How much of the socioeconomic differences in breast cancer patient survival can be explained by stage at diagnosis and treatment?

Application of causal mediation analysis to routine data

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Introducing breast cancer

- Most common cancer in UK
- Screening (50-70)
- Treatment with strict guidelines

- Northern and Yorkshire Cancer Registry, population-based, covering 12% of the English population
- Women with malignant breast cancers (N=36,793)
  - Diagnosed during the period 2000–2007
  - Followed up until 31 December 2007
Differences in survival after a diagnosis of breast cancer...
Possible explanations

• Differential stage at diagnosis?

• Differential treatment?
Differential stage at diagnosis?

Deprivation

<table>
<thead>
<tr>
<th>Stage at diagnosis (%)</th>
<th>Least deprived</th>
<th>Most deprived</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>37.6</td>
<td>40.9</td>
</tr>
<tr>
<td>II</td>
<td>43.0</td>
<td>43.7</td>
</tr>
<tr>
<td>III</td>
<td>6.8</td>
<td>6.2</td>
</tr>
<tr>
<td>IV</td>
<td>4.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Missing</td>
<td>8.0</td>
<td>5.7</td>
</tr>
</tbody>
</table>

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Differential treatment? – probability of getting major surgery

15-49 pre-screening

50-69 screening

70+ post-screening

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To study why...
If we look at stage

We can **decompose** the total effect (TCE) of deprivation on mortality into…

- Those mediated by stage (The indirect effect, NIE)

- Those not mediated by stage (The direct effect, NDE)

\[
TCE = \log(\text{odds}_{death} | \text{Dep} = \text{most}, \text{Stage}_{\text{Dep}=\text{most}}) - \log(\text{odds}_{death} | \text{Dep} = \text{least}, \text{Stage}_{\text{Dep}=\text{least}}) \\
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\]
If we look at treatment

We can decompose the total effect (TCE) of deprivation on mortality into...

- Those mediated by treatment (The indirect effect, NIE)
- Those not mediated by treatment (The direct effect, NDE)

\[
TCE = \log(\text{odds}_{\text{death}} | \text{Dep} = \text{most, Treat}^{\text{Dep=most}}) - \log(\text{odds}_{\text{death}} | \text{Dep} = \text{least, Treat}^{\text{Dep=least}})
\]

\[
NIE = \log(\text{odds}_{\text{death}} | \text{Dep} = \text{most, Treat}^{\text{Dep=most}}) - \log(\text{odds}_{\text{death}} | \text{Dep} = \text{most, Treat}^{\text{Dep=least}})
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NDE = \log(\text{odds}_{\text{death}} | \text{Dep} = \text{most, Treat}^{\text{Dep=least}}) - \log(\text{odds}_{\text{death}} | \text{Dep} = \text{least, Treat}^{\text{Dep=least}})
\]
G-formula results

6 months  12 months  3 years  5 years

Total effect  Effect via stage  Effect via treatment

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Conclusion

• Breast cancer survival differed between the most deprived and most affluent patients

• Effect of deprivation on mortality mediated via stage:
  o One third of at six months
  o One tenth at three/five years since diagnosis

• Effect of deprivation on mortality mediated via treatment:
  o None
Summary

• First application of the causal mediation tool in study of cancer registry data
• Population-based data
• Drawbacks
  o Data quality and detail, particularly to treatment (why are we particularly interested in treatment?)
  o Quality and thoroughness of diagnostic investigation
  o Comorbidity
• Useful for answering questions related to causality
  o Resource allocation
References

