Gender disparities in adult obesity: Investigating behavioral and social factors in childhood

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Obesity prevalence by Black/White race, gender, and age$^{1,2}$

1. Pediatric BMI ≥ 95$^{th}$ percentile CDC 2000; Adult BMI ≥ 30.0 kg/m$^2$
Methodologic challenge: Confounding?

- Exposure
  - Male/female sex (US)

- Health behaviors

- Parental education

- Outcome
  - Male/female sex (US)
  - Parental education
Research Questions

1. In U.S. Black young adults, to what degree might male-female differences in adolescent behaviors account for the gender gap?
   - Technique: Standardization

2. In U.S. Black young adults, are childhood family sociodemographic factors associated with the gender gap?
   - Technique: Cross-validation
Dataset: Add Health
(National Longitudinal Study of Adolescent Health)

- Baseline sampling: Wave I
  - School-based (grades 7 to 12)
  - Cluster-sampled private and public schools
  - Wave I (1994-95): aged 11 – 20

- Longitudinal follow-up: Waves II and III
  - Wave III (2001-02): aged 18 – 26

- Special features
  - Nationally representative
  - Oversampling, e.g. Blacks with a parent who had completed college
  - Height and weight measured (wave II, wave III)
  - Rich family data: caretaker interview + student interview
Analysis Datasets

• Non-Hispanic Black
  – Additional analyses in non-Hispanic Whites
• U.S.-born parents
• Non-pregnant at weighing
Question 1

• In U.S. Black young adults, to what degree might male-female differences in adolescent behaviors account for the gender gap?

—Technique: Standardization

Question 1 Exposure Variables

- Dinner with parents (wave I & wave II)
- Hours of television-viewing (wave II)
- Played a sport with mom (wave I or wave II)
- Played a sport with dad (wave I or wave II)
- Bouts of leisure-time moderate-to-vigorous physical activity (MVPA) (wave I & wave II)
  - During the past week, how many times did you . . .
    - go roller-blading, roller-skating, skate-boarding, or bicycling?
    - play an active sport, such as baseball, softball, basketball, soccer, swimming, or football?
    - do exercise, such as jogging, walking, karate, jumping rope, gymnastics or dancing?
Question 1 Outcome variable

• Incidence difference (ID)
  – Obesity incidence:
    • Wave II: non-obese
      – BMI <(95th %ile CDC 2000) and <30.0 kg/m²
    • Wave III: obese
      – BMI ≥ 30 kg/m²
  
• ID = (female incidence) – (male incidence)

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<tbody>
<tr>
<td></td>
<td>male</td>
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<tr>
<td>Obese (wave II) (%)</td>
<td>16.5</td>
</tr>
<tr>
<td>Final sample size (n)</td>
<td>700</td>
</tr>
</tbody>
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Excluded b/c obese, but otherwise eligible
Question 1 Statistical methods

- **Outcome**: \( ID = (\text{Incidence}_{\text{Female}}) - (\text{Incidence}_{\text{Male}}) \)
- **Hypothesis**: Setting males and females equal on adolescent behaviors attenuates incidence difference

1. Do behaviors differ for males and females?

2. Could the sex differences in the behaviors account for the inequality?
Gender differences, adolescence: Sport with a mother or father

- Sport with a mother:
  - Black male: 16%
  - Black female: 10%
  - p = 0.02

- Sport with a father:
  - Black male: 33%
  - Black female: 17%
  - p < 0.01
Gender differences, adolescence: Bouts of MVPA*

* MVPA = moderate-to-vigorous physical activity

p<0.01
Gender differences: Standardized for adolescent behaviors

<table>
<thead>
<tr>
<th>Age and education (AE)</th>
<th>ID (95% CI) (%age pts)</th>
<th>Female (%)</th>
<th>Male (%)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>9.8 (4.5, 15.1)</td>
<td>20.2</td>
<td>10.4</td>
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Gender differences: Standardized for adolescent behaviors

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<th>Female (%)</th>
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<tr>
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<td>9.8 (4.5, 15.1)</td>
<td>20.2</td>
<td>10.4</td>
</tr>
<tr>
<td>AE + Dinner with parents</td>
<td>9.9 (4.7, 15.0)</td>
<td>20.2</td>
<td>10.3</td>
</tr>
<tr>
<td>AE + TV hours per week</td>
<td>9.3 (4.1, 14.6)</td>
<td>19.6</td>
<td>10.3</td>
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Gender differences: Standardized for adolescent behaviors

