What's For Dinner:  
A Linear Analysis of Nutritional Data and an Application to Community Health

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Introduction

- Real World Applications of Linear Algebra
- Our own project in Linear Algebra I, Fall 2010, involving three foods, three nutrients, and a $5 college budget
Stigler’s Diet Problem
Previous Studies

Stigler’s Diet Problem
- Wheat flour, evaporated milk, cabbage, spinach, and navy beans for $39.93 per year for one man
Previous Studies

- Stigler’s Diet Problem
  - Wheat flour, evaporated milk, cabbage, spinach, and navy beans for $39.93 per year for one man
- Meal optimization in developing countries
Our Project

- Community-based
Our Project

- Community-based
  - Housing Authority of the City of Asheville (HACA)
Our Project

- Community-based
  - Housing Authority of the City of Asheville (HACA)
- Average family size of four
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- Food stamp budget
Our Project

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  - Housing Authority of the City of Asheville (HACA)
- Average family size of four
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- Eleven key nutrients
Our Budgets

- Annual income information per family provided by HACA
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- Food stamp estimates obtained at Food and Nutrition Service website by the U.S. Department of Agriculture (USDA)
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- Average food stamp allowance of $1-$3 per person per meal
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  - Estimates account for free school breakfast and lunch for children under 18
Our Budgets

- Annual income information per family provided by HACA
- Food stamp estimates obtained at Food and Nutrition Service website by the U.S. Department of Agriculture (USDA)
- Average food stamp allowance of $1-$3 per person per meal
  - Estimates account for free school breakfast and lunch for children under 18
- $12 per family for dinner, $6 for breakfast and lunch
Our Nutrients

- Recommended daily allowances (RDAs) of nutrients obtained through the USDA’s 2010 Dietary Guidelines for Americans
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- Macronutrients:
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  - Maximized calories, protein, carbohydrates, and fiber and minimized total fat
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  - Macronutrients:
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  - Micronutrients:
Recommended daily allowances (RDAs) of nutrients obtained through the USDA’s 2010 Dietary Guidelines for Americans

- Macronutrients:
  - Maximized calories, protein, carbohydrates, and fiber and minimized total fat

- Micronutrients:
  - Maximized calcium, potassium, vitamin A, vitamin C, and folate and minimized sodium
# Our Adjusted Nutrient Ranges

<table>
<thead>
<tr>
<th></th>
<th>Children 4-18</th>
<th>Adults 18-30</th>
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<tbody>
<tr>
<td>Calories</td>
<td>1300-2100</td>
<td>1900-2300</td>
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<tr>
<td>Protein (grams)</td>
<td>32.5-157.5</td>
<td>47.5-172.5</td>
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<tr>
<td>Carbs (grams)</td>
<td>179-289</td>
<td>261.5-316.5</td>
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<tr>
<td>Fiber (grams)</td>
<td>15-35</td>
<td>15-35</td>
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<tr>
<td>Total Fat (grams)</td>
<td>36-81.5</td>
<td>52.5-89.5</td>
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<tr>
<td>Calcium (mg)</td>
<td>1000-1300</td>
<td>1000-1300</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>4500-4700</td>
<td>4500-4700</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
<td>600-900</td>
<td>600-900</td>
</tr>
<tr>
<td>Vitamin C (µg)</td>
<td>45-75</td>
<td>45-75</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>300-400</td>
<td>300-400</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>0-2300</td>
<td>0-2300</td>
</tr>
</tbody>
</table>
Our Methods

- Created a list of 132 foods and their constituent nutrients
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  - Breads and grains, breakfast cereals, vegetables, fruit, nuts and seeds, legumes, poultry, fish, beef, and dairy
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  - Breads and grains, breakfast cereals, vegetables, fruit, nuts and seeds, legumes, poultry, fish, beef, and dairy
- Acquired current non-promotional prices for private label foods at Ingles Grocery Markets
Our Methods

- Created a list of 132 foods and their constituent nutrients
  - Breads and grains, breakfast cereals, vegetables, fruit, nuts and seeds, legumes, poultry, fish, beef, and dairy
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  - 14 locations within a 10 mile radius
Our Methods

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  - Breads and grains, breakfast cereals, vegetables, fruit, nuts and seeds, legumes, poultry, fish, beef, and dairy
- Acquired current non-promotional prices for private label foods at Ingles Grocery Markets
  - 14 locations within a 10 mile radius
  - Ingles prices are at or above discount grocery prices
Maximizing foods and nutrients using *Mathematica*
Creating Meals

