HEALTH CARE COSTS ASSOCIATED WITH ELEVATED BODY MASS INDEX AND THE COST-EFFECTIVENESS OF WEIGHT LOSS

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THE EPISTEMOLOGY OF HEALTH
(How do we determine what is healthy and what is not?)

- Associations and Causes
  - Yellow fingers and lung cancer
  - Coffee and lung cancer
  - Birth order and Downs syndrome
  - Autologous bone marrow transplantation and breast cancer survival
  - Poor control of diabetes and microvascular and macrovascular events
  - HIV and AIDS

HOW DO WE ESTABLISH CAUSALITY?

- Experiments, e.g., randomized trials (strongest evidence)
- Observational data
  - Coherence with existing information (biological plausibility)
  - Consistency of association
  - Time sequence
  - Specificity of association
  - Reversibility of association
  - Strength of association
    * Quantitative strength
    * Dose-response relationship
    * Study design

- Are there any randomized trials that demonstrate the beneficial impact of diet and exercise on health outcomes such as death, disease, and disability?

OBSERVATIONAL STUDIES: TWO POLAR OPPOSITES

- Smoking and lung cancer
- Hormone replacement therapy
GENERAL STRATEGY FOR IDENTIFYING THE DISEASE BURDEN/COSTS ASSOCIATED WITH ELEVATED BODY MASS INDEX

- Grab a bunch of people with elevated body mass indices (BMI) and a bunch of people with average/"ideal" BMIs
- Assess the difference in the disease burden / health care cost between the two groups
- Attribute the difference to elevated BMI

WHAT CAN GO WRONG?

- The two groups may not differ in BMI alone, but also may differ in other factors that affect disease burden/cost
  - Age
  - Gender
  - Socioeconomic status
  - Genetics
  - Medical conditions, obesity-related/unrelated
  - Other unmeasured/unmeasurable factors
- BMI might not be the cause of the disease/cost, but might be another expression of a common cause of both BMI and disease/cost (e.g., yellow fingers may not cause lung cancer, yellow fingers and lung cancer may both be caused by smoking)

HOW DO WE ADDRESS THESE ISSUES?

- To account for other differences between the groups:
  - Use statistical techniques that attempt to control for the differences
  - Often not possible to fully account for differences between groups in observational studies
- To sort out causal chain
  - Collect data that allow one to differentiate between the alternative, potential causes

HAVE WE SORTED OUT THE CAUSAL CHAIN?

- Do we know the independent effects of weight, physical activity, and fitness?
- Clinical judgment: What are health risks for an obese person who vigorously exercises an hour a day, 5 days a week, and -- where necessary -- maintains normal blood pressure, lipid, and blood sugar levels by taking niacin, statins, and metformin?
- Could our aesthetic judgments about overweight/obesity be affecting our scientific judgments?
BMI, PHYSICAL ACTIVITY, AND HEALTH CARE COST *

![Bar chart showing the relationship between Body Mass Index (BMI) levels and annual total cost.](chart.png)

- 18.5-24.9 kg/m²
- 25-29.9 kg/m²
- 30+ kg/m²

Annual total cost

- 0/wk
- 1-3/wk
- 4+/wk

**BAD NEWS?**

- The Swedish Obese Subjects (SOS) study invited participants to receive bariatric surgery (gastric banding, variable gastric banding, vertical banded gastroplasty, or gastric bypass).
- It constructed a comparison group by computerized matching, taking into account 18 variables related to morbidity and mortality.
  - Participants in this group were treated according to existing routines for obesity management at different primary health care centers.
- The study -- whose follow-up is ongoing -- periodically reports results:
  - Sjostrom et al. NEJM. 2004; 351:2683-93

$p < 0.01$ for any pair-wise comparisons of PA within each BMI level, controlled for gender, age, major diseases, chronic disease, and overall health risk status. 0/wk, n = 8920; 1-3/wk, n = 20,572; 4+/wk, n = 13,028

