Development of cancer projection methods at the 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.

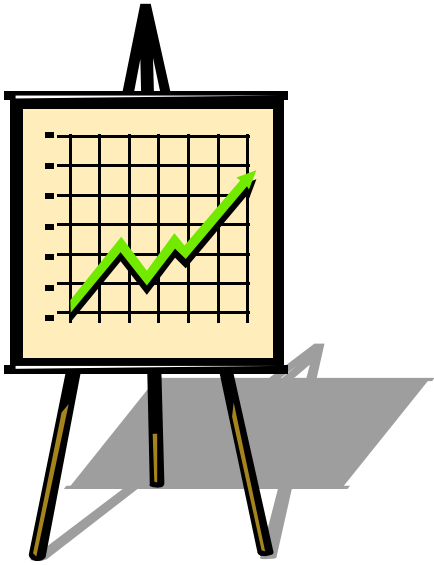
Many different applications

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

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

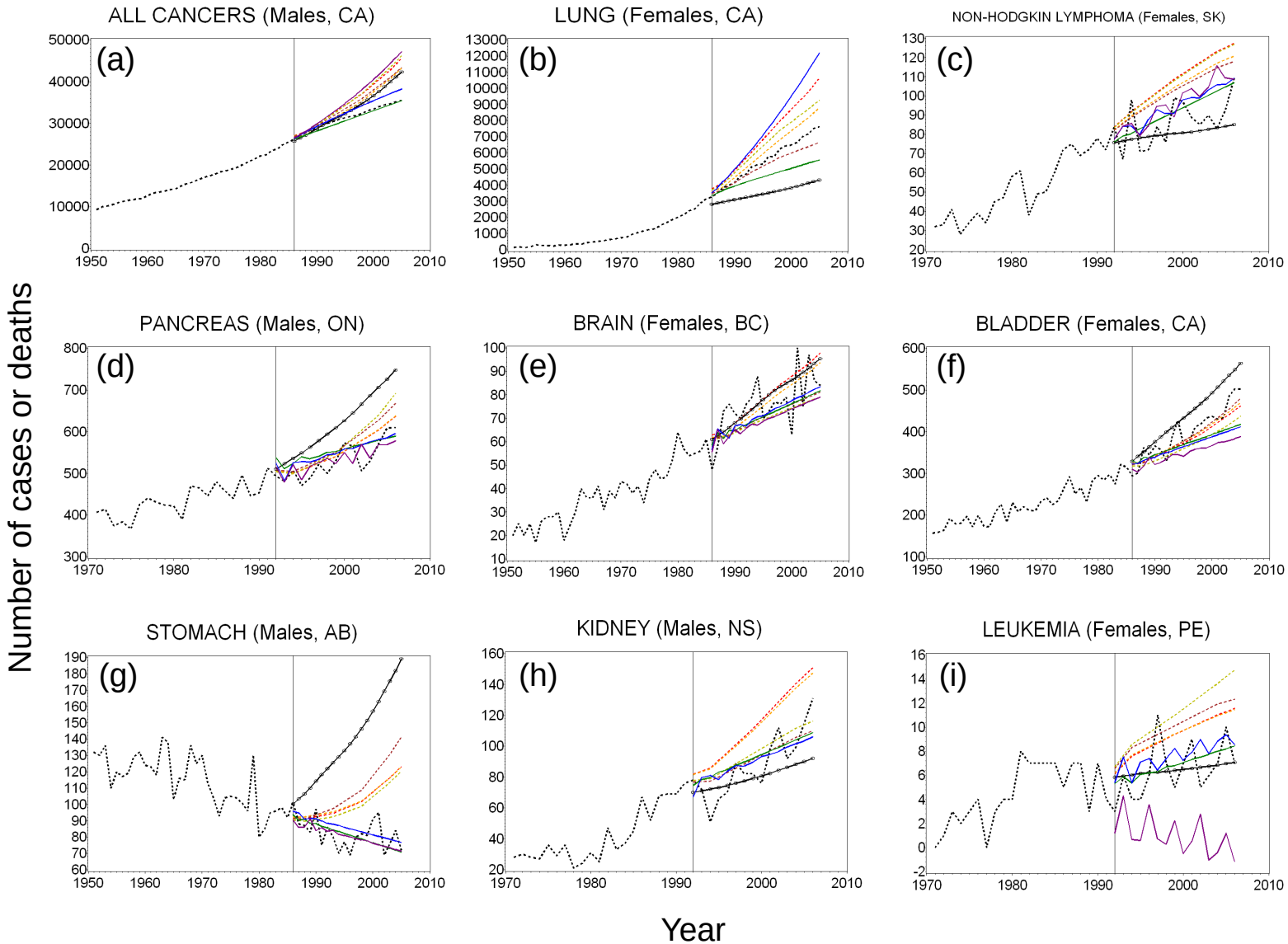
- Choosing a projection model involves several considerations:
  - What is the application?
  - What are the objectives?
  - What data are available?
  - Who are the users?