- Maximizing foods and nutrients using Mathematica
- First results: Nutritious, but not exactly palatable
Creating Meals

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- First results: Nutritious, but not exactly palatable
- Reducing the number of foods to maximize
Maximizing foods and nutrients using Mathematica
First results: Nutritious, but not exactly palatable
Reducing the number of foods to maximize
Breakfast per person for two adults
Creating Meals

- Maximizing foods and nutrients using *Mathematica*
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  - $\frac{1}{2}$ Apple +1 banana +6 oz. plain yogurt +1 oz. raisins +1 oz. cashews +1 oz. instant oats +2 oz. orange juice
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  - The “gap-fillers”: Instant oats and orange juice
Creating Meals

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- Breakfast per person for two adults
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  - The “gap-fillers”: Instant oats and orange juice
  - Grand total: $1.71 \times 2 = $3.42
### Meeting the RDAs

\[ \frac{1}{3}A + \frac{1}{3}A = \frac{2}{3} \text{ Adult RDA} \]

<table>
<thead>
<tr>
<th></th>
<th>Calories</th>
<th>1267-1533</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (grams)</td>
<td>32-115</td>
<td></td>
</tr>
<tr>
<td>Carbs (grams)</td>
<td>174-211</td>
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</tr>
<tr>
<td>Fiber (grams)</td>
<td>10-23</td>
<td></td>
</tr>
<tr>
<td>Total Fat (grams)</td>
<td>35-38.5</td>
<td></td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>667-867</td>
<td></td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>3000-3133</td>
<td></td>
</tr>
<tr>
<td>Vitamin A ((\mu)g)</td>
<td>400-600</td>
<td></td>
</tr>
<tr>
<td>Vitamin C ((\mu)g)</td>
<td>30-50</td>
<td></td>
</tr>
<tr>
<td>Folate ((\mu)g)</td>
<td>200-267</td>
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<tr>
<td>Sodium (mg)</td>
<td>0-1533</td>
<td></td>
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<table>
<thead>
<tr>
<th></th>
<th>Our $3.42 Breakfast</th>
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<tbody>
<tr>
<td>Calories</td>
<td>1267</td>
<td></td>
</tr>
<tr>
<td>Protein (grams)</td>
<td>38.7</td>
<td></td>
</tr>
<tr>
<td>Carbs (grams)</td>
<td>211</td>
<td></td>
</tr>
<tr>
<td>Fiber (grams)</td>
<td>19.8</td>
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</tr>
<tr>
<td>Total Fat (grams)</td>
<td>38.5</td>
<td></td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>867</td>
<td></td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>3133</td>
<td></td>
</tr>
<tr>
<td>Vitamin A ((\mu)g)</td>
<td>450.3</td>
<td></td>
</tr>
<tr>
<td>Vitamin C ((\mu)g)</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Folate ((\mu)g)</td>
<td>267</td>
<td></td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>372.6</td>
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</table>
What's in a Meal?: Lunch

### Ingredients

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown Rice</td>
<td>19.5 oz.</td>
</tr>
<tr>
<td>Turkey</td>
<td>2.9 oz.</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>9.2 oz.</td>
</tr>
<tr>
<td>Squash</td>
<td>1.9 oz.</td>
</tr>
<tr>
<td>Zucchini</td>
<td>9.2 oz.</td>
</tr>
<tr>
<td>Provolone</td>
<td>3 oz.</td>
</tr>
<tr>
<td>Kidney Beans</td>
<td>2.4 oz.</td>
</tr>
<tr>
<td>Cucumber</td>
<td>8 oz.</td>
</tr>
</tbody>
</table>

*Total Cost: $6.00*

### Nutrition Content

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>1267</td>
</tr>
<tr>
<td>Protein (grams)</td>
<td>73.1</td>
</tr>
<tr>
<td>Carbs (grams)</td>
<td>174</td>
</tr>
<tr>
<td>Fiber (grams)</td>
<td>23</td>
</tr>
<tr>
<td>Total Fat (grams)</td>
<td>36.4</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>867</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>3000</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
<td>428.1</td>
</tr>
<tr>
<td>Vitamin C (µg)</td>
<td>50</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>213.3</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>1076.7</td>
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## What’s in a Meal?: Dinner

