Projection mortality including shifts in the age at death distribution, the smoking epidemic, and trends from other countries

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Shortcomings current (extrapolative) mortality forecasts

- Not robust
- Highly dependent on historical period
- Unrealistically large future differences btwn countries

In reaction to these shortcomings

- **Extensions** to the Lee-Carter methodology , e.g. cohort based extension (Renshaw & Haberman 2006)
- Inclusion of **cohort dimension** (Cairns et al 2011a, Reither et al 2011)
- Approaches to detect and deal with **structural change** (Booth et al. 2002, Coelho & Nunes 2011, van Berkum et al. 2014)
- Increased interest in the potential of **including smoking** (and obesity) in mortality forecasting (Pampel 2005, Bongaarts 2006, Wang & Preston 2009, King & Soneij 2011, Preston et al. 2012)(US, micro)
- **Coherent forecasts** (e.g. Li & Lee, 2005; Cairns et al 2011b; Antonio et al. 2015)

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In addition

- Projection of **rates of mortality improvement instead of mortality rates** (Haberman & Renshaw 2012; Mitchell et al 2013; Bohk & Rau 2014)

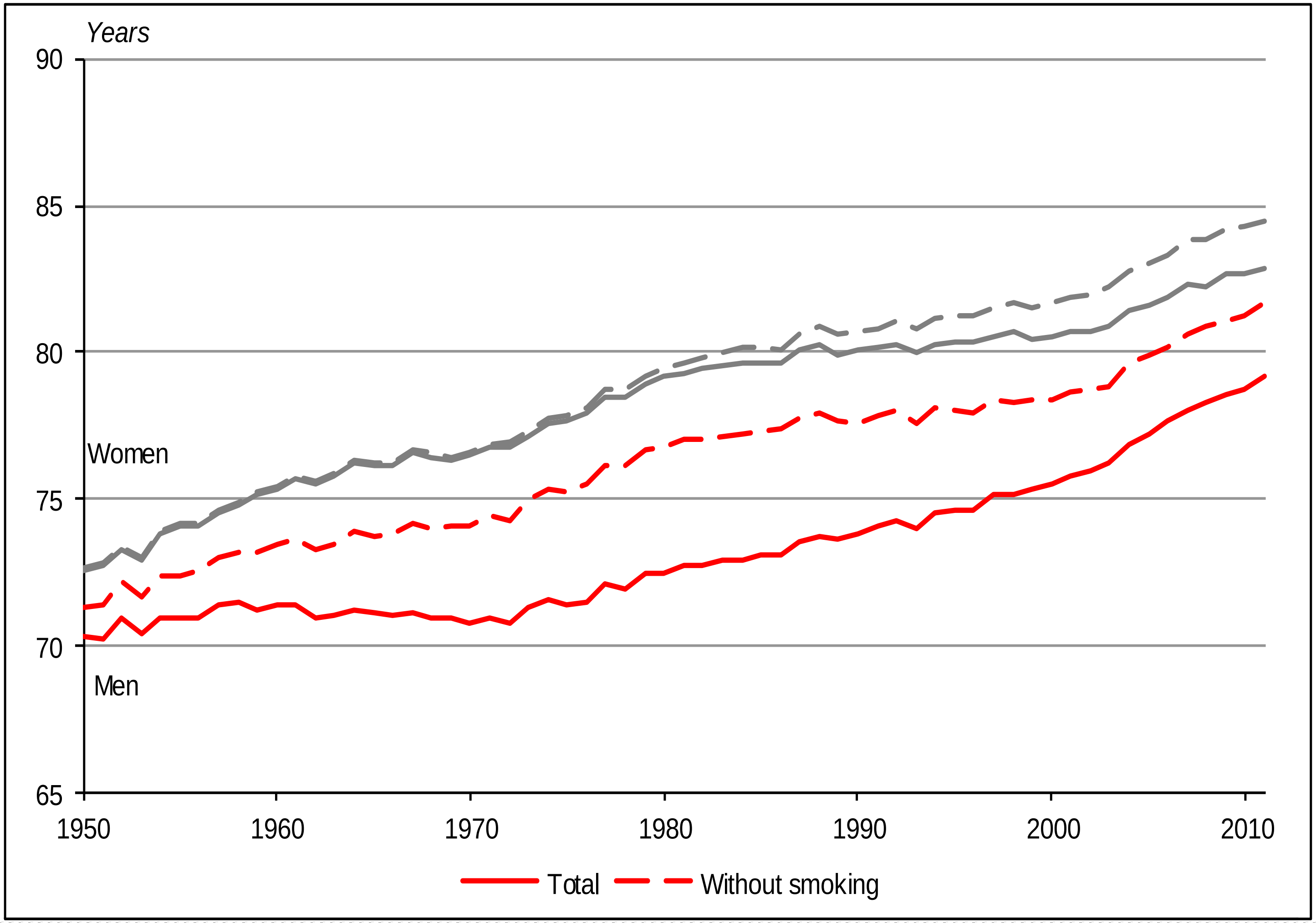
- Increased attention for **probabilistic** forecasts (Girosi & King 2008, Raftery et al 2013, Bohk & Rau 2014)

Janssen et al. Demography (1)

- Coherent + smoking
- Identify the most stable long-term mortality trend on which the projection should be based
  - Exclude the effects of important determinants with irregular trends, and predict them separately
  - Include the mortality experience of other – similar – countries and the opposite sex
- For the Netherlands

See: Janssen et al. 2013, Including the smoking epidemic in internationally coherent mortality projections. *Demography* 50(4), 1341-1362.

Total life expectancy and life expectancy without smoking, the Netherlands



Stoeldraijer, van Duin and Janssen (2013)

Janssen et al. 2013 Demography (2)

Coherent projection non-smoking-attributable mortality rates (Lee-Li)