RESULTS, SOS 6-YEAR FOLLOW-UP

<table>
<thead>
<tr>
<th>Variable</th>
<th>Surgery</th>
<th>Usual Care</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 years (%)</td>
<td>-23.4</td>
<td>0.1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>10 years (%)</td>
<td>-16.1</td>
<td>1.6</td>
<td>&lt;0.0001</td>
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<tr>
<td>Cumulative hospital days, 6 years</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14.0</td>
<td>6.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Non-surgery</td>
<td>7.8</td>
<td>6.0</td>
<td>0.18</td>
</tr>
<tr>
<td>Cumulative inpatient costs ($), 6 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9533</td>
<td>2540</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Non-surgery</td>
<td>2747</td>
<td>2177</td>
<td>0.17</td>
</tr>
<tr>
<td>Annual Pharmacy costs (SEK)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1849</td>
<td>1905</td>
<td>NS</td>
</tr>
<tr>
<td>Years 2-6</td>
<td>1950</td>
<td>2048</td>
<td>?NS?</td>
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- What conclusions (if any) should we draw about whether or not weight loss reduces healthcare costs?

TYPES OF STUDIES FOR QUANTIFYING THE COSTS OF ELEVATED BMI / MODIFYING BMI

- Cost-of-illness
  - Prevalence-based cost-of-illness studies (PBCOI)
    * Cohort studies
    * Attributable risk/cost studies
  - Incidence-based cost-of-illness studies

- Treatment of obesity studies
  - Randomized trials
  - Decision analyses/simulation models

COST-OF-ILLNESS STUDIES

- Prevalence- vs. Incidence-Based
  - Prevalence-Based (PBCOI)
    * Measure the value of resources used or lost due to a condition during a specified period of time (e.g., a year), regardless of the time of onset of the condition
      - If population/disease is in steady state, correctly weights different durations of disease
      - If not in steady state -- for example if the prevalence is increasing -- can misweight some costs
  - Incidence-Based
    * Measure the value of resources used or lost due to a condition from its onset until cure or death
PBCOI: COHORT STUDIES

- Identify two groups of study participants, those who have been exposed to the risk factor under study (e.g., elevated BMI) and those who have not been exposed
  - Two main types of published cohort studies:
    * Nationally representative samples
    * Less representative samples

- Estimate health care costs of study participants

- Predict (with varying degrees of technical sophistication) cost as a function of BMI
  - The cost difference associated with BMI is taken to represent the cost difference due to the exposure

NATIONALLY REPRESENTATIVE COHORT STUDIES

- Use data from nationally representative samples of individual study participants, e.g.,
  - Medical Expenditure Panel Survey (MEPS): self-report confirmed through physician offices, hospitals, and insurance coverage
  - National Health Interview Survey (NHIS)
  - Healthcare for Communities household telephone survey (HCC)
  - National Health and Nutrition Examination Survey (NHANES)
  - CDC Behavioral Risk Factor Surveillance System (BRFSS)

- Obtain estimates of cost and BMI for each study participant
  - Cost: obtain direct measures or obtain measures of resource use and multiply by estimates of unit costs

- Predict cost as a function of BMI
LESS REPRESENTATIVE COHORT STUDIES

- Use less representative sample of individual study participants, e.g.,
  - HMO's
  - Employers

- Obtain estimates of cost and BMI
  - Administrative data on costs (e.g., HMO or employer insurance records)
  - Direct measurement of BMI and risk factors or self-report of BMI and risk factors
    * Health Risk Appraisals
    * Health Surveys

- Predict cost as a function of BMI

PBCOI: ATTRIBUTABLE RISK/COST STUDIES

- Obtain national estimates of the one-year cost of diseases associated with BMI (from various sources)

- Obtain estimates of the population-attributable risk% (PAR%) or obesity-attributable etiologic fractions (i.e., proportion of disease/cost that is due to obesity)

