Changes in the age-at-death distribution by leading causes of death in Canada: An innovative analysis through a non-parametric method

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VID, International Conference, 2012
XXth century industrialized countries:

- Development of technological innovations leads to significant economic growth

- Improvement of the standard of living of human populations
  - more focus was directed towards sanitation habits
  - the development of new treatments and pharmaceutical drugs

- Decrease of infectious diseases and degenerative diseases
  - Life expectancy in industrialized countries, such as Australia, Canada, France, Italy, Japan, New Zealand, Spain and the United States, has increased by as much as 40 years.
Introduction

➤ Important modifications of:
   – The shape of age at death distribution
   – The survival curve

➤ Some countries such as Canada, France, Japan and the United States entered an old-age compression of mortality era characterized by:
   ▪ an increase of the adult modal age at death
   ▪ a concentration of senescent deaths around this age.
Compression of mortality: Canada

Ouellette and Bourbeau (2011):

- In Canada the compression of mortality began
  - around 1930 for females
  - latest years signs of shifting mortality

Source: Ouellette and Bourbeau (2011)
Compression of mortality: Canada

- around 1970 for males
- no shifting has been observed

Source: Ouellette and Bourbeau (2011)
Research questions

- Are there signs of male and female mortality compression when looking at the changes in the age-at-death distribution by leading cause of death?
  - Which causes of death are responsible for the overall (all causes combined) compression of Canadian mortality?
  - Did some causes of death contribute more than others to this general phenomenon of compression of male and female mortality?

- Similarly, which causes are responsible for the shifting of female mortality which has been observed in recent years in Canada?
Our research

- Determine if the shifting mortality scenario observed lately in Canada will likely be accompanied by a postponement or a prolongation of morbidity and disability episodes.

- Give some insight on the evolution of the determinants of mortality and may improve our understanding of the processes that have fuelled the compression of mortality.

- Since our analysis is conducted for male and female separately,
  - to determine which causes of death are responsible for the later onset of male mortality compression compared to their female counterparts,
  - to explain why male mortality hasn’t yet entered the shifting regime.

Source: Statistics Canada
Objectives

- Identify the causes, among the ones presented above, showing signs of mortality compression and the ones who do not

- Eventually identify the contribution of these causes to the general compression of mortality
Methodology

- For each cause, analyse the evolution through time
  - The modal age at death ($M$)
  - The standard deviation above the mode ($SD(M+)$).

- These changes are evaluated using a nonparametric smoothing approach, known as the P-splines method (Eilers and Marx, 1996).

- Assuming that, for each cause, death counts for single age- and year-intervals are Poisson distributed,
  - Poisson regression model is used to predict death counts and smooth death rates
  - P-splines are used to estimate the model (Currie et al., 2004):
    - Combines B-splines with a penalty to force estimated coefficients of adjacent B-splines to vary smoothly
    - Double goal: Accurate fit of the data and smooth behaviour
P-splines in action

Smoothing parameter = 0

Smoothing parameter = 10

Source: Ouellette (2011)
Data

Canadian Vital Statistics Data set

- contains confidential information on causes of female and male deaths that have occurred between 1974 and 2007 in Canada.

- provides detailed information on the causes of death by sex, single-year of age and calendar year.

- causes of death are classified according to the World Health Organization "International Statistical Classification of Diseases and Related Health Problems" (ICD).
Preliminary results

- Diseases of the circulatory system
Preliminary results

• Malignant neoplasms

Modal age at death over time, Malignant neoplasms of trachea, brochus, and lungs, Canada, 1974-2007

Modal age at death, Prostate cancer, Men Canada, 1974-2007
Future work

- Analysis of the dispersion of deaths above the mode
- Modify the methodology in order to ensure a certain coherence between the chosen causes of death and the whole set of causes
  - Identify the contribution of each leading cause to the general compression
  - Decompose the modal age at death (all causes) in order to identify the contribution of each leading cause of death
- Causes that will also be analysed:
  - Breast and colorectal cancer
  - Diabetes mellitus
  - Alzheimer’s disease
  - Influenza and pneumonia
  - Nephritis, nephrotic syndrome and nephrosis (kidney disease)
Thank you for your attention!

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