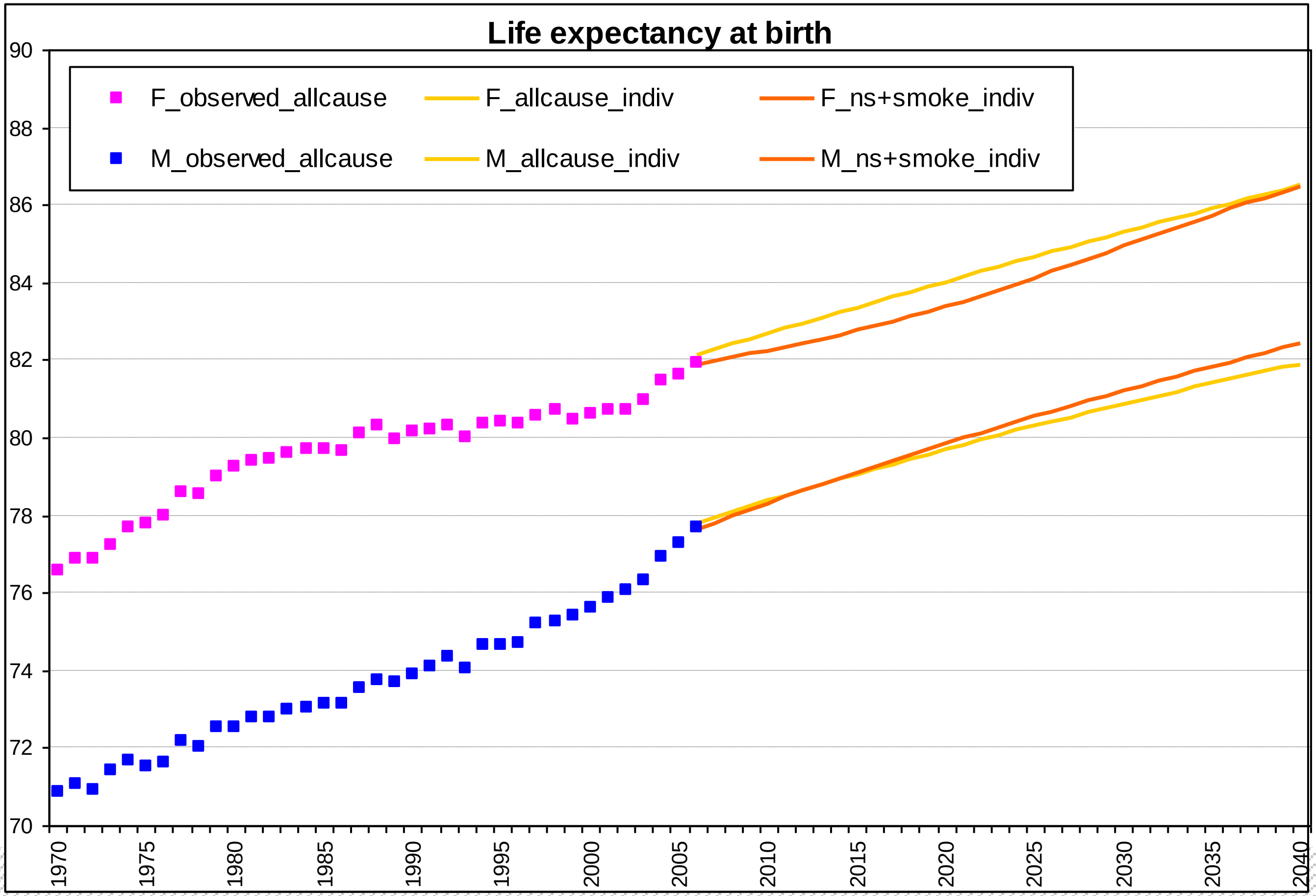
combined with

projection smoking-attributable mortality rates

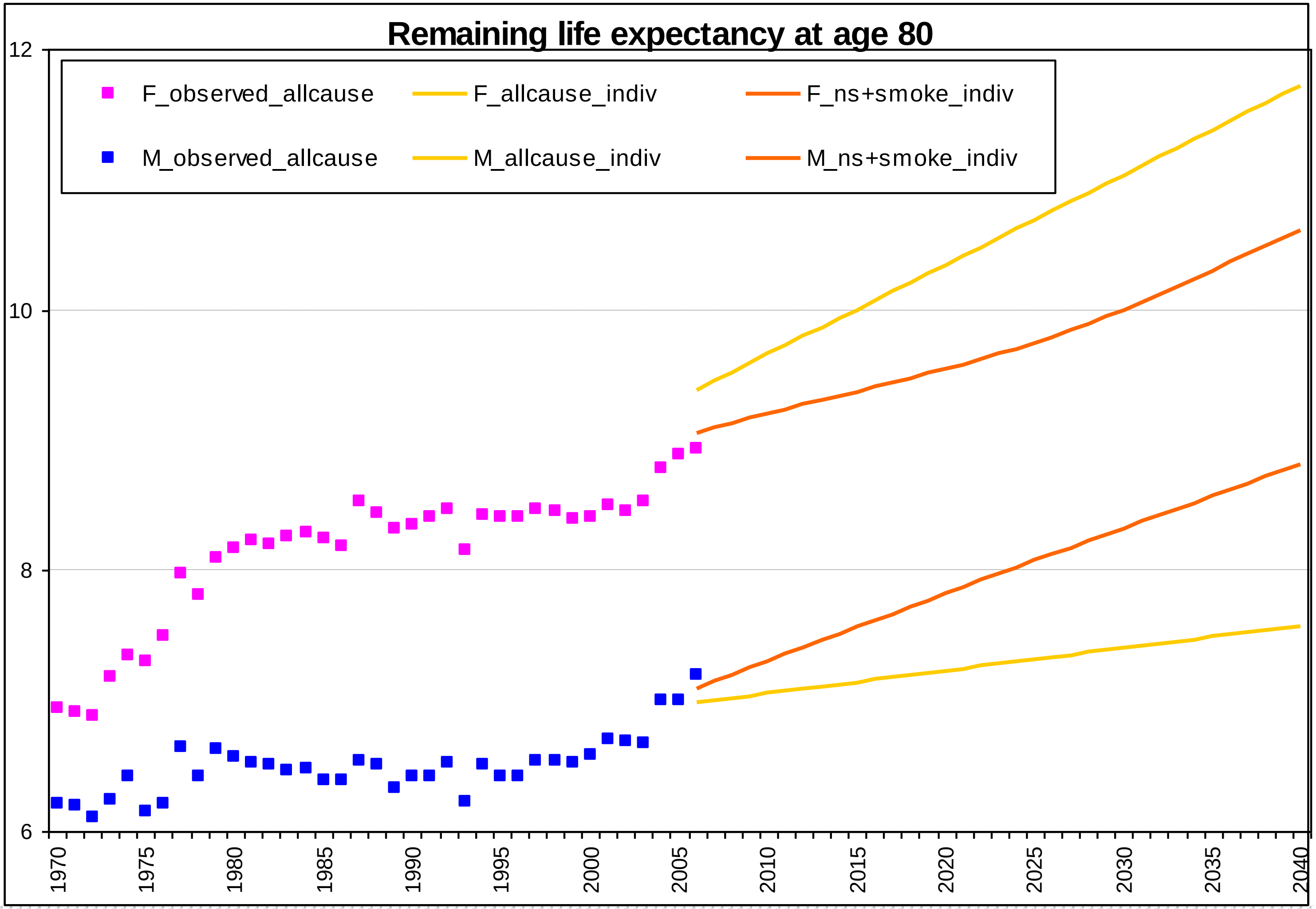
(age-period-cohort analyses)

- ⇒ Nonlinearity
- ⇒ Convergence btwn the sexes
- ⇒ Higher life expectancy values
- ⇒ More robust

Figure 1 Observed and projected life expectancy at birth for the projection of all-cause mortality vs the separate projection of non-smoking-related and smoking-related mortality, by sex, the Netherlands, 1970-2040



Janssen et al. 2013



Janssen et al. 2013

Projected e0 in 2040 by sex, for the different models, the Netherlands						
	All-cause mortality			NS + SM related mortality		
	Males	Females	F-M	Males	Females	F-M
LC	81.89	86.50	4.6	82.42	86.48	4.1
LL M+F*	82.17	86.55	4.4	83.98	85.49	1.5
LL NL+10	83.34	88.34	5.0	84.39	87.88	3.5
LL NL+21	83.68	87.77	4.1	85.04	87.17	2.1
Gains in e0 compared to projected 2006 values						
LC	4.11	4.38		4.80	4.62	
LL M+F*	4.91	3.99		5.89	4.11	
LL NL+10	6.01	6.09		6.98	5.97	
LL NL+21	6.37	5.71		7.55	5.49	
* common model						

Janssen et al. 2013

Paradigm shift mortality research

- From merely examining trends in life expectancy to examining the whole age-at death distribution
- Compression vs delay

