Health and Nutrition Modeling: New Approaches

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Next Generation Food Shock Modeling Workshop
Aspen Global Change Institute, Aspen, CO May 21, 2019
Modeling in Seattle Obesity Study (SOS)

- Socioeconomic factors
- Home built environment
  - e.g. Soda tax
- BE as activity space
- Diet quality
- PA

Energy balance influences Obesity (health)

Driving data → Configuration Intervention → Model → Outcome

?
Why do we model?
Census data are easy; health data are hard

Spatial analyses of diagnosed obesity and diabetes for 59,767 insured adults
Mapping obesity in Seattle by census block
Microsimulation modeling: Mapping diet quality by neighborhood

Soda (SSB) and salad consumption (servings per week) by Seattle census block

HEI 2010
A 30 m sampling grid is created for the entire KC area (>6,000,000 points).

Each point is visited serially (moving window or kernel function). Individual values are normalized to a “mean value per dwelling unit” and smoothed to create a spatially continuous surface.
Other examples of modeling diets and health

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Intervention</th>
<th>Model</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic</td>
<td>Replacement</td>
<td>Diet quality</td>
<td>BMI NCD risk</td>
</tr>
<tr>
<td>Socio economic</td>
<td></td>
<td>Diet cost</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Food groups</td>
<td></td>
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</tbody>
</table>
Dietary substitution models

• Replace foods with other foods
  – Replace typical snacks with tree-nuts.
  – Replace the American breakfast with RTE cereals.
  – Replace 100% juice with whole fruit
  – Replace milk with plant milk

• Replace nutrients with other nutrients.
  – Replace dairy fat with PUFAs
  – Replace animal proteins with plant proteins.
  – Replace “Western” diets with vegan diets.

• Diet quality and/or NCD risk are outcomes.
Replacing American snacks with tree nuts increases consumption of key nutrients among US children and adults: results of an NHANES modeling study

Colin D. Rehm and Adam Drewnowski

Nutrition Journal 2017 16:17
https://doi.org/10.1186/s12937-017-0236-5 | © The Author(s). 2017
Received: 8 August 2016 | Accepted: 28 February 2017 | Published: 7 March 2017
Replacing American Breakfast Foods with Ready-To-Eat (RTE) Cereals Increases Consumption of Key Food Groups and Nutrients among US Children and Adults: Results of an NHANES Modeling Study

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Nutrients 2017, 9(9), 1010; https://doi.org/10.3390/nu9091010

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Replace milk with plant milk: a hot topic

"An almond doesn’t lactate"—FDA to crack down on use of the word “milk"

FDA head says current products don’t meet labeling standards, guidance coming soon.

By Elaine Watson
18 Jul 2018 - Last updated on 18 Jul 2018 at 04:54 GMT

The increasing availability of plant-based alternatives to products a blessing for vegans, vegetarians, and others who—for reasons based fare. If milk makes you gassy, you can buy a white, milk-like coconuts. If you love the texture of beef but not the idea of eating with a meaty texture that bleed beet juice.
Nutrient substitution models

- Replace “bad” nutrients with “good” nutrients
  - Take a large observational cohort: 5,158,337 person years of follow up. Very impressive.
  - Model the exchanging of good and bad dietary fats.
  - Replace “bad” dairy fat with vegetable fats and PUFA.
  - Switch regression coefficients to model reduced CVD risk, and claim health benefits.

- Not so fast.
Over-reliance on regression models

• Substitution effects of substituting dairy fat with other sources of energy were estimated by the difference in the coefficients between fat sources and their covariances with the use of a time-dependent Cox proportional hazard regression model adjusted for age (continuous), BMI (8 categories), total energy intake (quintiles), race, smoking, physical activity, alcohol consumption, menopausal status and menopausal hormone use (NHS and NHS II participants only), oral contraceptive use (NHS II participants only), baseline hypertension, and baseline hypercholesterolemia, and dietary intakes of fruit, vegetables, coffee, and protein.