  - e.g. suppose 40% of the population is nonoverweight/obese and 5% have coronary heart disease (CHD); suppose 60% of the population is overweight/obese and 20% have CHD, then the PAR% equals:

  \[
  \frac{(0.6 \times (0.20-0.05))}{(0.6 \times 0.2) + (0.4 \times 0.05)} = 0.09 / (0.12 + 0.02) \\
  \text{Fract OW x (Risk diff) / Expected risk} \\
  = 0.64
  \]

  i.e., 9% of the 14% total is "due" to obesity

  - More formally:

  \[
  \frac{P(RR - 1)}{(1 + P(RR - 1))}
  \]

  where \( P \) equals prevalence of obesity and \( RR \) equals the relative risk for disease (e.g., 0.2/0.05)

- Multiply cost x PAR% to obtain the cost-of-illness
PBCOI: ATTRIBUTABLE RISK/COST STUDIES (cont.)

- Issues with PAR%
  - Cause vs. association
  - Can PAR% be transferred between studies, or are they specific to the prevalence of the risk factor, the prevalence of disease, other factors?
    * Prevalence of overweight differs widely
    * Prevalence of disease differs within ethnic groups at the same BMI

COST-EFFECTIVENESS STUDIES

- Even if we can prove that elevated BMI is associated with excess costs, does not necessarily mean that we can save money by having people reduce their BMI

- Should therefore evaluate the value for the cost of weight loss programs

- Cost-effectiveness studies compare the difference in costs and difference in outcomes between patients who "lose weight" with those who do not. Observed differences in costs and outcomes (assumed to be) caused by observed weight loss

\[
\frac{\Delta C}{\Delta E}
\]
COST-EFFECTIVENESS STUDIES (III)

- Studied Interventions include:
  - Lifestyle intervention (multidisciplinary)
    * University-based
    * Commercial weight loss programs
    * Managed care programs
  - Weight loss medications
  - Bariatric surgery
- Outcomes used for these studies vary
  - lb/kg/BMI units lost
  - Case of diabetes mellitus prevented
  - Quality-adjusted life years saved
- How should we compare studies with these different outcomes?

RESULTS:
HETEROGENEITY OF REPORTED RESULTS

- Prevalence of obesity assumed in the different studies
- Cost outcome
  - Stratified by category of overweight and obesity
  - Nonstandard definitions of overweight and obesity (what is the impact?)
  - Gender-specific vs all
  - Per-person vs national estimates
  - Costs, charges, expenditures
  - Year in which costs were expressed
### ONE-YEAR COST ESTIMATES

<table>
<thead>
<tr>
<th>Author</th>
<th>Overweight</th>
<th>Obese</th>
</tr>
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<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>Anderson</td>
<td></td>
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<td>Finkelstein '03</td>
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<td>Wolf-Colditz '98</td>
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<tr>
<td>Mean</td>
<td>276</td>
<td>469</td>
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<tr>
<td>National</td>
<td>21B</td>
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### OVERWEIGHT/OBESITY, CHRONIC DISEASE, AND COST

- Most of the studies that controlled for chronic medical conditions associated with obesity found that there was still an "independent" effect of weight after accounting for these.
- Some studies controlled for variables that may be in the causal pathway of overweight/obesity (e.g., poor nutritional habits, hyperlipidemia, blood glucose, depression, etc.).
- What conclusions (if any) should we draw about whether or not overweight / obesity alone increases health care costs?
### RESULTS GIVEN CONTROL FOR COMORBIDITIES

<table>
<thead>
<tr>
<th>Study</th>
<th>Unadj Adj cost</th>
<th>BP</th>
<th>Lipid</th>
<th>Gluc/diab</th>
<th>Depr</th>
<th>CHD</th>
<th>Other</th>
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<td>Daviglus</td>
<td>1010</td>
<td>x</td>
<td>x</td>
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<td></td>
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<td>690</td>
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<td></td>
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<td>EKG</td>
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<tr>
<td>Raebel</td>
<td>699</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td></td>
<td>456</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Wang '02</td>
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<td>x</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>533</td>
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<td></td>
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<tr>
<td>Wang '04</td>
<td>1028</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>Arthritis, back pain</td>
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<tr>
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<td>654</td>
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<td>x</td>
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<td>x</td>
<td></td>
<td>Muscular pain</td>
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Average cost, unadjusted: 1100
Average cost, adjusted: 360