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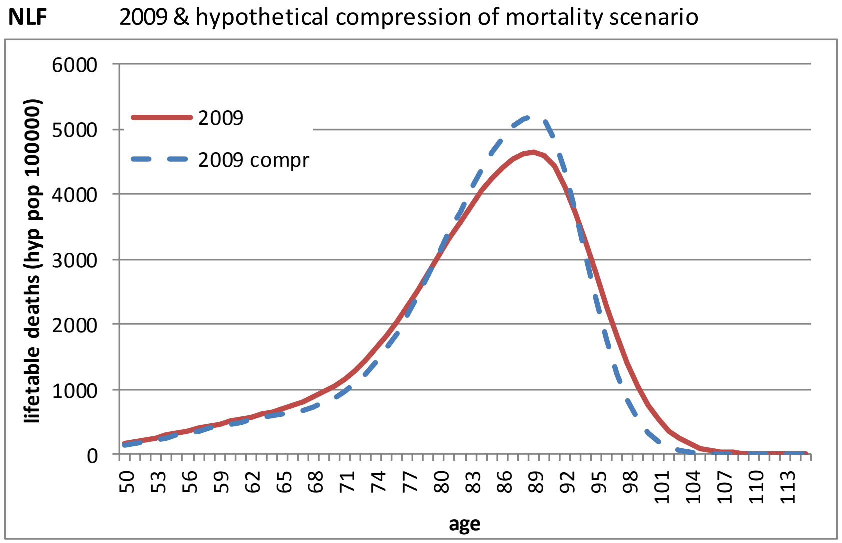
Changes in age at death distribution

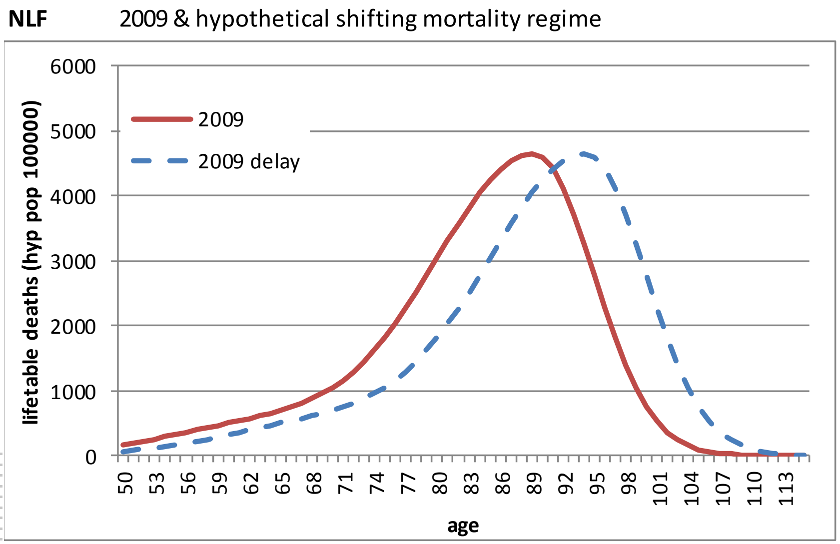
Compression of mortality scenario (Fries 1980)

- Rectangularization
- declining variability in the age of dying



› Shifting mortality regime / **mortality delay** (e.g. Vaupel 2010)

- Increase in modal age at dying
- No changes in shape



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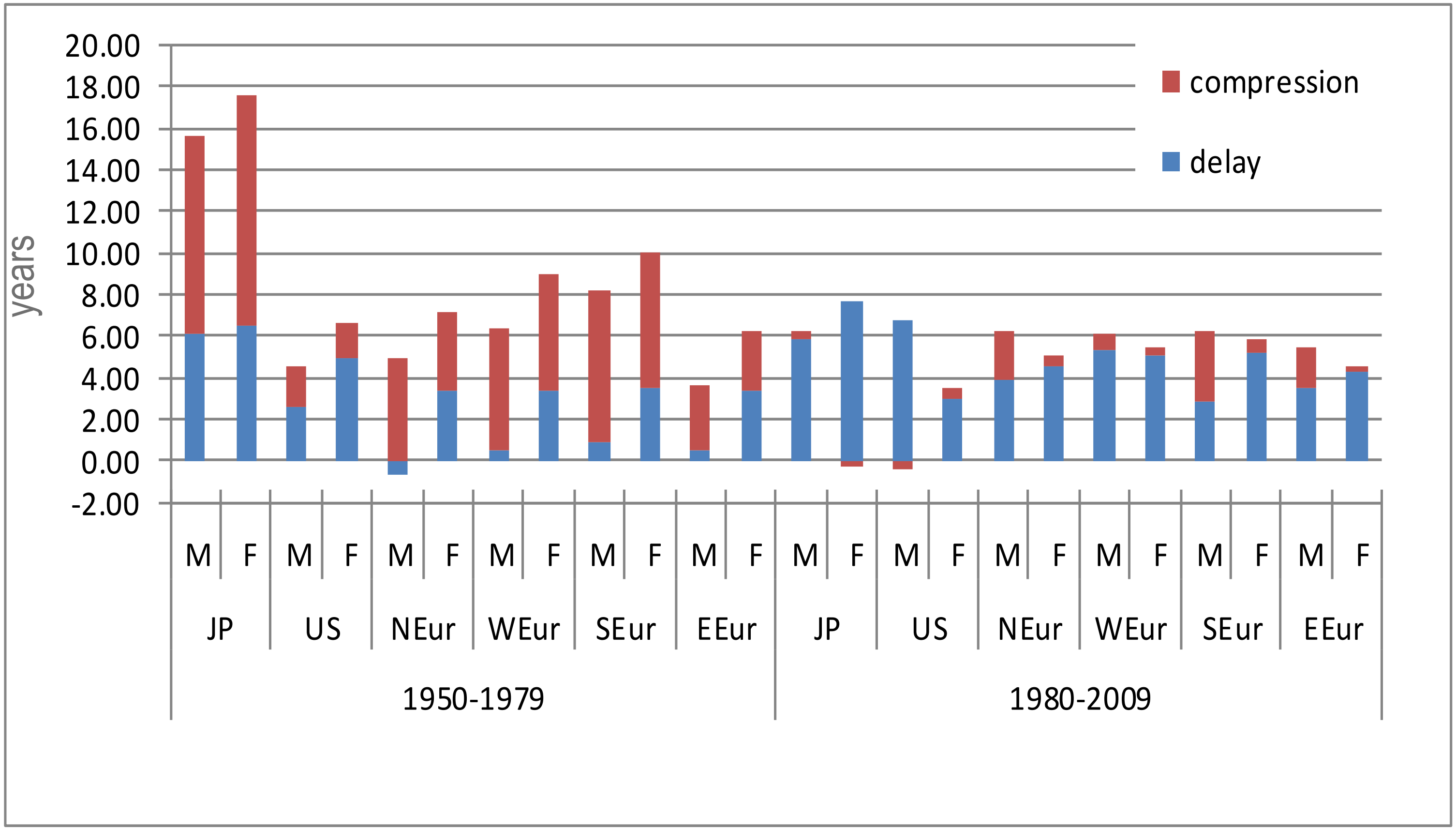
Importance of delay vs compression

