AN APPLICATION OF PROPENSITY-SCORE MATCHING: THE EFFECT OF CHILDBEARING ON OBESITY RISK

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Motivation

• To what extent does childbearing contribute to obesity prevalence in women?

• Importance:
  • **Societal**: Ethnic and SES-based disparities in obesity
  • **Public health burden**: To what extent do child-bearing patterns contribute to rising obesity prevalence?
  • **Individual**: Women’s decision-making and expectations
Methodological challenges in previous studies

• Study design 1: In post-menopausal women, compare parous vs non-parous
  • Minority of childless women different from other women
  • Timing: Did wt gain precede births – or occur long after?
  • Generalizability: elderly target population, births in 1940s-1970s

• Study design 2: Compare post-pregnancy vs pre-pregnancy weight
  • Does not account for existing trajectory of weight gain
  • Generalizability: births in 1970s, 1980s; not population-based

• Study design 3: Compare weight gain or obesity incidence in parous versus non-parous women
  • Parous women are different from non-parous women
  • Generalizability: Births in 1970s, 1980s; not population-based
  • Possible selection bias: lots of exclusions
Methodological challenges in previous studies

• Study design 1: In post-menopausal women, compare parous vs non-parous
  • Minority of childless women different from other women
  • Timing: Did wt gain precede births – or occur long after?
  • Generalizability: elderly target population

• Study design 2: Compare post-pregnancy vs pre-pregnancy weight
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• Study design 3: Compare weight gain or obesity incidence in parous versus non-parous women
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  • Generalizability: Births in 1970s, 1980s; not population-based
  • Possible selection bias: lots of exclusions
Why propensity scores?

Address confounding

- Lack of comparability between exposed and unexposed, “exchangeability”

- Two aspects of lack of comparability
  - Imbalance – uncontrolled confounding
  - Lack of overlap (“positivity”) – extrapolation
    - indicates possible uncontrolled confounding, no data on which to evaluate
How model-dependent are our inferences?

Severe imbalance, good overlap

Slight imbalance, good overlap

Severe imbalance, no overlap

Moderate imbalance, partial overlap

From Gelman and Hill, 2003
Study Design

• Goals:
  • Achieve generalizability
  • Prevent selection bias
  • Improve exchangeability (achieve balance, test for non-overlap)

• Design: Prospective longitudinal cohort comparing parous and non-parous women
  • Data: Population-representative contemporary population of child-bearing women
  • Restriction & variable selection: Limit exclusions & induced bias
  • Analysis: Women in prime child-bearing years & propensity-score matching
Data: Add Health

Longitudinal Design

Wave I 1994-1995
Students 90,118
School Admin 144†

Wave II 1996
School Admin 128

Wave III 2001-2002
Adolescents in grades 7-12
(20,745)

Wave IV 2007-08
Adolescents in grades 8-12
(14,738)

In-School Administration

In-Home Administration

Adolescents in grades 7-12
(20,745)
Parent 17,670

Parent 17,670

Young Adults Aged 18-26*
(15,197)

Adults Aged 24-32†
(15,701)

Partners 1,507

Students 90,118

Adolescents in grades 8-12
(14,738)

† 144 schools participated in school administration. School administration questionnaires from 143 of these schools.

*24 respondents were 27-28 years old. †52 respondents were 33-34 years old.
Implementation of p-score matching

- **Exposure**: parous/non-parous, wave 4
- **Outcome**: obesity (BMI $\geq 30.0$ kg/m²) at wave 4

- Step 1: Logistic regression to predict “propensity” to parity (exposure)
- Step 2: Assign each respondent a p-score, $Pr(\text{parous})$
- Step 3: Match each parous women to 1+ non-parous women (ATT)
  - *Stata’s psmatch2* (January 2012)
    - How good a match is necessary? calipers: 0.1 sd of p-score
    - Boot-strapping to get 95% CIs, 100 iterations

help for psmatch2

Mahalanobis and Propensity score Matching

    psmatch2 depvar [indepvars] [if exp] [in range] [, outcome(varlist) pscore(varname) neighbor(integer) ai(integer) radius caliper(real) mahalanobis(varlist) kernel llr kerneltype(type) bwidth(real) spline nknots(integer) common trim(real) noreplacement descending odds index logit ties quietly w(matrix) ate]

Description

    psmatch2 implements full Mahalanobis matching and a variety of propensity score matching methods to adjust for pre-treatment observable differences between a group of treated and a group of untreated. Treatment status is identified by depvar==1 for the treated and depvar==0 for the untreated observations.

    psmatch2 is being continuously improved and developed. Make sure to keep your version up-to-date as follows

    . ssc install psmatch2, replace

By default psmatch2 calculates approximate standard errors on the
Choosing matching algorithm

