Comparing Instrumental Variables and Propensity Score Approaches to Estimating Cost Effectiveness of Breast Cancer Surgery

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INTRODUCTION

• Breast Cancer is the second leading cause of cancer-related deaths in American women
• Early stage breast cancer is an important issue for elderly women
  – Majority of diagnoses occur among those over 65
  – 75% of those over 65 diagnosed with early stage disease
  – Five year survival in this group is 73%

INTRODUCTION (II)

• Breast-conserving treatment has become a viable alternative to mastectomy for those with early stage disease
  – clinical trials show equivalent survival
• Breast conserving surgery followed by radiation therapy (BCS with RT) is the preferred treatment (Consensus Conference, 1991)
  – provides the surgical equivalent of mastectomy while preserving the breast
  – BCS with RT may be more costly than mastectomy

OBJECTIVES

Evaluate cost effectiveness of BCS with RT relative to Mastectomy using observational data of elderly women with early stage breast cancer

Compare analytical approaches to addressing selection bias in observational studies

SELECTION BIAS

• Healthier group more likely to get BCS with RT
• This healthier group would have better outcomes regardless of surgery
• Would better observed outcomes be caused by BCS with RT or is it confounded by indication?

APPROACHES TO ADDRESS SELECTION BIAS

• Risk adjustment
• Propensity Score Analysis
• Instrumental Variables Analysis
DATA SOURCES

Stage eligibility: Physician survey
Quality of life: Patient interviews conducted in 1997
Baseline info: Claims data, census data, and Area Resource File

SAMPLE

• National Random Sample (5%)
• Breast cancer diagnosis or relevant surgery procedure code in years 1992, 1993, and 1994
• Ages 67 and older
• Only stage I or stage II breast cancer
• Excluded if diagnoses suggest mastectomy or BCS with RT

OUTCOMES

• Quality Adjusted Life Years (QALYs)
  - discounted annual survival adjusted for quality of life over 5 year period
  - Quality of life measured by year using Visual Analogue Scale administered in patient interviews 3-5 years post-surgery
  - Survival from denominator Claims file
• Costs
  - Total Medical Costs over 5-year post-surgery period
  - We use the amount reimbursed by Medicare

COVARIATES

• Demographics: age, race,
• Severity measures: Breast cancer disease stage, Charlson index, Medical costs prior to surgery
• Characteristics of health care system
• Zip code level proxies for demographics: education, income, poverty level

ANALYSIS STRATEGY

• Estimate QALYs, Costs, and the incremental cost-effectiveness ratio using four approaches
  1. No severity adjustment
  2. Severity adjustment using observed severity measures: Ordinary least squares regressions for QALYs and costs
  3. Severity adjustment using propensity score analysis
  4. Severity adjustment using "unobserved" severity measures (i.e. instrument variables analysis)
• Evaluate differences in the four levels of severity adjustment

PROPENSITY SCORE ANALYSIS

• The propensity score is the probability a subject is assigned to treatment, conditional on observed cofounders
• In this analysis:
  – We formed 4 strata using the estimated propensity score
  – We estimated treatment effect based on the interaction of treatment with propensity score strata in an OLS regression
INSTRUMENTAL VARIABLES ANALYSIS

- Adjusts for observed and unobserved cofounders through a pseudo-randomization process
- Instrumental variables meet two conditions:
  - Highly correlated with the treatment choice
  - Not directly related to risk factors
- Instrumental variables used for this project
  - Distance to hospital with radiation therapy facility
  - Region of residence (North vs. South)
  - Medicare physician fee differential between mastectomy and breast conserving surgery

Table 1. Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>BCSRT</th>
<th>Mastectomy</th>
<th>Stat Signif</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 67-74 (%)</td>
<td>66.6</td>
<td>54.2</td>
<td>***</td>
</tr>
<tr>
<td>Race: Non-white (%)</td>
<td>5.7</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>Disease Stage: 1 (%)</td>
<td>71.4</td>
<td>50.9</td>
<td>***</td>
</tr>
<tr>
<td>Charlson Index</td>
<td>1.27</td>
<td>1.71</td>
<td>***</td>
</tr>
<tr>
<td>Pre-surgery costs ($)</td>
<td>4206</td>
<td>6913</td>
<td>***</td>
</tr>
</tbody>
</table>

Table 2. QALYs by treatment type and by adjustment method

<table>
<thead>
<tr>
<th></th>
<th>BCSRT</th>
<th>Mastectomy</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-year Quality Adjusted Life Years:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no risk adjustment</td>
<td>3.54</td>
<td>3.22</td>
<td>0.32 (0.26, 0.38)</td>
</tr>
<tr>
<td>risk adjustment</td>
<td>3.40</td>
<td>3.28</td>
<td>0.12 (0.09, 0.19)</td>
</tr>
<tr>
<td>Propensity Score Adj.</td>
<td>3.35</td>
<td>3.27</td>
<td>0.08 (-0.01, 0.17)</td>
</tr>
<tr>
<td>IV risk adjustment</td>
<td>3.11</td>
<td>3.40</td>
<td>-0.29 (-0.35, -0.23)</td>
</tr>
</tbody>
</table>

Table 3. Costs by treatment type and by adjustment method

<table>
<thead>
<tr>
<th></th>
<th>BCSRT</th>
<th>Mastectomy</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-year Medical Costs:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no risk adjustment</td>
<td>$48,604</td>
<td>$40,125</td>
<td>$8,479 (4852 to 12105)</td>
</tr>
<tr>
<td>risk adjustment</td>
<td>$52,724</td>
<td>$38,525</td>
<td>$14,199 (10279 to 18118)</td>
</tr>
<tr>
<td>Propensity Score Adj.</td>
<td>$54,423</td>
<td>$38,616</td>
<td>$15,807 (11146 to 17252)</td>
</tr>
<tr>
<td>IV risk adjustment</td>
<td>$79,229</td>
<td>$28,233</td>
<td>$50,997 (12879 to 89114)</td>
</tr>
</tbody>
</table>
Table 4. Incremental Cost Effectiveness Ratio by treatment type and by adjustment method

<table>
<thead>
<tr>
<th>Incremental cost-effectiveness ratio ($ per QALY)</th>
<th>95% Confidence Interval</th>
<th>Lower CI ($ per QALY)</th>
<th>Upper CI ($ per QALY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental Costs per QALY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no risk adjustment</td>
<td>26,495</td>
<td>16,600</td>
<td>39,600</td>
</tr>
<tr>
<td>risk adjustment</td>
<td>118,325</td>
<td>70,040</td>
<td>250,000</td>
</tr>
<tr>
<td>Propensity Score adj.</td>
<td>197,587</td>
<td>105,000</td>
<td>Dominated</td>
</tr>
<tr>
<td>IV risk adjustment</td>
<td>Dominated</td>
<td>150,200</td>
<td>Dominated</td>
</tr>
</tbody>
</table>

CONCLUSIONS

• Breast conservation surgery with radiation costs more than mastectomy with a possible improvement in quality of life. Not cost-effective.

• The propensity score analysis is comparable to the traditional risk adjustment analysis

• The adjustment using Instrumental Variables analysis is much greater than the adjustments in the other analyses
  • This could be the adjustment for unmeasured severity