› 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

Contribution of delay and compression to change in eo

1950-2009, 24 European countries + JP + USA

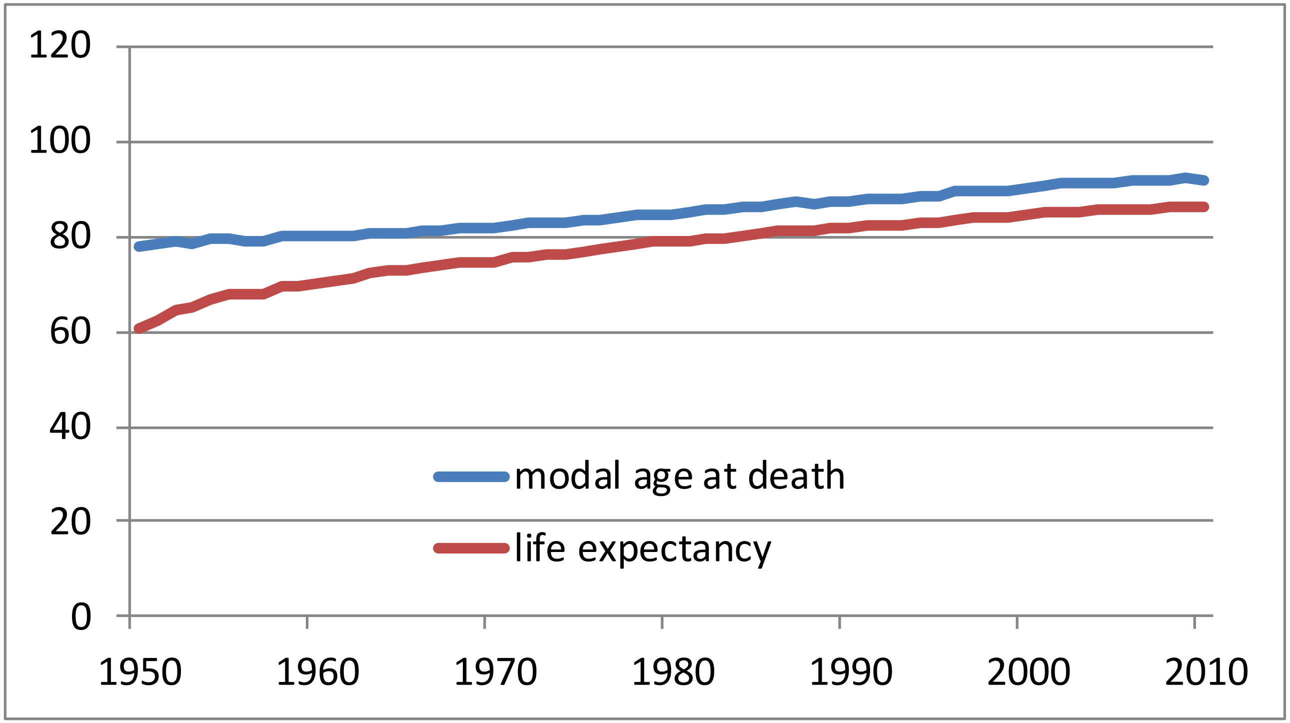


Janssen & de Beer (in preparation) Changes in the contribution of mortality delay versus compression before and after the mode to the recent increase in life expectancy

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 e_0

Japanese women – M increases parallel with eo



Source data: Human Mortality Database www.mortality.org

Importance of delay vs compression

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› 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 (Bongaarts 2005; Terblanche 2015) are still scarce (only M, only single populations, do not take into account smoking)

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Objective

- To estimate future life expectancy for the Netherlands by **simultaneously** taking into account:
  - the effect of smoking
  - the mortality experience of the opposite sex and in other countries
  - developments in mortality delay and compression

Data & methods

- NL; 1950-2012; 40+
- All-cause mortality and population numbers by sex and single year of age (Statistics Netherlands)
- Applying a mortality model which distinguishes delay and compression to mortality of the total population, mortality of non-smokers, and mortality of smokers
- Simplified CoDe mortality model (de Beer & Janssen, submitted)
- Calculation of mortality of nonsmokers (nsm), smokers (smm) =>
  - Smoking-attributable mortality (SAMF)(single year)
  - qnsm <- qall*(1-SAMF) ; qsmm <- qnsm*RR1
  - Adjusted indirect Peto & Lopez method (Peto et al. 1992; Janssen et al. 2013)
  - Lung-cancer deaths by sex and five-year age groups (WHOSIS)

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Projections

Individual

- Projections using the parameters of the CoDe mortality model for non-smokers for NL up to 2050 (only delay; delay & compression)
- Combine with projection smoking-atttributable mortality fractions
- Comparison with Lee-Carter

Coherent

- Trend delay non-smoking France women
- Comparison with individual forecast

Up to 2050

1950-2012; 1980-2012

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Simplified CoDe mortality model, 40+

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

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

$$+ I(x > x_2)\left[\frac{b_3 e^{b_3(x-M)}}{1+\frac{b_3}{g}e^{b_3(x-M)}} + c_2\right]$$

background + adult age + middle age + old age

$x_2 = M$; $x_1 = M - h$

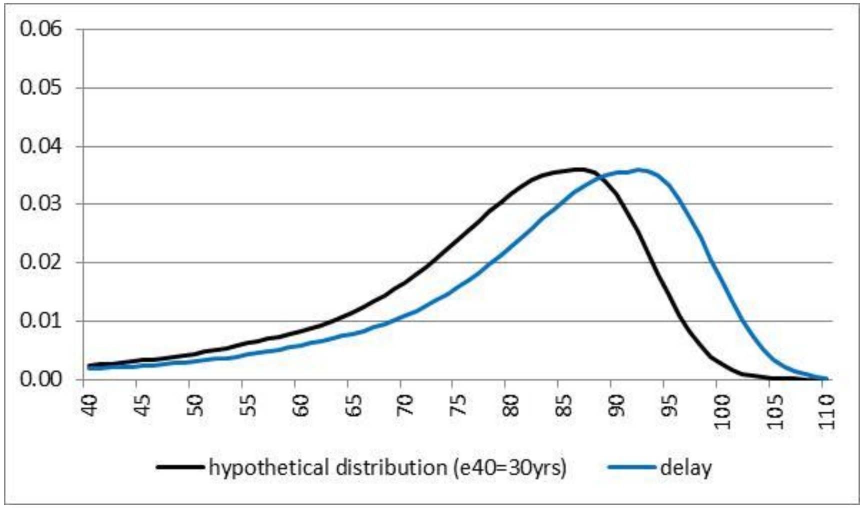
g (0.7) and h (30) time invariant

five interpretable time-varying parameters: a, b_1, b_2, b_3, M

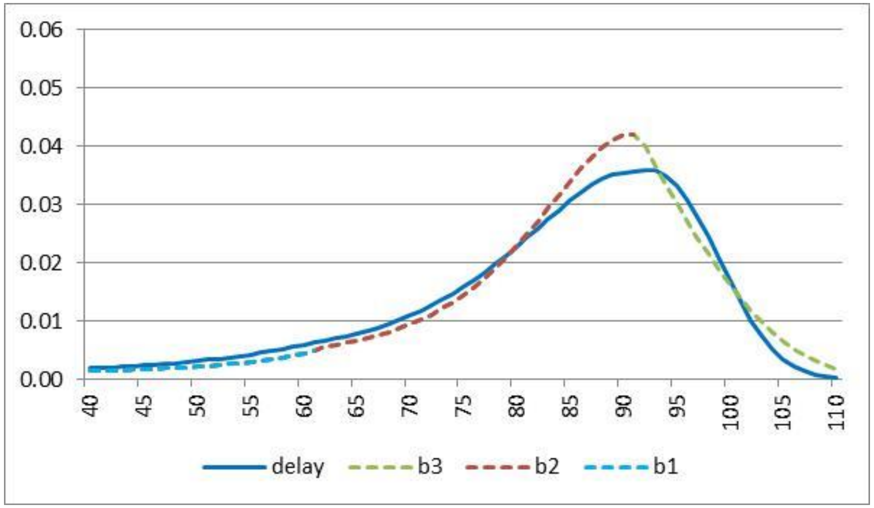
See: Janssen & de Beer (2016)

