Analyzing long-term BMI change following gastric bypass surgery

Nils Carlsson
Division of Public Health Sciences
Department of Surgery
Obesity and overweight

- Obesity and overweight are conditions in which excess body fat accumulates.
- Both are associated with increased mortality.
- Both are associated with increased incidence of many illnesses, including hypertension, diabetes, coronary heart disease, and stroke.
How to classify overweight and obesity

- BMI = \frac{weight\,(kg)}{height^2\,(m^2)}
- Overweight: BMI ≥ 25.
- Obese: BMI ≥ 30.
- What BMI is not: an absolute indicator of healthy versus unhealthy weight
- What BMI is: a convenient and useful way to approximate body fat in an individual

Lebron James: Perennial NBA All Star
Height: 6’ 8” (203 cm)
Weight: 249 lbs (113 kg)
BMI: 27.4 kg/m²
Obesity and overweight in the United States

• More than one-third of U.S. adults are obese, while two-thirds are overweight.
• Improving diet and exercising regularly are two ways to prevent excess fat accumulation.
• Bariatric surgery is most effective; refers to a variety of procedures in which part of the stomach is either removed or modified.
Types of Bariatric Surgery

- Four examples of bariatric surgery procedures are gastric bypass, sleeve gastrectomy, adjustable gastric band, and biliopancreatic diversion with duodenal switch.
Our Research

• Our research focused on gastric bypass surgery (most common of all bariatric procedures)

• Looked at two outcomes after surgery:
  1. BMI change as a function of time after surgery
  2. Complications after surgery (in progress)
Methods

• We used data abstracted from the clinical records of Dr. Christopher Eagon, a bariatric surgeon here at WUSM, to form a retrospective cohort

• Data were abstracted into 3 excel files:
  1. Demographics
  2. BMI measurements (post-op and pre-op)
  3. Post-surgery complications
Let the SAS begin!

- The 3 excel files were converted into SAS data files using the `PROC IMPORT` statement
  - `proc import`
  - `datafile = "H:\bmi_data";`
  - `out = Nilslib.bmi_data;`
  - `sheet = 'sheet 1';`
  - `run;`
Merging of Data

• Next step was to merge the 3 files, now in SAS datefile format, into one to facilitate analysis
• Done using DATA step
• data Nilslib.merged_data;
• merge Nilslib.bmi_data Nilslib.demographics_data Nilslib.complications_data;
• by ID;
• run;
Unadjusted Analysis

- File now ready for analysis.
- 1st step: unadjusted analysis. A B-spline polynomial fitting method was used to fit a curve to BMI change as a function of time after surgery
  
  ```
  proc sgplot data=Nilslib.merged_data ;
  title "bmi_change, unadjusted ";
  yaxis VALUES=(-40 to 10 by 5) label="bmi change";
  xaxis VALUES=(0 to 20 by 0.2) label="duration after surgery";
  pbspline x=duration y=bmi change/NKNOTS=7 nomarkers LINEATTRS=(COLOR=red PATTERN=1 THICKNESS=2 )
  clm="95% CLM" ;
  run;
  ```
Unadjusted Analysis

unadjusted BMI change, knots = 7

BMI change (kg/m²)
duration (years)
BMI Loss Example

Height: 5’ 9” (175 cm)
Weight: 325 lbs (147 kg)
**BMI: 48 kg/m²**

ΔBMI = 21 kg/m²
Δ Weight = 145 lbs (66 kg)

Height: 5’ 9” (175 cm)
Weight: 180 lbs (82 kg)
**BMI: 27 kg/m²**
Multivariable Adjusted Analysis

• Following unadjusted analysis, a linear mixed model was fit to the data
• Mixed model: one that takes into account the correlation between multiple measurements for the same individual
• `proc mixed data = Nilslib.merged_data noclprint covtest noitprint ord;`
• `class ID duration_cat primary_insurance (ref = "Private Insurance") sex race;`
• `model bmi_change = AGE pre_surg_bmi duration_cat primary_insurance sex race duration Duration_2 duration_3 duration_4 duration_5 duration_6 /solution ddfm = bw outpm = Nilslib.predicted;`
• `random intercept Duration / subject = ID type = un;`
• `run;`
## Results

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Estimate</th>
<th>P-value</th>
<th>Covariate</th>
<th>Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.03</td>
<td>0.02</td>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-surg BMI</td>
<td>-0.27</td>
<td>&lt;.0001</td>
<td>Female</td>
<td>-0.30</td>
<td>0.32</td>
</tr>
<tr>
<td>Pre- Surgery BMI Measurement Date</td>
<td></td>
<td></td>
<td>Male (reference)</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>BMI Measured &gt;90 days pre-op</td>
<td>-0.35</td>
<td>0.30</td>
<td>Hispanic</td>
<td>1.57</td>
<td>0.37</td>
</tr>
<tr>
<td>BMI Measured 30-90 days pre-op</td>
<td>0.31</td>
<td>0.37</td>
<td>African-American</td>
<td>1.32</td>
<td>0.00</td>
</tr>
<tr>
<td>BMI Measured &lt;30 days pre-op (reference)</td>
<td>0.00</td>
<td></td>
<td>Caucasian (reference)</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Primary Insurance</td>
<td></td>
<td></td>
<td>Medicaid</td>
<td>-0.17</td>
<td>0.75</td>
</tr>
<tr>
<td>Medicaid</td>
<td></td>
<td></td>
<td>Duration</td>
<td>-24.08</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Medicare</td>
<td>0.74</td>
<td>0.01</td>
<td>Duration^2</td>
<td>11.30</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Other Government</td>
<td>-0.31</td>
<td>0.62</td>
<td>Duration^3</td>
<td>-2.29</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Self Pay</td>
<td>0.65</td>
<td>0.49</td>
<td>Duration^4</td>
<td>0.23</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Private Insurance (reference)</td>
<td>0.00</td>
<td></td>
<td>Duration^5</td>
<td>-0.01</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Duration^6</td>
<td>0.00</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>
Predicting BMI Change After Surgery
BMI Change Analysis

• We used PROC GPLOT to plot the predicted BMI change generated from the estimates in the linear mixed model

• First define axes:

• \texttt{axis1 label=(height=3.5 angle=-90 rotate=90 'BMI change')} order=( -40 to 10 by 5) value=( height=2.5) offset=(3);

• \texttt{axis2 label=(height=3.5 'Duration (years)')}, order=(0 to 20 by 5) value=(height=2.5) offset=(3);
BMI Change Analysis

• Now we use PROC GPLOT

```
proc gplot data=Nilslib.predicted;
plot lower*duration upper*duration pred*duration/ areas = 4 overlay vaxis=axis1
  haxis=axis2 ;
title2 h=4 'Predicting Bmi Change From Duration after surgery';
run;
```
Predicting BMI Change After Surgery: entire cohort
Predicting BMI change after surgery: sample person
Conclusions

• Gastric bypass surgery is an effective way to treat obesity
• The long follow-up times present in this data set allow us to observe noticeable and persistent BMI loss after surgery
• Limitation: thinning of data after ~12 years post surgery
Next Steps

• Analyzing complications after bariatric surgery
• Analyzing remission/improvement of comorbidities after surgery
Acknowledgements

• Dr. J. Christopher Eagon
• Dr. Cynthia Herrick
• Zhuchen Xu
• Zhongyu Li
• Nikki Freeman
• Dr. Su-Hsin Chang