Examples of recent comparative work

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

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

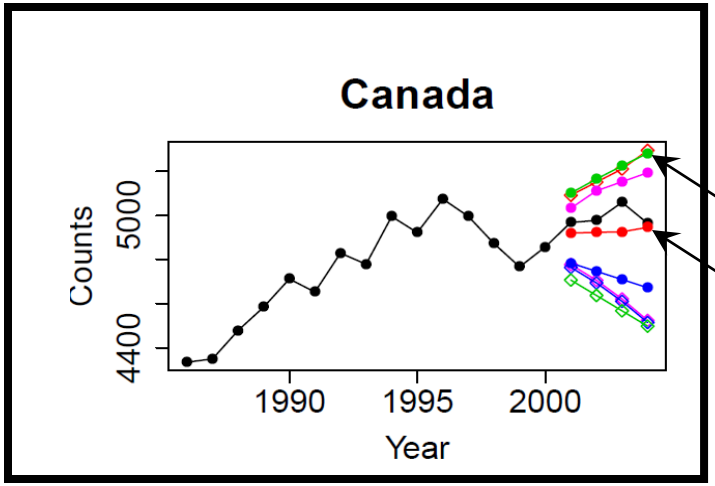
* www.kreftregisteret.no/en/Research/Projects/Nordpred/Nordpred-software/

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

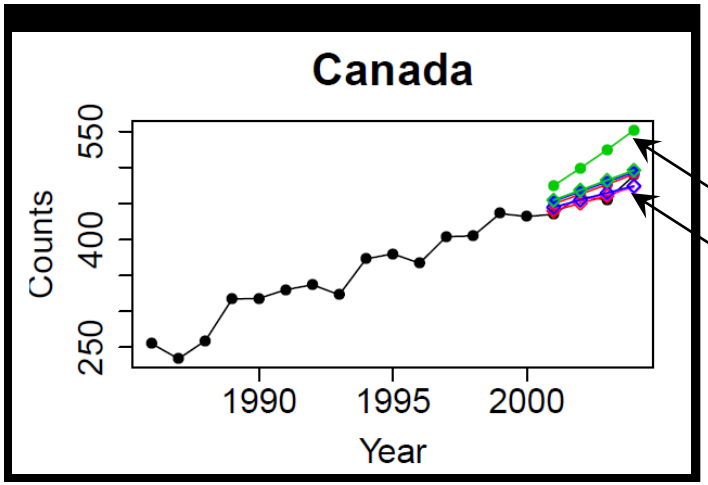
Comparative Results (some examples)



Breast cancer mortality, females, Canada

current CCS method

nordpred method



Melanoma mortality, males, Canada

current CCS method

nordpred method

Comparative Results (some examples) – con't

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.