Effects of the parameters of the model

Increase in M that corresponds with 5 yrs increase in e40



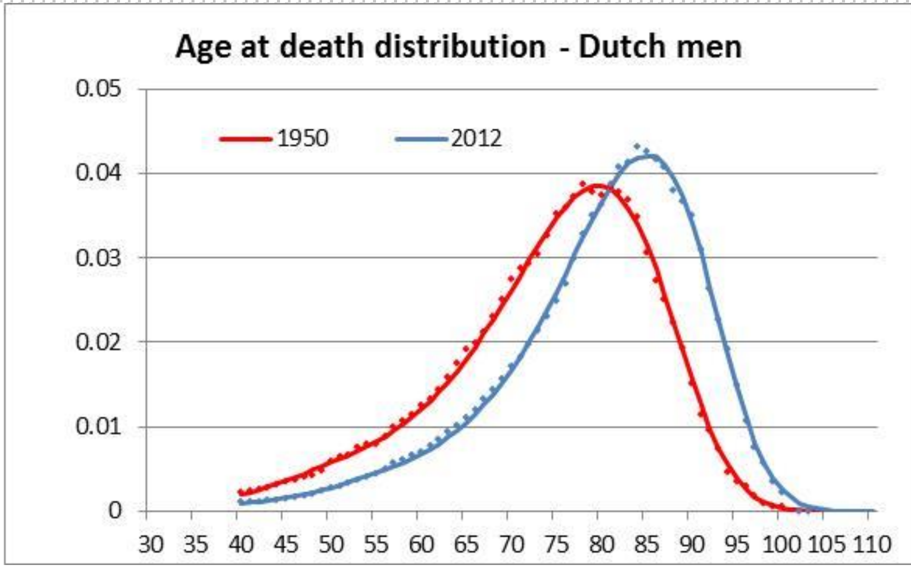
Increase in b1 and b2, and decrease in b3 that all three correspond with a 0.5 yrs increase in e40

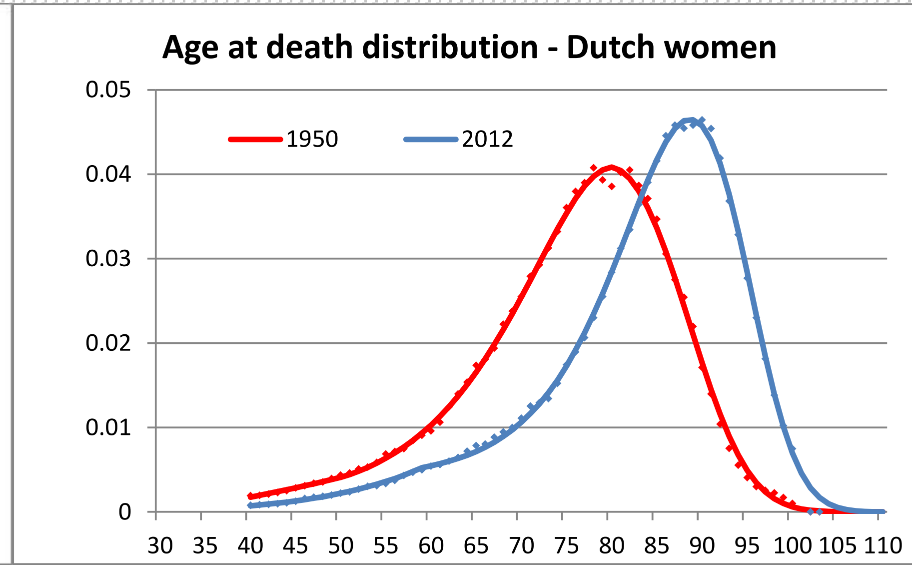


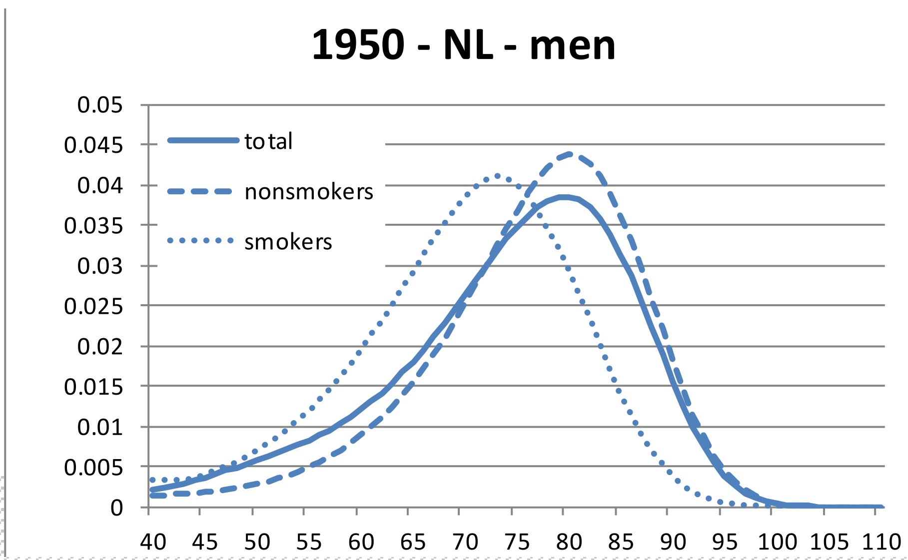
Janssen & de Beer (2016)