### COST-EFFECTIVENESS OF TREATMENT OF OBESITY

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Outcome measure</th>
<th>Result</th>
</tr>
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<tbody>
<tr>
<td>Randomized controlled trials, nationally representative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPP</td>
<td>Lifestyle vs placebo</td>
<td>DM Prevented</td>
<td>$24,400</td>
</tr>
<tr>
<td>DPP</td>
<td>Metformin weakly dominaed by lifestyle</td>
<td>QALY</td>
<td>$51,600</td>
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<tr>
<td>Randomized</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Wylie-Rosett</td>
<td>Computerized lifestyle</td>
<td>Lb lost</td>
<td>$6 - $18</td>
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<tr>
<td>Foxcroft</td>
<td>Orlistat</td>
<td>QALY</td>
<td>$76,667</td>
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<td>Cohort Studies</td>
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<td></td>
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<tr>
<td>Martin</td>
<td>Medical vs surgical</td>
<td>$/LB lost</td>
<td>&gt;$250 both arms, NS</td>
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</table>
COST-EFFECTIVENESS OF TREATMENT OF OBESITY

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Outcome measure</th>
<th>Result</th>
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<tr>
<td>Decision Analyses</td>
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<tr>
<td>DPP (Herman)</td>
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<td>Spielman</td>
<td>Commercial WL</td>
<td>Cost/lb lost</td>
<td>$2 - $26</td>
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<tr>
<td>Oster</td>
<td>Unspecified</td>
<td>% weight loss</td>
<td>Dominates</td>
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</tbody>
</table>

SUMMARY OF FINDINGS (I)
- Incremental cost of ~ $301 per overweight person and ~$1100 per obese person
- Costs of overweight/obesity greater for overweight/obese women than for overweight/obese men
  - Occurs even though men are more likely to be overweight, and there is at most a tendency for more women than men to be obese

SUMMARY OF FINDINGS (II)
- Cost of treating obesity
  - Few studies
  - Heterogeneous outcomes
  - The three studies that directly compared lifestyle intervention with medications found lifestyle to be more cost-effective (what does insurance cover?)
  - Only three published studies estimated lifetime benefits (vs. within-trial benefits)
  - The two long-term decision analyses of the DPP (Herman et al, Eddy et al) arrived at very different conclusions about the cost-effectiveness of treating obesity (why?)
SO WHAT?

- You perform a cost-of-illness study, and report that overweight is responsible for approximately $300 in health care costs per person per year in the U.S. (i.e., approximately $21 billion per year)
- What are these numbers supposed to be?
  - Actual measures of cost?
  - Warning signs?
  - Projections of what they will be?
- What incentives do investigators have to report higher or lower results?
- How do these numbers help us make decisions?
  - About treatment?
  - About Prevention?
- What numbers would be better?

CONCLUSIONS (I)

“Overweight/obesity is a major public health problem that costs society billions of dollars, and we should be doing everything we can to combat it.”

- Reasons to agree with this statement
  - Consistent association between BMI, health, and cost
  - Biological plausibility
  - Quantitatively strong association
  - Dose response
  - Correct time sequence
CONCLUSIONS (II)

- Reasons to question this statement

  - The bulk of the evidence we have for this statement come from studies like the ones that supported our public health decisions about smoking and lung cancer and about hormone replacement therapy and CAD

  - We haven't performed a single trial that demonstrates the impact of weight loss on final health outcomes such as death, disease, and disability

    * When we had the chance (randomizing 5,000 patients and following them for 7 years), why did we decide to study weight loss in diabetics rather than weight loss in the general public?

  - We haven't disaggregated the independent effects of weight, physical activity, and fitness

  - Even if overweight/obesity is a health/economic problem, it is not clear we have cost-effective interventions for its treatment / prevention

CONCLUSIONS (III)

- At the moment, there are better and worse opinions about statements of this kind, but definitive evidence is lacking