Projecting future mortality in the Netherlands taking into account mortality delay and smoking

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Background

- Conventional extrapolative mortality projection methods do not capture:
  - Impact of life-style epidemics (non-gradual trends + large differences)
  - Mortality delay: the shift in the age-at death distribution towards older ages
Changes in age at death distribution

Compression of mortality scenario (Fries 1980)
- Rectangularization
- Declining variability in the age of dying

Shifting mortality regime / delay of ageing (Vaupel 2010)
- Increase in modal age at dying
- No changes in shape
Importance of delay vs compression

› Delay: a limit to life exp is unlikely for the near future

› Past trends:
  • Over time: delay increases in importance
  • Delay more important than compression
  • In some countries trends in modal age at dying run parallel to trends in e0

› Mortality projections including age-at-death distribution are still scarce (only M, only single populations, do not take into account smoking)
Japanese women – M increases parallel with eo

Source data: Human Mortality Database www.mortality.org
Important role of smoking

- Added value of incorporating smoking in mortality projections has been demonstrated recently
- Within Europe, smoking most important determinant of mortality levels, trends and differences
- Cohort effect, non-linear trends
- Smoking greatly affects (trends in) the age-at-death distribution (Janssen et al. 2015)
- For NL, strong impact of smoking on mortality trends => smoking is taken into account in the official mortality forecast (Stoeldraijer et al. 2013, Janssen et al. 2013)
Total life expectancy and life expectancy without smoking, the Netherlands

Stoeldraijer, van Duin and Janssen (2013)
Objective

› To estimate future life expectancy for the Netherlands by simultaneously taking into account the effect of smoking and developments in delay and compression of mortality
Data & methods

› NL; 1950-2012
› All-cause mortality and population numbers by sex and single year of age (CBS)
› Lung-cancer deaths by sex and five-year age groups (WHOSIS)
› Adjusted Peto et al method => smoking-attributable mortality fractions (SAMF)
› Applying a simplified version of the CoDe mortality model (de Beer & Janssen, submitted) to the total population, non-smokers, and smokers. Aged 40+.
Simplified CoDe mortality model, 40+

Modelling $q(x)$ with minimum number of interpretable parameters

$$q(x) = a + I(x \leq x_1) \left[ \frac{b_1 e^{b_1(x-M)}}{1 + b_1 e^{b_1(x-M)}} \right] + I(x_1 < x \leq x_2) \left[ \frac{b_2 e^{b_2(x-M)}}{1 + b_2 e^{b_2(x-M)}} + c_1 \right] + I(x > x_2) \left[ \frac{b_3 e^{b_3(x-M)}}{1 + b_3 e^{b_3(x-M)}} + c_2 \right]$$

background + adult age + middle age + old age

$x_2 = M; x_1 = M - h$

g (0.7) and $h$ (30) time invariant

five interpretable time-varying parameters: $a,b_1,b_2,b_3,M$
Effects of the parameters of the model

Increase in M that corresponds with 5 yrs increase in e40

Increase in b1 and b2, and decrease in b3 that all three correspond with a 0.5 yrs increase in e40
Age at death distributions