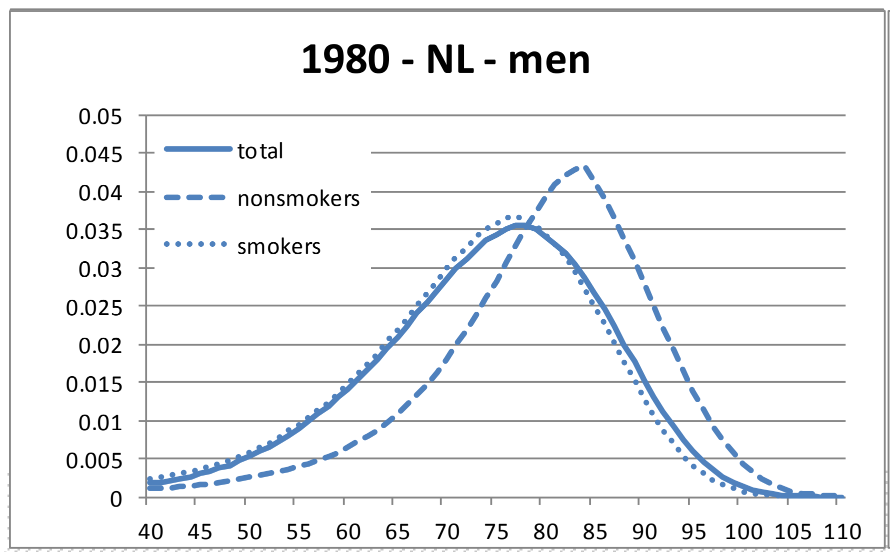
Results

Age at death distributions









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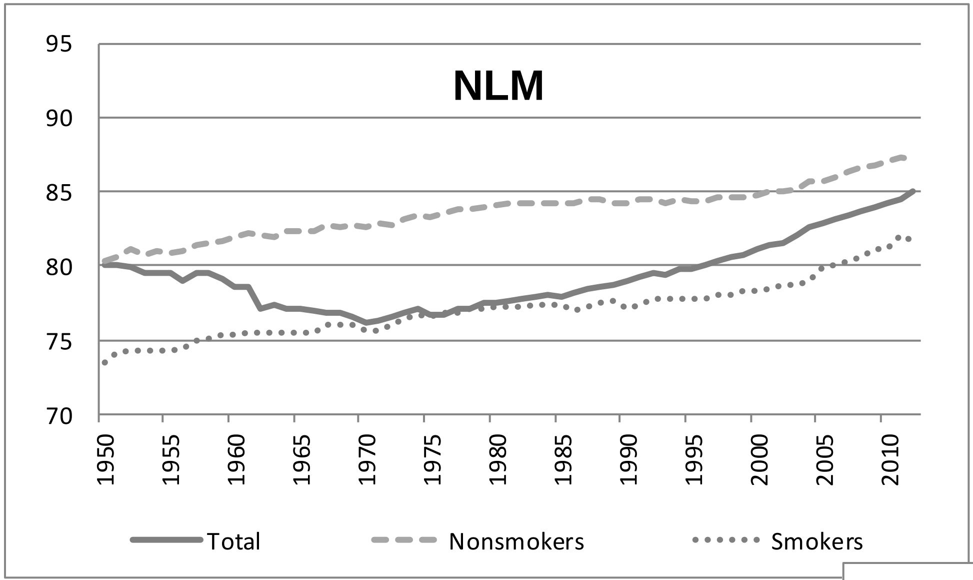
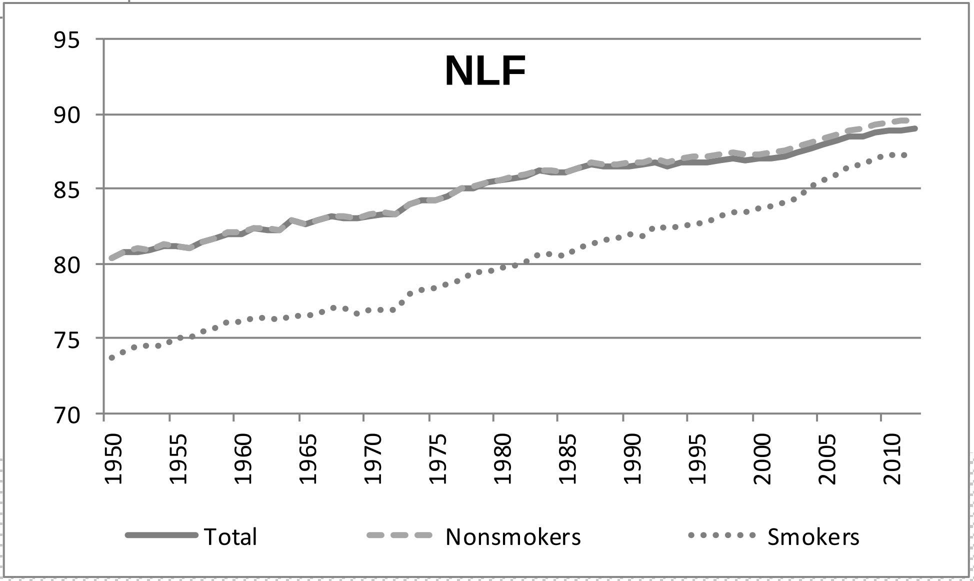
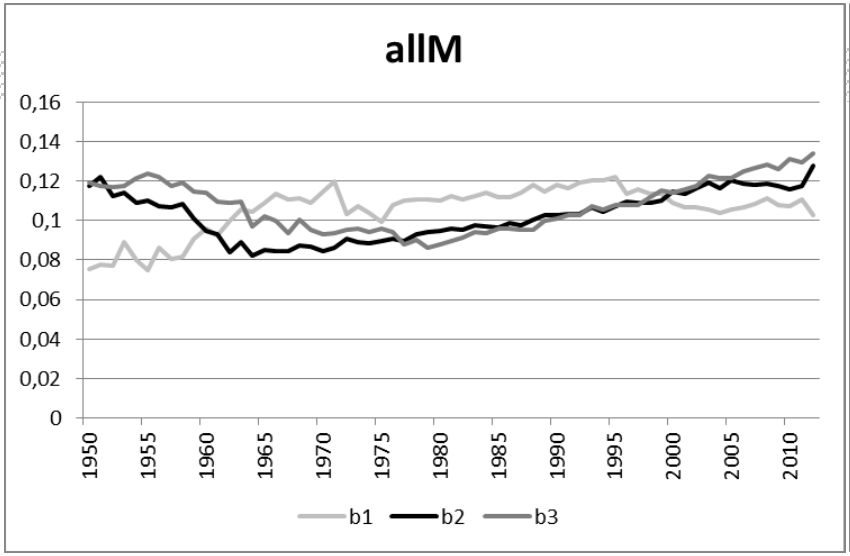
Model age of death

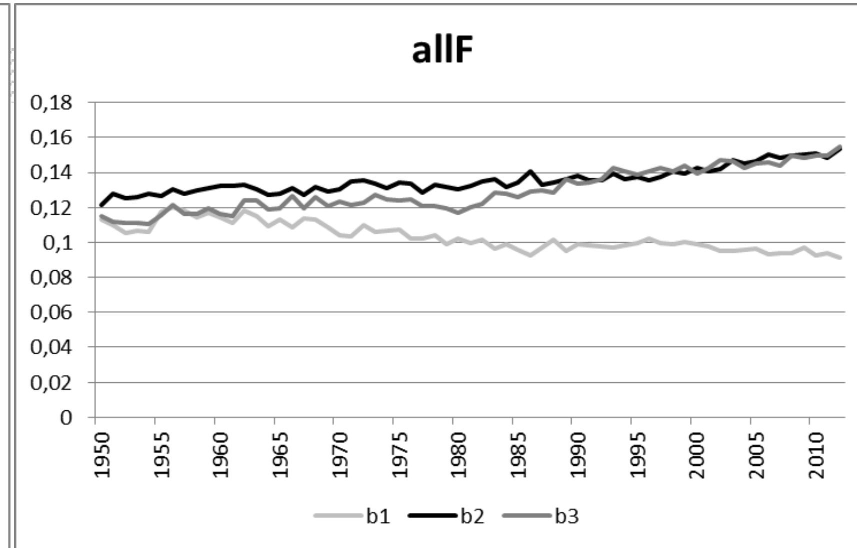


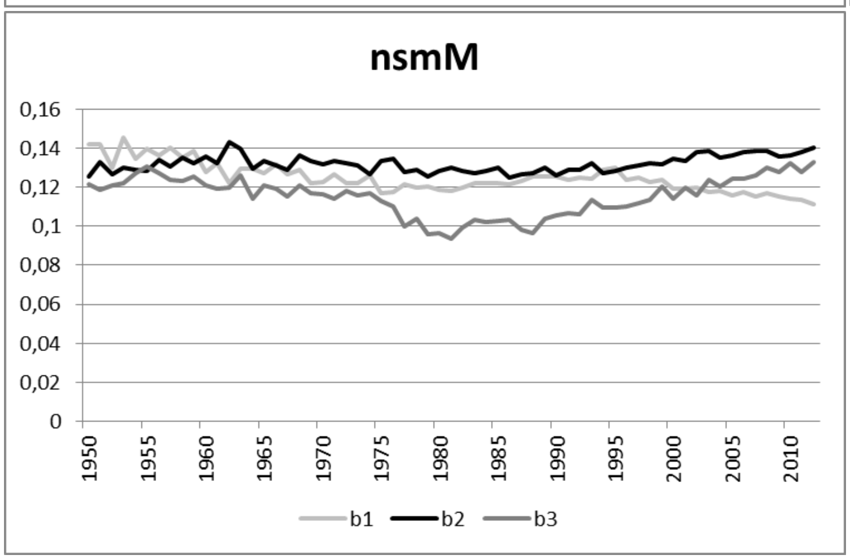


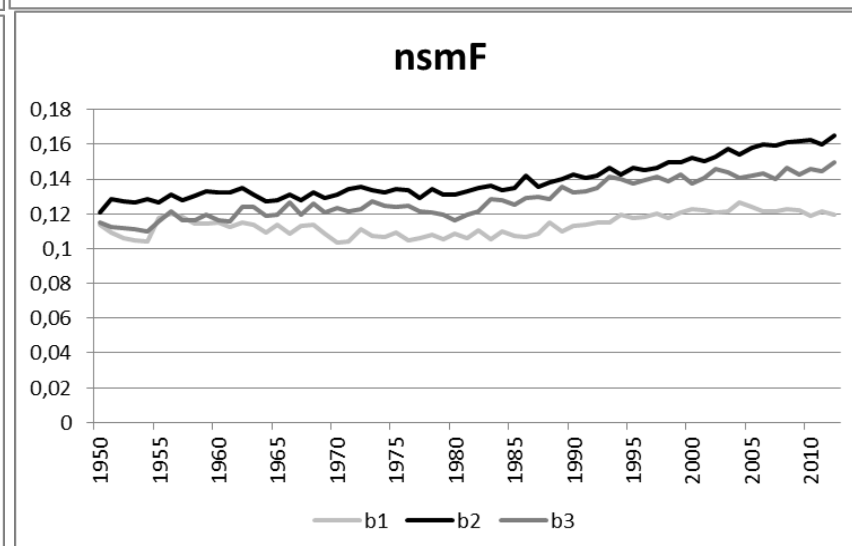
Janssen & de Beer (2016)