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<td>9.3 (4.1, 14.6)</td>
<td>19.6</td>
<td>10.3</td>
</tr>
<tr>
<td>AE + Sport with mom</td>
<td>9.2 (4.1, 14.4)</td>
<td>19.7</td>
<td>10.4</td>
</tr>
<tr>
<td>AE + Sport with dad</td>
<td>10.0 (4.8, 15.2)</td>
<td>20.6</td>
<td>10.6</td>
</tr>
<tr>
<td>AE + Bouts of MVPA per week</td>
<td>10.9 (5.7, 16.0)</td>
<td>20.9</td>
<td>10.1</td>
</tr>
<tr>
<td>AE + All behavioral variables</td>
<td>10.2 (5.2, 15.2)</td>
<td>20.1</td>
<td>9.8</td>
</tr>
</tbody>
</table>
Question 1 Summary

• Gender differences in adolescent behaviors
  – No differences:
    • family dinners
    • hours of television-viewing
  – Greater in boys than girls:
    • Playing sports with a mother
    • Playing sports with a father
    • Reported bouts of MVPA

• But setting males and females equal did not produce smaller gender gap
  – Behaviors examined not associated with six-year incident obesity
Research Question 2

• In U.S. Black young adults, are childhood family sociodemographic factors associated with the gender gap?
  –Technique: Cross-validation

Question 2 Exposure variables

- Exposures: wave I & wave II (ages 11-20)
  - Number of minors in household
  - Birth order among biological full-siblings
  - Female caregiver’s age at child’s birth
- Family structure:
  - two biological parents
  - two parents (other)
  - single mother
  - other
- Parental education
  - < high school
  - high school graduate
  - some college or vocational
  - college or professional degree
Question 2 Outcome variable

• Prevalence difference (PD)
  – Obesity prevalence
    • wave III (ages 18-26): Obese
      – BMI ≥ 30.0 kg/m²
    • wave II (ages 12-20): any weight status
  • PD = (female prevalence) – (male prevalence)
Question 2 Statistical methods

- **Outcome:** $PD = (\text{Prevalence}_{\text{Female}}) - (\text{Prevalence}_{\text{Male}})$
- **Null hypothesis:** PD is same across strata of the exposure variable.

1. Among Blacks, do PDs vary across sociodemographic strata?

2. If so, is there a similar pattern in other racial groups?
Gender gap: Variation across family structure

Unadjusted
Multivariable-adjusted: \( p=0.29 \)
Gender gap: Variation across parental education

Multivariable-adjusted: $p=0.01$
Gender gap: Variation across parental education -- Whites

Unadjusted: p=0.34

Multivariable-adjusted: p=0.05
Circumstantial evidence: Early-life SES & obesity

- Female excess obesity: North Africa, Brazil, the Middle East, Central America?
- Female – male obesity ~ equal: White U.S., Western Europe, China?

Women more obese: U.S. Black, Brazil, U.S. White, U.S. Mex-Am
No gender gap: Switzerland, Canada non-aboriginal
Men more obese: Canada aboriginal, Russia, Mongolia, South Korea, China, Indonesia, Australia, South Africa Black
Conclusions

- Consider alternatives to standard regression
  - Social determinants research involve complex causal relationships beyond simple confounding
- Standardization – Could setting groups equal *at specific level* account for the inequality between the groups?
- Cross-validation – Is inequality uniform in population? If not, what are *clues from variation* about social and environmental determinants?
The End
Literature: Obesity gender gap

- Gender interacts with age, ethnicity, socioeconomic status, time
- Intentional behaviors
  - Exercise: females < males; Black women < White women
  - Almost all studies in Caucasians. Exception: Black women, Pitt County
  - “Findings suggest . . . childhood SEP is inversely related to adulthood obesity in females and not associated in males . . .”
- Neighborhoods/Built Environment
  - “An ecology of obesity that includes disparities for women but not men is particularly difficult to explain, given that residential segregation by gender is minimal.”
  - “… understanding interactions by gender may be crucial…”

Conditioning in sex disparities research

- SEX
- Physiologic traits affecting metabolism
- Adult SES
- Obesity
- Parental education
- Health behavior
Question 1 Exposure Variables

- Dinner with parents (wave I & wave II)
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Question 1 Statistical methods

• **Outcome**: ID = (Incidence\text{Female}) – (Incidence\text{Male})

• **Hypothesis**: Setting males and females equal on adolescent behaviors attenuates incidence difference

1. Calculate obesity incidence for females and males
   • Logistic regression models, gender-stratified
     • to keep genders in same regression model, interactions between gender and all variable strata
   • Standardize females and males to same variable distributions
     \[
     \text{Incidence}_M = \left(\frac{e^{\beta_0 + \Sigma x^*\beta_k}}{e^{\beta_0 + \Sigma x^*\beta_k} + 1}\right)
     \]
     \[
     \text{Incidence}_F = \left[\frac{e^{(\beta_0 + \beta_1\text{female} + \Sigma x^*\beta_k + \Sigma x^*\beta[k\text{female}] + 1)}}{e^{(\beta_0 + \beta_1\text{female} + \Sigma x^*\beta_k + \Sigma x^*\beta[k\text{female}]) + 1}}\right]
     \]

