smoker</td>
<td>1</td>
<td>0.018</td>
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Total R-squared = 0.25  
Adjusted R-squared = 0.63

Adjusted R-squared = R-squared / Correlation (biomarker Main vs. biomarker Reliability)
### Sodium (mg): Regression calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>8.024</td>
<td>0.111</td>
</tr>
<tr>
<td>Centered Log (self-reported sodium)</td>
<td>0.120</td>
<td>0.050</td>
</tr>
<tr>
<td>BMI group: overweight</td>
<td>0.149</td>
<td>0.062</td>
</tr>
<tr>
<td>BMI group: obese</td>
<td>0.297</td>
<td>0.062</td>
</tr>
<tr>
<td>Age group: 25-39y</td>
<td>0.103</td>
<td>0.093</td>
</tr>
<tr>
<td>Age group: 40-54y</td>
<td>0.171</td>
<td>0.088</td>
</tr>
<tr>
<td>Age group: 55-74y</td>
<td>0.053</td>
<td>0.095</td>
</tr>
<tr>
<td>Gender: Female</td>
<td>-0.276</td>
<td>0.050</td>
</tr>
<tr>
<td>Language Preference: English</td>
<td>-0.094</td>
<td>0.054</td>
</tr>
<tr>
<td>Supplement use: Yes</td>
<td>0.085</td>
<td>0.045</td>
</tr>
<tr>
<td>Log (GPAQ total)</td>
<td>0.023</td>
<td>0.011</td>
</tr>
<tr>
<td>Restaurant score</td>
<td>-0.016</td>
<td>0.008</td>
</tr>
<tr>
<td>Fast food: &lt; 1 per week</td>
<td>0.001</td>
<td>0.063</td>
</tr>
<tr>
<td>Fast food: 1-2 times per week</td>
<td>0.026</td>
<td>0.072</td>
</tr>
<tr>
<td>Fast food: &gt; 2 times per week</td>
<td>0.244</td>
<td>0.121</td>
</tr>
</tbody>
</table>

Referent group: normal weight, < 25y, male, Spanish speaker, non-supplement user, and never fast food. Log(self-reported sodium) centered at 7.95
Sodium: Regression calibration example

PROFILE “Referent group”: normal weight, < 25y, male, Spanish speaker, non-supplement user, never fast food, restaurant score = 0, and GPAQ total activity = 0.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean SR sodium</th>
<th>SR sodium</th>
<th>ln(SR sodium)</th>
<th>log(SR sodium)</th>
<th>calibrated sodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2,833.69</td>
<td>3000</td>
<td>7.949336</td>
<td>8.00637</td>
<td>6222.913595</td>
</tr>
<tr>
<td>Centered Log (self-reported sodium)</td>
<td></td>
<td></td>
<td>0.12</td>
<td>5.93328</td>
<td>5.933279</td>
</tr>
<tr>
<td>BMI group: overweight</td>
<td></td>
<td></td>
<td>0.149</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>BMI group: obese</td>
<td></td>
<td></td>
<td>0.297</td>
<td>0.7119935</td>
<td>0.297</td>
</tr>
<tr>
<td>Age group: 25-39y</td>
<td></td>
<td></td>
<td>0.103</td>
<td>0</td>
<td>0</td>
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<tr>
<td><strong>Age group: 40-54y</strong></td>
<td></td>
<td></td>
<td>0.171</td>
<td>0</td>
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<tr>
<td>Age group: 55-74y</td>
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<td>0.053</td>
<td>0</td>
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<td>Gender: Female</td>
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<td>Log (GPAQ total)</td>
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<tr>
<td>Restaurant score</td>
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<tr>
<td>Fast food: &gt; 2 times per week</td>
<td></td>
<td></td>
<td>0.244</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ \log(SR \text{ sodium}) = 8.7359935 \]
\[ \text{calibrated \ sodium} = 6222.913595 \]
\[ \log(SR \text{ sodium}) = 9.0559935 \]
\[ \text{calibrated \ sodium} = 8569.747087 \]
Correlation between primary & reliability studies

Sample size = 85
Summary of sodium-potassium

Self-reported diet data underestimated potassium intake by 1.3\% in men; 4.6 \% in women; sodium intake underestimated by 19.8\% in men; 20.8\% in women

For **potassium intake**, a higher body mass, a lower restaurant score*, and more supplement use were associated with significant *under-estimation*

For **sodium intake**, being older, having higher body mass index and lower restaurant score were associated with significant *under-estimation* of sodium intake

Systematic *underestimation of sodium* varied by Hispanic/Latino background (p=0.04)

*Underestimation of potassium was also associated with visiting fast food outlets less frequently: 1-2 times/wk vs >3 times/wk.*
Overall Summary

• Biomarker-calibrated measures of diet can be used to adjust for measurement error and has potential to improve diet-disease associations.

• Under-reporting whether due to quantifying amorphous foods (e.g., rice dishes) or missed foods (drinks), math/spatial skills, lack of familiarity with measurements used or other reasons underscore need to better prepare respondent to describe foods.
References

- http://www.cscce.unc.edu/hchs/


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- National Institute of Deafness and Other Communication Disorders
- National Institute of Dental and Craniofacial Research
- National Institute of Minority Health and Health Disparities
- National Institute of Health-Office of Dietary Supplements