Additional parameters







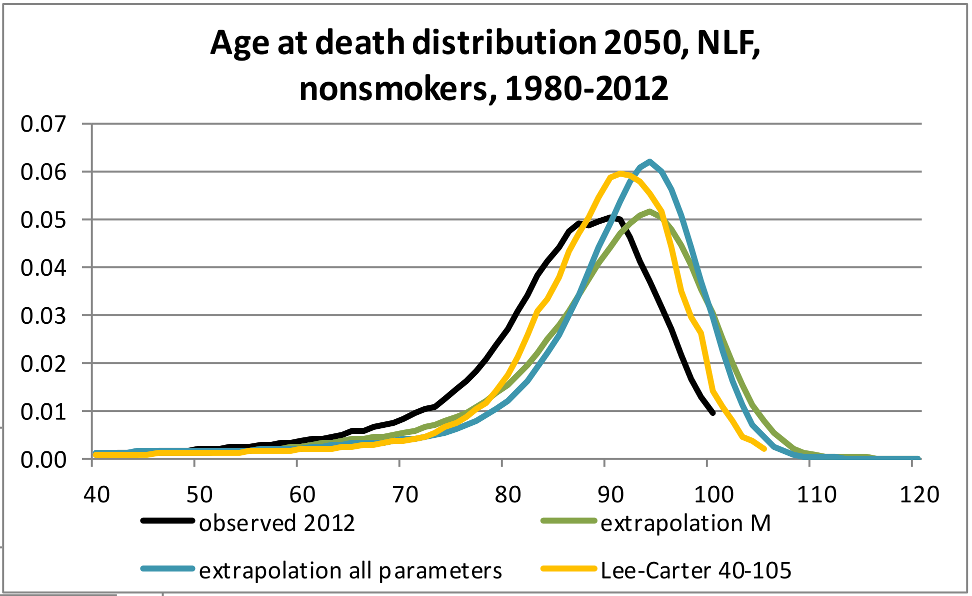


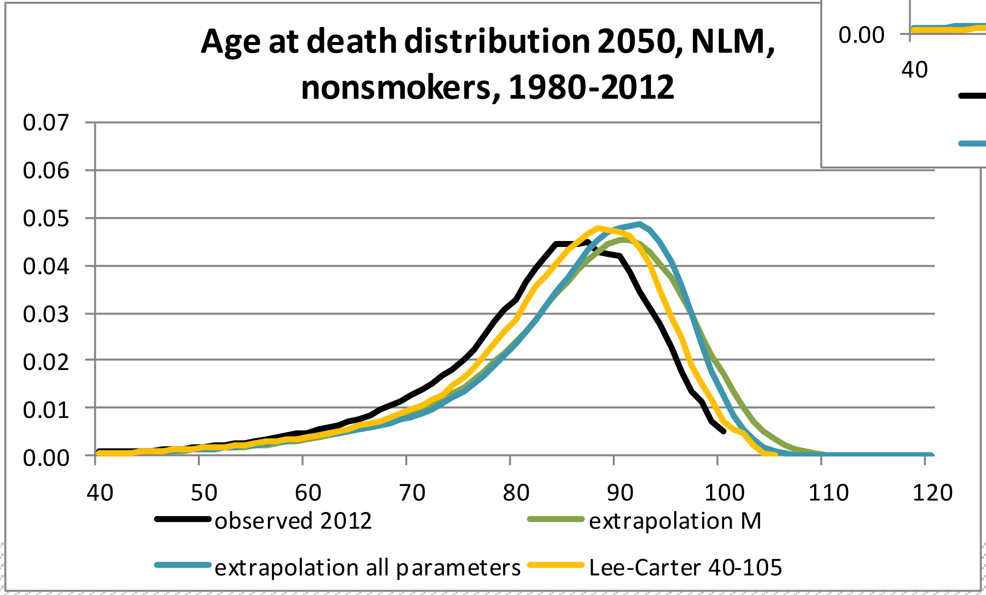
Janssen & de Beer (2016)

e40 2050, the Netherlands

	1950-2012		1980-2012	
	men	women	men	women
nonsmokers (e40 2012 = 42.76 (M), 45.15 (F))				
extrapolation M; rest similar to 2012 ns	46.80	50.51	46.37	49.62
extrapolation a, b1, b2, b3, M	46.47	50.58	46.00	50.02
LC 40-100	45.94	49.23	45.07	48.68

Difference with Lee-Carter





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e40 2050, the Netherlands

	1950-2012		1980-2012	
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nonsmokers (e40 2012 = 42.76 (M), 45.15 (F))				
extrapolation M; rest similar to 2012 ns	46.80	50.51	46.37	49.62
extrapolation a, b1, b2, b3, M	46.47	50.58	46.00	50.02
LC 40-100	45.94	49.23	45.07	48.68
total (e40 2012 = 40.22 (M), 43.57 (F))				
extrapolation nonsmokers (M) + SAM (APC)	45.63	48.79	45.20	47.92
extrapolation nonsmokers (all parameters) + SAM (APC)	45.21	48.94	44.87	48.51
LC 40-100	42.69	47.54	44.89	46.39
SAM = smoking-attributable mortality				
APC = age-period-cohort analyses				

