Development of cancer projection methods at the Public Health Agency of Canada

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Public Health Agency of Canada

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Outline

• Background and Rationale
• Considerations for Model Selection
• Applications
• Summary of potential issues
Background

• Cancer projections are an important and long-standing function of the Public Health Agency of Canada (the Agency)
  – Canadian Cancer Statistics projections
  – Peer-reviewed papers and monographs on projections and methods
  – Supporting national and international projection workshops
  – Working collaboratively with partners (e.g., Canadian Partnership Against Cancer)

• Recent work at the Agency has focused on improving projection accuracy through development and comparison of statistical methods
  – Updating Canadian Cancer Statistics methods
  – Examining methods for small areas/rare cancers
  – Comparing models for accurate short- and long-term projections
Why project the future burden of cancer?

Fundamentally, future planning is essential for an effective cancer control program

- Cancer projections can be used for:
  - Resource allocation according to expected health care demands (i.e., expected numbers of new cancer patients requiring care)
  - Early warning signals of rising incidence and the need for preventative action
  - Evaluation of competing control strategies
Many different projection models

Numerous models co-exist, each with a different approach to cancer projection

- Microsimulation models (National Cancer Institute)
- State-space model (National Cancer Institute/American Cancer Society)
- Autoregression model (American Cancer Society)
- Functional data analysis (Australian Institute of Health and Welfare)
- Model averaging (New Zealand Ministry of Health)
- APC power model regression ‘Nordpred’ (Cancer Research UK)
- Piece-wise linear regression (Joinpoint)
- Bayesian models
- etc.
## Many different applications

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>SELECTED MODEL</th>
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<tbody>
<tr>
<td>Assess impact of risk factor reduction, and increased early detection and access to treatment</td>
<td>Microsimulation model</td>
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<td>Projecting trends in rare cancers and/or small populations</td>
<td>Bayesian autoregressive model</td>
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<td>Projecting trends for cancers with strong cohort effects</td>
<td>APC regression model</td>
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<td>Short-term projection of cancers with unstable rates (e.g. prostate incidence)</td>
<td>Five-year average model</td>
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<tr>
<td>etc.</td>
<td>etc.</td>
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</table>
Projection models

Comparing projection models involves several criteria:
- **Accuracy** of projections
- **Reliability** based on rigorous testing and use
- **Ease of use** in terms of implementation and maintenance
- **Flexibility** to evolve with user needs

Choosing a projection model involves several considerations:
- What is the application?
- What are the objectives?
- What data are available?
- Who are the users?
## Examples of recent comparative work

<table>
<thead>
<tr>
<th>Research group</th>
<th>Cancer types</th>
<th>Geographical area</th>
<th>Observation period</th>
<th>Horizon</th>
<th>Models</th>
<th>Best model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordic Cancer Union</td>
<td>CCS list, ex. brain, liver</td>
<td>Denmark, Finland, Iceland, Norway, Sweden</td>
<td>1958-1987 (incidence)</td>
<td>10 years</td>
<td>• APC models</td>
<td>Nordpred (modified) or 5-yr average</td>
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<td>• power models</td>
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<td>• short-base models</td>
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<td>• polynomial APC</td>
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<td></td>
<td>• 5-year averages</td>
<td></td>
</tr>
<tr>
<td>Agency</td>
<td>CCS list, ex. prostate</td>
<td>All Canada, provinces</td>
<td>1981-2000 (incidence / mortality)</td>
<td>3 years</td>
<td>• Nordpred</td>
<td>Nordpred</td>
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<td></td>
<td></td>
<td></td>
<td>• CCS method</td>
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<tr>
<td>SFU</td>
<td>All cancers, melanoma, prostate, NHL, bladder, brain, thyroid, testis, kidney, breast, ovary</td>
<td>All Canada, provinces, territories</td>
<td>1981-2000 (mortality)</td>
<td>4 years</td>
<td>• Nordpred</td>
<td>Nordpred (modified) or 5-yr average</td>
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<td>• CCS method</td>
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<td>• Joinpoint</td>
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<td>• state space</td>
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<td>• autoregression</td>
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<td></td>
<td>• 5-year average</td>
<td></td>
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<tr>
<td>Agency</td>
<td>CCS list (ex. prostate inc.; kidney, liver, uterus, mult. myeloma, mortality)</td>
<td>All Canada, provinces (ex. QC incidence)</td>
<td>1972-1991 (incidence)</td>
<td>5 years</td>
<td>• Nordpred</td>
<td>Nordpred</td>
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<td>1951-1985 (mortality)</td>
<td></td>
<td>• multivariate time series</td>
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<td></td>
<td></td>
<td>• 5-year average</td>
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<tr>
<td>C-Projections</td>
<td>CCS list, ex. Hodgkin lymphoma</td>
<td>Alberta, AHR 1 AHR 2</td>
<td>1983-2002 (incidence &amp; mortality)</td>
<td>5 years</td>
<td>• CCS method</td>
<td>'hybrid' method</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>• 'hybrid' method</td>
<td>Bayesian methods</td>
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Examples of various projection models
Example: *Canadian Cancer Statistics (CCS)*