Predictor variables: Unique ID of school attended at the first survey, age, age^2, US region (S, NE, MW, W), urbanicity, regionxurbanicity, parental education, Black race, Blackxparental education, immigrant, immigrant black, mexican, cuban, Puerto Rican, Central Am, Other Hispanic, Hispanicximmigrant, chinese, filipino, Vietnamese, etc.,
Creating matching variable, logit1a

qui logistic parous
    age_yr_w4 ageyrsq_w4 region1 region2 region4
    rural suburb
    ruralxreg1 ruralxreg2 ruralxreg4
    suburxbreg1 suburxbreg2 suburxbreg4
    highedcat1 highedcat2 highedcat3 highedcat4 highedcat6
    black nonbwrace
    blackxhhighed1 blackxhhighed2 blackxhhighed3 blackxhhighed4 blackxhhighed6
    usborn gennonblwh genblack
    mexam cuban puertorican centrsoutham otherhisp hispmix
    genmexam gencuban genpuertorican gencentrsoutham genotherhisp
    chinese filipino japan asiaindn korean vietnam asianoth asianmix
    i.scid_n
    if w4_selectf==1, coef;

*****************************

* CONSTRUCTING FINAL SAMPLE
*    childhood to w4
*****************************;
predict pr1a_w4 if w4_selectf==1;
gen logit1a=log(pr1a_w4/(1-pr1a_w4));
Lack of comparability

Descriptive characteristics by parity in unmatched sample

<table>
<thead>
<tr>
<th></th>
<th>Parous</th>
<th>Non-Parous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% (N)</td>
<td>52.3</td>
<td>47.7</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>(3593)</td>
<td>(3186)</td>
<td>(6779)</td>
</tr>
</tbody>
</table>

**Region (adolescent residence)**

<table>
<thead>
<tr>
<th>Region</th>
<th>Parous</th>
<th>Non-Parous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>44.1%</td>
<td>32.0%</td>
<td>38.3%</td>
</tr>
<tr>
<td>Midwest</td>
<td>32.1%</td>
<td>30.9%</td>
<td>31.5%</td>
</tr>
<tr>
<td>West</td>
<td>14.2%</td>
<td>18.9%</td>
<td>16.5%</td>
</tr>
<tr>
<td>Northeast</td>
<td>9.7%</td>
<td>18.2%</td>
<td>13.7%</td>
</tr>
</tbody>
</table>

**Mother’s education**

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Parous</th>
<th>Non-Parous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; HS</td>
<td>23.6%</td>
<td>12.8%</td>
<td>18.5%</td>
</tr>
<tr>
<td>&gt; college</td>
<td>3.6%</td>
<td>10.1%</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

% are weighted for complex survey sampling and non-response
Distribution of p-scores by parity

Slight imbalance, good overlap

psgraph, p(pr1a_w4) saving (hist_1log_1-1.gph,replace) title("Histogram: Model 1A, caliper .1logit, no replace");
## Covariate balance before & after matching

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample</th>
<th>Parous</th>
<th>Non-parous</th>
<th>% bias</th>
<th>% reduction</th>
<th>bias</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years), w4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>28.7</td>
<td>28.1</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>28.5</td>
<td>28.5</td>
<td>-2</td>
<td>94.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>US REGION, w1 (ref=SOUTH)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>20.8%</td>
<td>24.8%</td>
<td>-10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>22.8%</td>
<td>25.3%</td>
<td>-6</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>24.8%</td>
<td>26.1%</td>
<td>-3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>23.5%</td>
<td>26.1%</td>
<td>-1</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>10.8%</td>
<td>16.2%</td>
<td>-16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>13.2%</td>
<td>11.6%</td>
<td>4.5</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>URBANICITY, w1 (ref=urban)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>19.7%</td>
<td>14.2%</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>16.5%</td>
<td>18.4%</td>
<td>-5</td>
<td>66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>suburb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>52.8%</td>
<td>53.7%</td>
<td>-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>52.9%</td>
<td>53.7%</td>
<td>-2</td>
<td>16.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PARENTAL EDUCATION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;high school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>14.6%</td>
<td>7.7%</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>10.6%</td>
<td>10.8%</td>
<td>-1</td>
<td>97.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vocational degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>8.8%</td>
<td>8.4%</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>10.3%</td>
<td>9.9%</td>
<td>1</td>
<td>-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RACE &amp; ETHNICITY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-H BLACK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>25.7%</td>
<td>21.8%</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>24.2%</td>
<td>24.5%</td>
<td>-1</td>
<td>93.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-H CHINESE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched</td>
<td>0.3%</td>
<td>2.3%</td>
<td>-18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matched</td>
<td>0.4%</td>
<td>0.1%</td>
<td>3</td>
<td>81.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% do not account for complex survey design or non-response
% Obesity in Parous vs Non-parous

Demographic match, 1:1 neighbor, no replacement

N=5,438 of 6,601

psmatch2 parous, outcome(ob_constr_w4) pscore(logit1a) caliper(.1) com noreplacement descending;

dif = 7.3 %pts
(95% CI: 4.9, 9.6)
% Obesity in Parous vs Non-parous

Demographic match, 1:1 neighbor, no replacement

N=5,438 of 6,601

psmatch2 parous, outcome(ob_constr_w4) pscore(logit1a) caliper(.1) com noreplacement descending;