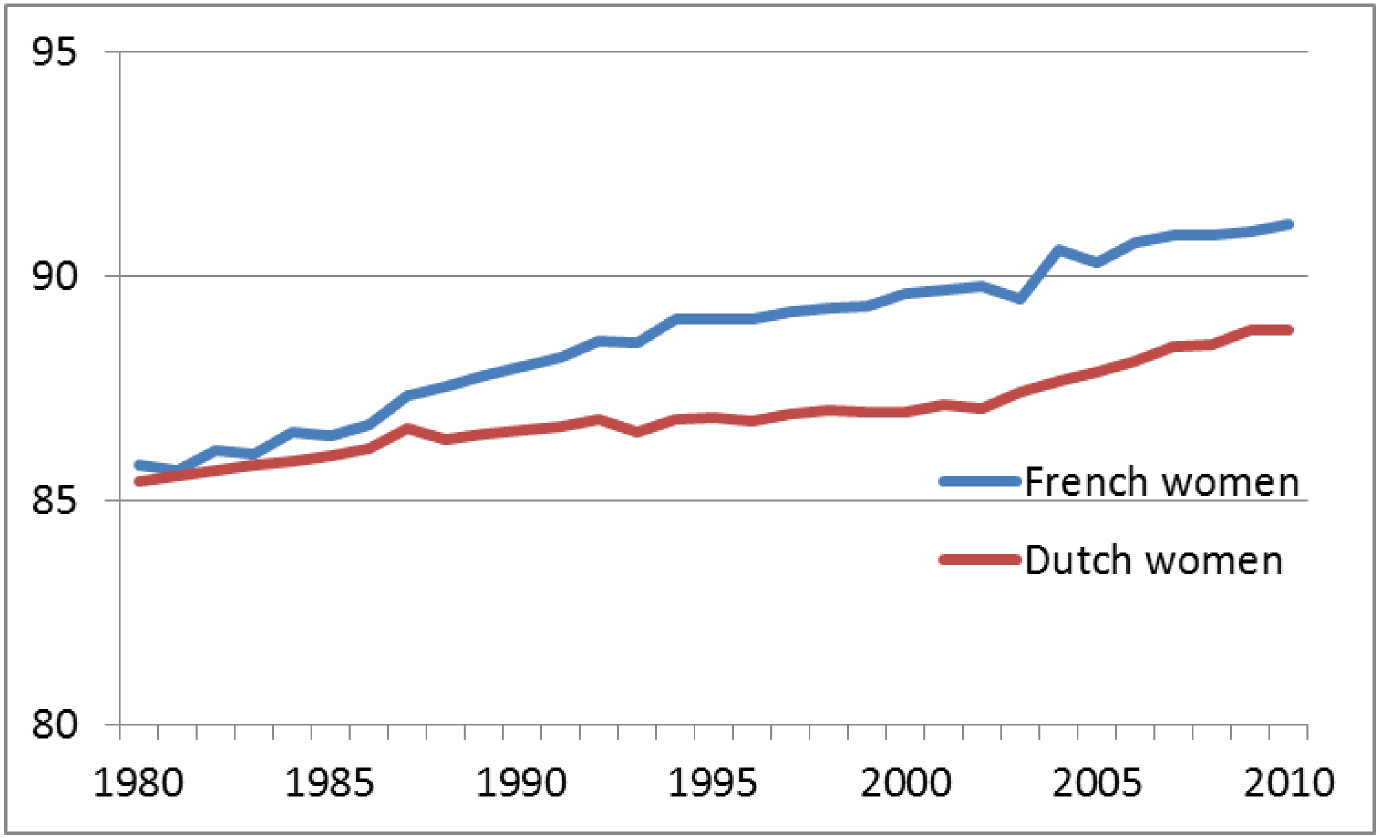
Janssen & de Beer (2016)

For age-period-cohort projection of smoking-attributable mortality see Stoeldraijer et al (2014)

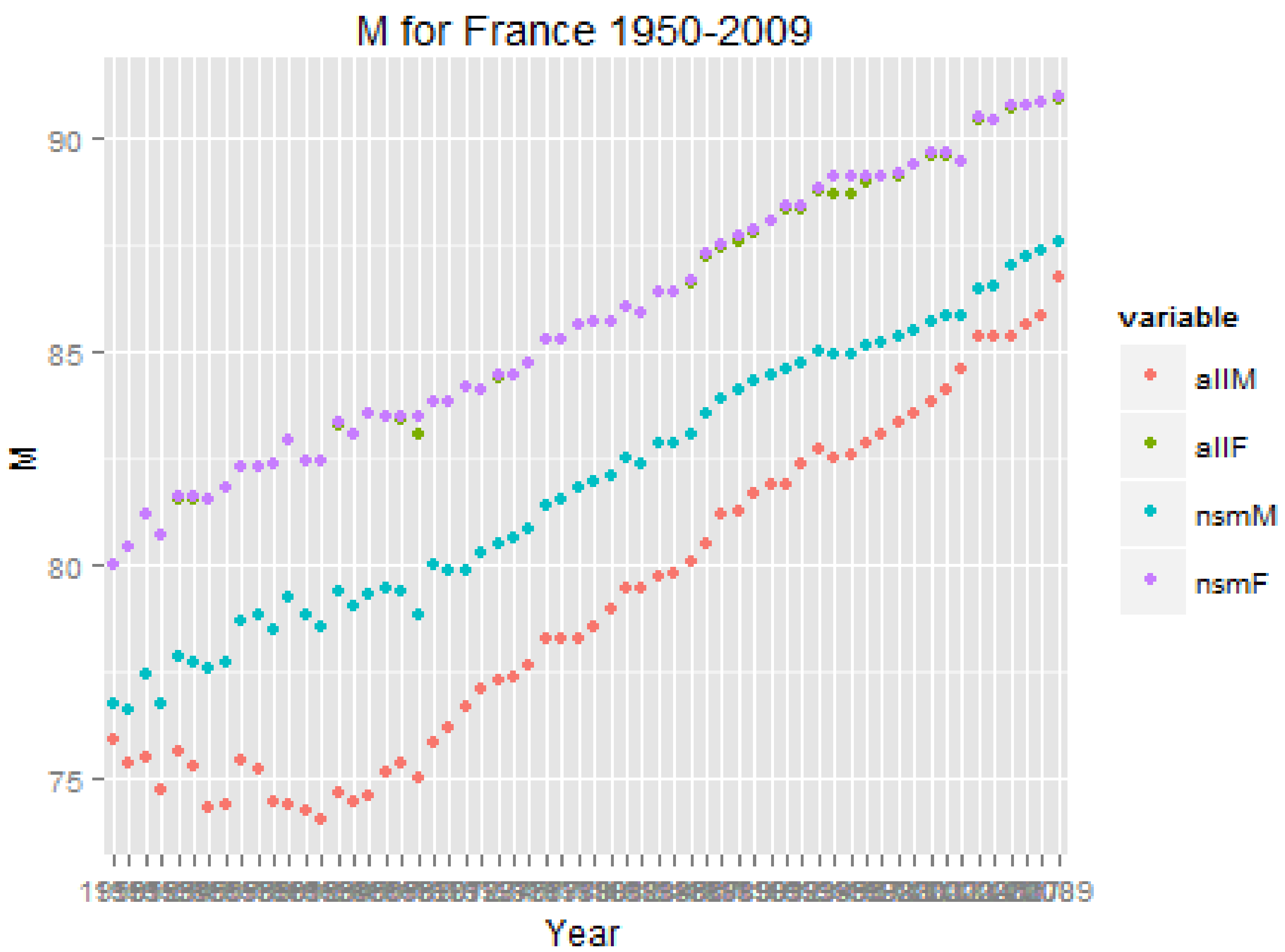
e40 2050, the Netherlands, coherent forecast

- Use of development M nsm among France women
- 1.9 years per decade (M)(equal for 1950-2009, 1980-2009, equal for M & F)

Modal age at death - Dutch and French women



preliminary results



preliminary results

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e40 2050, the Netherlands, coherent forecast

- Use of development M nsm among France women
- 1.9 years per decade (M)(equal for 1950-2009, 1980-2009, equal for M & F)
- In comparison to e40 2050 for individual forecasts

  M 1950-2012 +3.0; M 1980-2012 +3.4

  F 1950-2012 +1.5 ; F 1980-2012 +2.4

preliminary results

Summary of results

- For non-smokers and smokers, mortality delay is more linear than for the total population, and more similar for M and W
- Extrapolation of mortality delay (and compression) => higher e40 compared to LC, more delay, and more deaths at higher ages
- Extrapolation of compression parameters resulted in slightly lower e40 for men, and a slighly higher e40 for women
- Adding projection of SAM => highest difference for women (all-nsm); Separate projection for men 1950-2012 highest effect.
- Using the development of M among French female nonsmokers resulted in another strong increase in projected e40, esp. among men

Conclusion

Projection by means of the modal age at death should – for NL – take into account smoking

LC seems not able to fully capture the (continued) delay

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Future plan

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

Research grant Netherlands Organisation for Scientific Research (NWO) (grant no. 452-13-001)

NWO
Netherlands Organisation for Scientific Research

Thank you for your attention!

www.futuremortality.com

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