**Age at death distribution - Dutch men**

- **1950**
- **2012**

**1950 - NL - men**

- **total**
- **nonsmokers**
- **smokers**

**Age at death distribution - Dutch women**

- **1950**
- **2012**

**1980 - NL - men**

- **total**
- **nonsmokers**
- **smokers**
Model age of death

NLM

NLF
Additional parameters

**allM**

- **b1**
- **b2**
- **b3**

**allF**

- **b1**
- **b2**
- **b3**

**nsmM**

- **b1**
- **b2**
- **b3**

**nsmF**

- **b1**
- **b2**
- **b3**
e40 2050, the Netherlands

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<tbody>
<tr>
<td></td>
<td>men</td>
<td>women</td>
<td>men</td>
<td>women</td>
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<tr>
<td>nonsmokers (e40 2012 = 42.76 (M), 45.15 (F))</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>extrapolation M; rest similar to 2012 ns</td>
<td>46.80</td>
<td>50.51</td>
<td>46.37</td>
<td>49.62</td>
</tr>
<tr>
<td>extrapolation a, b1, b2, b3, M</td>
<td>46.47</td>
<td>50.58</td>
<td>46.00</td>
<td>50.02</td>
</tr>
<tr>
<td>LC 40-100</td>
<td>45.94</td>
<td>49.23</td>
<td>45.07</td>
<td>48.68</td>
</tr>
<tr>
<td>total (e40 2012 = 40.22 (M), 43.57 (F))</td>
<td></td>
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<tr>
<td>extrapolation nonsmokers (M) + SAM (APC)</td>
<td></td>
<td></td>
<td>45.20</td>
<td>47.92</td>
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<tr>
<td>extrapolation nonsmokers (all parameters) + SAM (APC)</td>
<td>45.21</td>
<td>48.94</td>
<td>44.87</td>
<td>48.51</td>
</tr>
<tr>
<td>LC 40-100</td>
<td>42.69</td>
<td>47.54</td>
<td>44.89</td>
<td>46.39</td>
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</table>

SAM = smoking-attributable mortality
APC = age-period-cohort analyses
Difference with Lee-Carter

Age at death distribution 2050, NLM, nonsmokers, 1980-2012

Age at death distribution 2050, NLF, nonsmokers, 1980-2012
Conclusion

› Changes in delay and compression for total population result from changes in the age at death distribution of smokers and non-smokers, and the prevalence of smoking

› For both non-smokers and smokers, the delay is more linear than for the total population, and more similar for M and F

› Projection by means of the modal age at death should – for NL – take into account smoking and should not ignore compression & expansion

› Such projections result in higher life exp values, more delay, and more deaths at advanced ages compared to Lee Carter
Future plans

1) From individual to coherent mortality projection

2) Novel mortality projection technique for Europe: trends in lifestyle-related mortality trends (smoking + obesity + alcohol) + trends in the age-at-death distribution + trends in other countries

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Thanks for your attention
References

› De Beer, J. & F. Janssen (submitted), A new model to describe the full age pattern of mortality and to assess delay and compression of mortality.
Parameters of the CoDe model (for ages 40+)

<table>
<thead>
<tr>
<th></th>
<th>total population</th>
<th>nonsmokers</th>
<th>smokers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>-0.0017  0.0000 0.0000</td>
<td>0.0009  0.0005 0.0002</td>
<td>0.0031  0.0009 0.0000</td>
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<tr>
<td>b1</td>
<td>0.0755  0.1103 0.1029</td>
<td>0.1419  0.1188 0.1115</td>
<td>0.2137  0.1152 0.0948</td>
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<tr>
<td>b2</td>
<td>0.1177  0.0948 0.1277</td>
<td>0.1258  0.1285 0.1402</td>
<td>0.1157  0.1017 0.1044</td>
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<tr>
<td>b3</td>
<td>0.1193  0.0880 0.1341</td>
<td>0.1215  0.0963 0.1329</td>
<td>0.1057  0.0933 0.1215</td>
</tr>
<tr>
<td>M</td>
<td>79.9984 77.5729 85.0469</td>
<td>80.4220 84.0962 87.2444</td>
<td>73.5540 77.2369 81.4735</td>
</tr>
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| Women            |                 |            |         |
| a                | 0.0007  0.0002 -0.0003 | 0.0007  0.0004 0.0005 | 0.0002 -0.0010 -0.0011 |
| b1               | 0.1133  0.1020 0.0916 | 0.1136  0.1084 0.1193 | 0.1303  0.0983 0.0809 |
| b2               | 0.1211  0.1305 0.1535 | 0.1211  0.1313 0.1649 | 0.1087  0.0939 0.1301 |
| b3               | 0.1150  0.1168 0.1548 | 0.1150  0.1166 0.1496 | 0.0873  0.0938 0.1531 |
| M                | 80.3754 85.5382 89.0655 | 80.3748 85.6003 89.5696 | 73.7691 79.7570 87.5596 |
Past smoking intensities (40+)