• So what. Switch adjusted coefficients; save lives.
Food-level nutrient substitution models

- Reducing 5% dietary energy from dairy fat means reducing milk, yogurt, cheese, and many mixed foods.
- In practice, a 5% energy reduction means removing dairy products altogether.
- Dairy fits into multiple food patterns that vary by age, gender, income, and race/ethnicity.
- PUFA sources are not the same for everyone.
- We need to do a food-level substitution for dairy and PUFA sources that is food-pattern specific (age, gender, kcal, ED).
## What happens when dairy fat is removed?

<table>
<thead>
<tr>
<th>N</th>
<th>Observed</th>
<th>Model 1 (remove all)</th>
<th>Model 2 (remove 5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=15,260</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Energy, kcal</strong></td>
<td>2080 (2055, 2105)</td>
<td>1454 (1435, 1474)***</td>
<td>1580 (1558, 1601)***</td>
</tr>
<tr>
<td><strong>Protein, %E</strong></td>
<td>15.8 (15.5, 16)</td>
<td>14.2 (13.9, 14.5)</td>
<td>14.7 (14.4, 15)</td>
</tr>
<tr>
<td><strong>Saturated fat, %E</strong></td>
<td>11.4 (11.2, 11.5)</td>
<td>8.7 (8.6, 8.9)***</td>
<td>9.6 (9.4, 9.7)***</td>
</tr>
<tr>
<td><strong>PUFA, %E</strong></td>
<td>8.0 (7.9, 8.1)</td>
<td>8.3 (8.2, 8.5)</td>
<td>8.2 (8.1, 8.4)</td>
</tr>
<tr>
<td><strong>MUFA, %E</strong></td>
<td>12 (11.9, 12.1)</td>
<td>11.4 (11.2, 11.5)</td>
<td>11.6 (11.4, 11.7)</td>
</tr>
<tr>
<td><strong>Dairy fat, %E</strong></td>
<td>5.6 (5.4, 5.8)</td>
<td>0 (0, 0)***</td>
<td>1.7 (1.6, 1.9)***</td>
</tr>
<tr>
<td><strong>Added sugar, %E</strong></td>
<td>13.4 (13.1, 13.8)</td>
<td>16 (15.5, 16.4)***</td>
<td>15.2 (14.8, 15.6)***</td>
</tr>
<tr>
<td><strong>Calcium, mg</strong></td>
<td>965 (949, 981)</td>
<td>715 (700, 730)***</td>
<td>784 (772, 796)***</td>
</tr>
<tr>
<td><strong>Vitamin D, mcg</strong></td>
<td>4.8 (4.7, 5)</td>
<td>2.7 (2.5, 2.9)***</td>
<td>3.4 (3.2, 3.6)***</td>
</tr>
<tr>
<td><strong>Vitamin A, mcg</strong></td>
<td>637 (618, 656)</td>
<td>490 (465, 516)***</td>
<td>531 (510, 553)***</td>
</tr>
<tr>
<td><strong>Riboflavin, mg</strong></td>
<td>2.1 (2.1, 2.1)</td>
<td>1.8 (1.7, 1.9)**</td>
<td>1.9 (1.8, 1.9)*</td>
</tr>
<tr>
<td><strong>Niacin, mg</strong></td>
<td>25.1 (24.8, 25.4)</td>
<td>25.8 (25.2, 26.3)</td>
<td>25.6 (25.1, 26)</td>
</tr>
<tr>
<td><strong>Vitamin B12, mcg</strong></td>
<td>4.8 (4.7, 4.9)</td>
<td>3.6 (3.5, 3.7)***</td>
<td>4 (3.9, 4.1)***</td>
</tr>
</tbody>
</table>

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*a* Model 1 removes all dairy fat. Model 2 removes up to 5% dairy fat for each individual; *b*.
Global and regional health effects of future food production under climate change: a modelling study

Dr Marco Springmann PhD, Daniel Mason-D’Croz MA, Sherman Robinson PhD, Tara Garnett PhD, Prof H Charles J Godfray PhD, Prof Douglas Gollin PhD, Prof Mike Rayner DPhil, Paola Ballon PhD, Peter Searborough DPhil

Show more
How Lancet sausage is made

• We converted the food availability estimates for fruit and vegetables and for red meat into food consumption estimates by using regional data about food waste, combined with conversion factors into edible matter.
  – J Gustavsson, C Cederberg, U Sonesson, R Van Otterdijk, A Meybeck
    Global food losses and food waste: extent, causes and prevention, FAO, Rome (2011)

• We linked food supply to body weight by pairing FAO food balance sheets for the years 1980–2009 with WHO data on BMI, using a polynomial trend.