2. Calculate standardized obesity IDs
   • 95% CI for IDs: delta method

3. Compare IDs
   • age & parental education (AE)
   • age & parental education (AE) plus adolescent behavior
### Question 2 Sample characteristics

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<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Sample size (n)</td>
<td>943</td>
<td>1,153</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>21.7</td>
<td>21.4</td>
</tr>
<tr>
<td>Obese (%)</td>
<td>23.7</td>
<td>35.6</td>
</tr>
<tr>
<td>&lt; HS graduate (%)</td>
<td>15.3</td>
<td>21.0</td>
</tr>
<tr>
<td>HS graduate (%)</td>
<td>36.7</td>
<td>37.3</td>
</tr>
<tr>
<td>Some college or vocational (%)</td>
<td>27.0</td>
<td>24.5</td>
</tr>
<tr>
<td>College, professional degree (%)</td>
<td>21.1</td>
<td>17.2</td>
</tr>
<tr>
<td>Single mother (%)</td>
<td>44.9</td>
<td>44.6</td>
</tr>
<tr>
<td>2 biological parents (%)</td>
<td>28.3</td>
<td>32.8</td>
</tr>
<tr>
<td>2 parents (other) (%)</td>
<td>14.6</td>
<td>12.6</td>
</tr>
<tr>
<td>Other (%)</td>
<td>12.2</td>
<td>10.0</td>
</tr>
</tbody>
</table>
1. For each exposure stratum, calculate obesity prevalence for males and females
   - Logistic regression model
     - Gender-stratified estimates from same model: interactions between gender and every variable stratum
     - Covariate strata set same for males and females
     - \( \text{Prevalence}_M = \frac{e^{\beta_1 \text{expos}_i}}{e^{\beta_1 \text{expos}_i} + 1} \)
     - \( \text{Prevalence}_F = \frac{e^{(\beta_1 \text{expos}_i + \beta_2 \text{female} + \beta_3 \text{expos}_i \times \text{female})}}{e^{(\beta_1 \text{expos}_i + \beta_2 \text{female} + \beta_3 \text{expos}_i \times \text{female})} + 1} \)

2. For each exposure stratum, calculate obesity PD
   - 95% CI for PDs: delta method

3. For each exposure, test whether PDs vary across its strata
   - Modified Wald test
Other work: early-life SES & obesity

- South Africa: Cape Town township, household sample\(^1\)
  - Large gender disparity: 50% women obese, 9% men obese
  - Extreme childhood poverty: + obesity in women, not men
    - Measures: hunger, family finances, father employment

- Dutch famine study: 1944-45 ration cut\(^2\)
  - Follow-up at age 59 years old
  - In utero maternal calorie restriction: + BMI, +waist in women, not men
    - Association most pronounced > 10 weeks of gestation

\(^1\)Case A, Menendez A. 2009. Econ and Hum Biol 7: 271-82
Future directions

• Early childhood experience – potentially differential effects on females vs males
  – Adult obesity: investigate social and nutritional deprivation

• Adult weight gain: physiologic regulation of energy balance
  – Physiological systems: Central nervous system, HPA axis
  – Social, behavioral, environmental disrupters: stress, mood disorders, dieting, etc.
Limitations

- Self-reported data
- Only one anthropometric measure: BMI
- Particular age period
- Selection bias, particularly in Black males
New project

- **Background:** The SEP gradient for obesity is steeper in women than men

- **Research questions:** Do parity patterns contribute to greater socioeconomic disparities in obesity incidence in women versus men in U.S. Black and White young adults?

- **Study design:**
  - Add Health
  - Obesity: wave IV (late 20s/early 30s)
    - BMI
    - waist circumference
  - Exposure: assessed waves I, II, III, IV
    - Parity and pregnancy
Methodology for health disparities

• Unresolved: Application of causal theory, e.g., causal diagramming, to health disparities research
  – What does “race” represent on a DAG?
  – Do arrows go into “race”? Into “sex”?

• Important implications:
  – Adjustment strategies
  – Recognize potential biases from sampling strategy and covariate adjustment
Sex disparity in U.S. Blacks: Explanations investigated

1. Innate physiological differences between Blacks and Whites
   – sex-linked genetic traits in Blacks?
2. Innate cultural differences between Blacks and Whites
3. Behavioral differences between Black males and females
   – i.e., physical activity
4. Differential treatment of Black males and females
   – i.e., parents