Estimated cancer cases and rates for current year

– are estimated from the most recent available data (3-5 years behind)
– calculated for over 20 cancer types at national level and for all provinces/territories
– generated primarily using regression models from the Nordpred* package in R (as of the 2012 report)
– provide a current picture of cancer in Canada

* www.kreftregisteret.no/en/Research/Projects/Nordpred/Nordpred-software/
Statement of the problem

• The current CCS projection methodology has reoccurring, unresolved problems
  – Default method (Poisson model) is unsuitable for small areas, rare cancers, and for trends affected by screening/interventions
  – Process for deciding between Poisson and 5-year average estimates tends to be time consuming and subjective
  – Software is inefficient and not amenable to change

• CCS projection methods have not changed since 2003
  – Since then, substantial work has occurred in Canada and abroad on cancer projection; new methods and software are available
Comparative Results (some examples)

Breast cancer mortality, females, Canada

Melanoma mortality, males, Canada
Accuracy of various models for projecting cancer mortality in Canada. Values are the percentage of data scenarios where projection error ≤ 5%. Most accurate model(s) for a cancer is/are shown in red.

<table>
<thead>
<tr>
<th></th>
<th># scenarios</th>
<th>Nordpred</th>
<th>Reduced Nordpred</th>
<th>CCS method</th>
<th>ARL</th>
<th>ARQ</th>
<th>SSML</th>
<th>SSMQ</th>
<th>Joinpoint</th>
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<tbody>
<tr>
<td>All data scenarios</td>
<td>159</td>
<td>27.0</td>
<td>26.4</td>
<td>22.0</td>
<td>25.8</td>
<td>18.2</td>
<td>24.5</td>
<td>18.9</td>
<td>26.4</td>
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<tr>
<td>All sites combined</td>
<td>26</td>
<td>65.4</td>
<td>65.4</td>
<td>57.7</td>
<td>61.5</td>
<td>61.5</td>
<td>69.2</td>
<td>57.7</td>
<td>65.4</td>
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<tr>
<td>Melanoma</td>
<td>17</td>
<td>17.6*</td>
<td>17.6*</td>
<td>0.0</td>
<td>5.9</td>
<td>11.8</td>
<td>5.9</td>
<td>11.8</td>
<td>11.8</td>
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<tr>
<td>Prostate</td>
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<td>36.4*</td>
<td>9.1</td>
<td>9.1</td>
<td>9.1</td>
<td>9.1</td>
<td>36.4*</td>
<td>18.2</td>
<td>36.4*</td>
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<tr>
<td>Bladder</td>
<td>21</td>
<td>19.0</td>
<td>14.3</td>
<td>23.8*</td>
<td>23.8*</td>
<td>9.5</td>
<td>19.0</td>
<td>9.5</td>
<td>14.3</td>
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<td>Brain</td>
<td>14</td>
<td>28.6*</td>
<td>21.4</td>
<td>28.6*</td>
<td>28.6*</td>
<td>21.4</td>
<td>28.6*</td>
<td>21.4</td>
<td>28.6*</td>
</tr>
<tr>
<td>NHL</td>
<td>19</td>
<td>5.3</td>
<td>31.6</td>
<td>0.0</td>
<td>21.1</td>
<td>10.5</td>
<td>10.5</td>
<td>10.5</td>
<td>15.8</td>
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<td>Kidney</td>
<td>20</td>
<td>25.0</td>
<td>20.0</td>
<td>25.0</td>
<td>25.0</td>
<td>5.0</td>
<td>15.0</td>
<td>10.0</td>
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<tr>
<td>Breast</td>
<td>11</td>
<td>36.4*</td>
<td>36.4*</td>
<td>36.4*</td>
<td>36.4*</td>
<td>18.2</td>
<td>27.3</td>
<td>18.2</td>
<td>27.3</td>
</tr>
<tr>
<td>Ovary</td>
<td>10</td>
<td>10*</td>
<td>10*</td>
<td>10*</td>
<td>10*</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>10*</td>
</tr>
</tbody>
</table>

* tied for best model
Recommendations

1. nordpred is recommended as the default projection method, beginning with the CCS 2012 report
   a. standard nordpred for common cancers (large* annual counts)
   b. modified nordpred (no cohort effect, reduced trend) for moderately sparse data (moderate* annual counts)

2. The five-year average method is recommended for:
   a. rare cancers/small areas (small* annual counts)
   b. prostate incidence
Recommendations

- Prostate incidence
  - 5-year average

All cancer types, mortality and incidence (excl. prostate)

- Reduced nordpred
  - (ADP power-5 decreased trend)

- Standard nordpred
  - (APC power-5 default trend)
Issues arising in cancer projections

• Suitability of the projection model

• Comparability of statistics

• Difficulties with small areas / rare cancers

• Data quality issues
Cancer Projections

Selected References

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Thank you

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