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

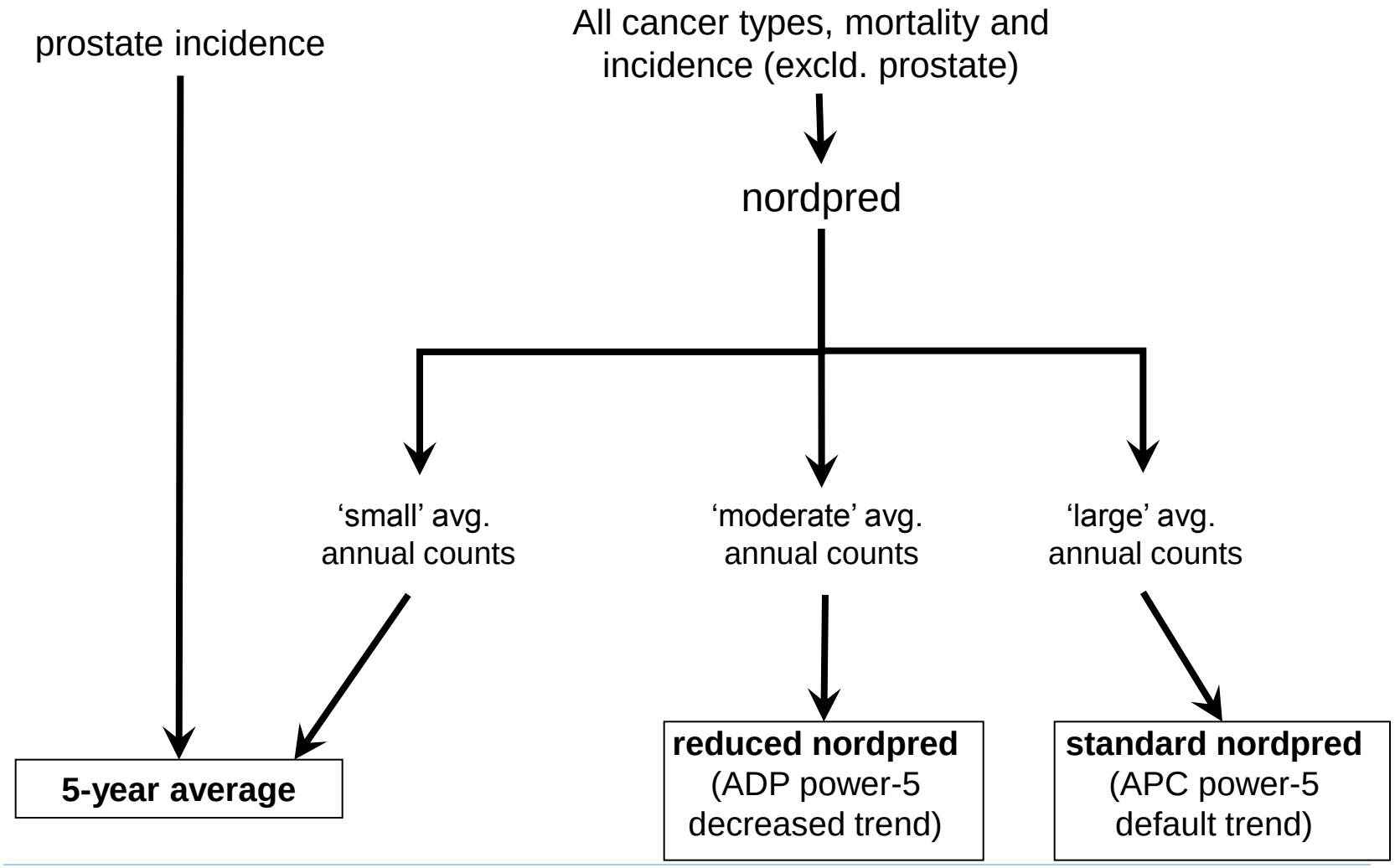
* tied for best model

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



Issues arising in cancer projections

- Suitability of the projection model
- Comparability of statistics
- Difficulties with small areas / rare cancers
- Data quality issues

Selected References

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Thank you

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