### Ingredients

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs</td>
<td>6</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>10 oz.</td>
</tr>
<tr>
<td>Spinach</td>
<td>1.6 oz.</td>
</tr>
<tr>
<td>Black Beans</td>
<td>3.4 oz.</td>
</tr>
<tr>
<td>Cheddar Cheese</td>
<td>8 oz.</td>
</tr>
<tr>
<td>Chicken</td>
<td>4.8 oz.</td>
</tr>
<tr>
<td>Applesauce</td>
<td>11.5 oz.</td>
</tr>
<tr>
<td>Bananas</td>
<td>2.1 lbs.</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$10.04</strong></td>
</tr>
</tbody>
</table>

### Nutrition Content

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Calories</td>
<td>2350.6</td>
</tr>
<tr>
<td>Protein (grams)</td>
<td>158.8</td>
</tr>
<tr>
<td>Carbs (grams)</td>
<td>293.7</td>
</tr>
<tr>
<td>Fiber (grams)</td>
<td>39.2</td>
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<tr>
<td>Total Fat (grams)</td>
<td>71</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>1359.5</td>
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<tr>
<td>Potassium (mg)</td>
<td>6266.7</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
<td>990.1</td>
</tr>
<tr>
<td>Vitamin C (µg)</td>
<td>100</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>533.3</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>2360.2</td>
</tr>
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</table>
## Total Nutritive Content

\[ 2A + \frac{2}{3}K \]

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Values</th>
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<tbody>
<tr>
<td>Calories</td>
<td>4667-6000</td>
</tr>
<tr>
<td>Protein (grams)</td>
<td>117-450</td>
</tr>
<tr>
<td>Carbs (grams)</td>
<td>642-826</td>
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<tr>
<td>Fiber (grams)</td>
<td>40-93</td>
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<td>Total Fat (grams)</td>
<td>129-233</td>
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<tr>
<td>Calcium (mg)</td>
<td>2666.7-3467</td>
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<tr>
<td>Potassium (mg)</td>
<td>12000-12533</td>
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<tr>
<td>Vitamin A (µg)</td>
<td>1600-2400</td>
</tr>
<tr>
<td>Vitamin C (µg)</td>
<td>120-200</td>
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<tr>
<td>Folate (µg)</td>
<td>800-1067</td>
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<tr>
<td>Sodium (mg)</td>
<td>0-6133</td>
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### Our Daily Values

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value</th>
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<tbody>
<tr>
<td>Calories</td>
<td>4885</td>
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<tr>
<td>Protein (grams)</td>
<td>271</td>
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<tr>
<td>Carbs (grams)</td>
<td>679</td>
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<tr>
<td>Fiber (grams)</td>
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<tr>
<td>Total Fat (grams)</td>
<td>146</td>
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<tr>
<td>Calcium (mg)</td>
<td>3094</td>
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<tr>
<td>Potassium (mg)</td>
<td>12400</td>
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<tr>
<td>Vitamin A (µg)</td>
<td>1869</td>
</tr>
<tr>
<td>Vitamin C (µg)</td>
<td>200</td>
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<tr>
<td>Folate (µg)</td>
<td>1013</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>3810</td>
</tr>
</tbody>
</table>
State of the project

- Succeeded in creating palatable meals high in nutrient content and low in cost
State of the project

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- Our results vs. real world applications
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  - Nutrition content can be slightly compromised in order to exchange foods for palatability, while remaining within a set budget
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  - Limited database
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- Our results vs. real world applications
  - Nutrition content can be slightly compromised in order to exchange foods for palatability, while remaining within a set budget

- Difficulty in generating specific meals
  - Limited database
  - Purchasable quantities of foods
Our Goals

- Create a meal plan for one week for a family of four
Our Goals

- Create a meal plan for one week for a family of four
- Pamphlets with meal plans and recipes
Our Goals

- Create a meal plan for one week for a family of four
- Pamphlets with meal plans and recipes
- Workshop with HACA
What's For Dinner?

Friedrich, Garrett

Our Sources

The Cost of Subsistence

Dietary Guidelines for Americans 2010

The Economics of Nutrition
P. G. K. Panikar Economic and Political Weekly, Vol. 7, No. 5/7, Annual Number (Feb., 1972), pp. 413-430

FNS SNAP Program Eligibility Screening Tool
http://www.snap-step1.usda.gov/fns/

Interview
Lanou, Amy J. “Proper Nutrition Restraints.” Personal interview. 3 October 2011.

Long Term Effects of Dietary Sodium Reduction on Cardiovascular Disease Outcomes: Observational Follow-up of the Trials of Hypertension Prevention (TOHP)

Nutritional Adaptations of Linear Programming for Planning Rural Development