• The diet and weight-related relative risk parameters were obtained from pooled analyses of prospective cohort studies (23, 24) and from meta-analyses of prospective cohort and case-control studies.(18-22)
  – A Berrington de Gonzalez, P Hartge, JR Cerhan, et al. Body-mass index and mortality among 1.46 million white adults
  – L Dauchet, P Amouyel, S Hercberg, J Dallongeville Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies
Emergency rations: grains, oil, sugar: Good or bad?

<table>
<thead>
<tr>
<th></th>
<th>Emergency food ration</th>
<th>Chile Art 2o</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy</strong></td>
<td>488 kcal</td>
<td>&lt;350 kcal</td>
</tr>
<tr>
<td><strong>Sat fat</strong></td>
<td>8.3 g</td>
<td>&lt;6 g</td>
</tr>
<tr>
<td><strong>Sugar</strong></td>
<td>37 g</td>
<td>22.5 g</td>
</tr>
<tr>
<td><strong>Sodium</strong></td>
<td>18 mg</td>
<td>800 mg</td>
</tr>
</tbody>
</table>
Final observation: Nothing stays still

- Nothing stands still.
- Countries will not stay poor or rice dependent for long.
- Nutrition transition is well under way.
- Soon, LMIC will be eating less rice, and more chicken and more dairy.
Health modeling: The future

Health is always the modeling outcome.

What if health were only the beginning?
Can health be used to model and predict other outcomes?
Health as predictor of behavior: 2016 US voting patterns

Size of the bubble denotes electoral votes by state. Election results 2016 from ballotpedia.org. Percent obese by state 2014 from Centers for Disease Control.

Washington DC
California
New York
Thank you

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How to measure nutrient density?

Concept of a nutritious food: toward a nutrient density score

Adam Drewnowski

ABSTRACT
The American diet is said to be increasingly energy-rich but nutrient-poor. To help improve the nutrient-to-energy ratio, the 2005 Dietary Guidelines for Americans recommend that consumers replace some foods in their diets with more nutrient-dense options. Such dietary

Energy-dense sweets and fats have long been contrasted, unfavorably, to foods that contained substantial amounts of key nutrients per serving or per unit weight. The terms energy-dense and nutrient-poor are commonly used to characterize foods perceived as unhealthy and to distinguish them from more nutritious foods.

Nutrient profiling of foods: creating a nutrient-rich food index

Adam Drewnowski and Victor Fulgosi III

Nutrient profiling of foods, described as the science of ranking foods based on their nutrient content, is fast becoming the basis for regulating nutrition labels, health claims, and marketing and advertising to children. A number of nutrient profile models have now been developed by research scientists, regulatory agencies, and by the food industry. Whereas some of these models have focused on nutrients to limit, others have emphasized nutrients known to be beneficial to health, or some combination of both. Although nutrient profile models are often tailored to specific goals, the development process sought to follow the same scientific principles. These principles include the selection of index nutrients and reference amounts in an appropriate algorithm for calculating nutrient density; inclusion of only sound, robust, and widely accepted empirical evidence; and development of an internal quality control and validation mechanism. These principles apply regardless of model development.

The Nutrient Rich Foods Index helps to identify healthy, affordable foods

Adam Drewnowski

ABSTRACT
Background: The Nutrient Rich Foods (NRF) index is a formal scoring system that ranks foods on the basis of their nutrient content, higher consumption of foods and nutrients to encourage, healthy eating index values, and lower energy intake overall. The documented links between nutrient-rich foods, overall health, and lower risk for chronic diseases support its use.

Uses of nutrient profiling to address public health needs: from regulation to reformulation

Adam Drewnowski

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