Parous Non-parous

UNMATCHED (UNADJ)

40.9% 33.6%

dif = 7.3 %pts (95% CI: 4.9, 9.6)

MATCHED (ADJ)

38.9% 38.3%

dif = 0.6 %pts (95% CI: -2.2, 3.3)
% Obesity in Parous vs Non-parous

Demographic match, 1:1 neighbor, with replacement

N=6,592 of 6,601

psmatch2 parous, outcome(ob_constr_w4) pscore(logit1a) caliper(.1) com;

dif = 7.3 %pts (95% CI: 4.9, 9.6)

UNMATCHED (UNADJ)

Parous: 40.9%
Non-parous: 33.6%

MATCHED (ADJ)

Parous vs Non-parous
% Obesity in Parous vs Non-parous
Demographic match, 1:1 neighbor, with replacement

![Bar chart showing obesity prevalence](chart)

- **UNMATCHED (UNADJ)**
  - Parous: 40.9%
  - Non-parous: 33.6%
  - $\text{dif} = 7.3\%$ pts (95% CI: 4.9, 9.6)

- **MATCHED (ADJ)**
  - Parous: 40.8%
  - Non-parous: 41.7%
  - $\text{dif} = -0.9\%$ pts (95% CI: -4.9, 3.2)

N = 6,592 of 6,601
% Obesity in Parous vs Non-parous

Demographic match, 4:1 neighbor, with replacement

N=6,592 of 6,601

dif = 7.3 %pts
(95% CI: 4.9, 9.6)

Parous vs Non-parous

UNMATCHED (UNADJ)

MATCHED (ADJ)
% Obesity in Parous vs Non-parous

Demographic match, 4:1 neighbor, with replacement

dif = 7.3 %pts  
(95% CI: 4.9, 9.6)

dif = -1.4 %pts  
(95% CI: -4.5, 1.7)

Parous
Non-parous

N=6,592 of 6,601
Motivation for w3-w4 incidence analysis

Add Health: w3-w4 incidence

**Longitudinal Design**

**In-School Administration**
- Wave I: 1994-1995
  - Students: 90,118
  - School Admin: 144†
- Wave II: 1996
  - School Admin: 128
- Wave III: 2001-2002
  - Partners: 1,507
- Wave IV: 2007-08
  - Adults Aged 24-32†: 15,701
  - Adults Aged 24-32†: (15,701)
  - Adolescents in grades 7-12 (20,745)
  - Adolescents in grades 8-12 (14,738)
  - Young Adults Aged 18-26*: (15,197)

**In-Home Administration**
- Parent: 17,670

*24 respondents were 27-28 years old. †52 respondents were 33-34 years old.
‡ 144 schools participated in school administration. School administration questionnaires from 143 of these schools.

---

23
Distribution of p-scores by parity: incidence analysis

Incident ob, ATT: caliper .1logit, no replace

More (moderate) imbalance, good overlap
Compare this prevalence graph to incidence graph above

Histogram of Propensity Scores for Parity, Model 1A, caliper .1

Slight imbalance, good overlap
% Incident Obesity in Parous vs Non-parous
Demographic match, 1:1 neighbor, no replacement

N=2,715 of 2,731
% Incident Obesity in Parous vs Non-parous

Demographic match, 1:1 neighbor, with replacement

7-yr Obesity incidence

Parous Non-parous

UNMATCHED (UNADJ)

19.3% 16.1%

dif = 3.2 %pts
(95% CI: -0.3, 6.6)

MATCHED (ADJ)

19.4% 18.5%

dif = 0.9 %pts
(95% CI: -4.9, 6.7)

N=2,730 of 2,731
Distribution of p-scores by parity: incidence analysis

Incident ob, ATT: caliper .1logit, no replace

Moderate imbalance, good overlap
Interpreting results

• **Summary:** No evidence that child-bearing contributes to obesity incidence or prevalence in young U.S. women

• **Target population:** women who gave birth by early 20s (incidence) or age ~30 years (prevalence),
  • Population: young mothers of mostly pre-school aged children
  • Causal action: postponing or abstaining from childbearing

• **Heterogeneity**
  • Marginal effect could mask risk/protectiveness of child-bearing
  • Could attempt to identify at-risk women, e.g., race, pre-preg BMI

• **Mechanisms**
  • Child-bearing: biological and social phenomenon
Acknowledgements

• Funding:
  • RWJF H&SS small grant, University of Michigan
  • Carolina Population Center Summer-in-Residence Grant Writing Fellowship (2012)
  • NCI K01CA172717

• Collaborators:
  • Mariah Cheng, Katherine Hoggatt, Anna-Maria Siega Riz

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Example with overlap problem

```
ASIAN, Incident ob, ATT: caliper .1logit, no replace
```

```
Propensity Score

Untreated
Treated: On support
Treated: Off support
```
THE END