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Future mortality in European countries, taking into account the impact of lifestyle epidemics

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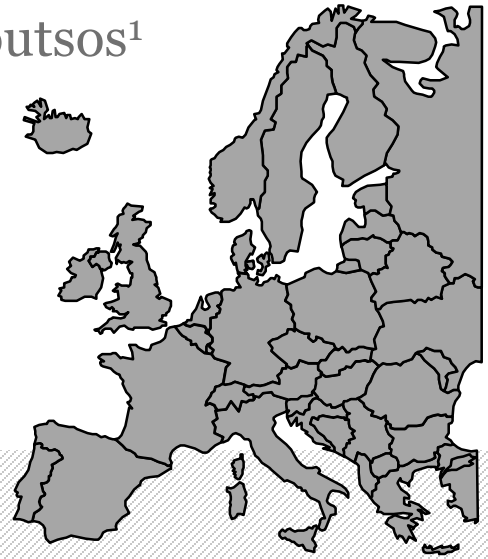


Importance of lifestyle factors

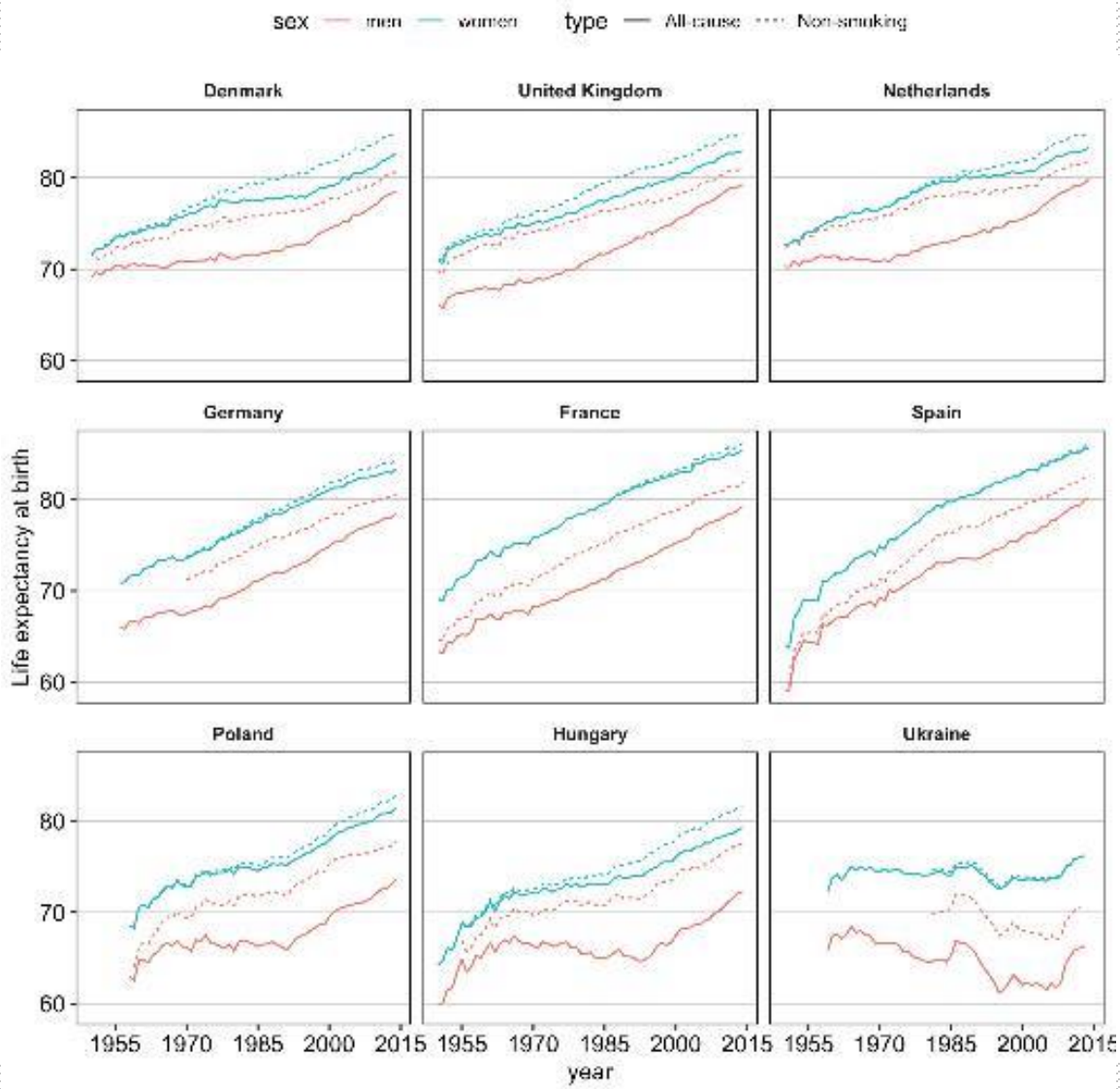
- In the EU, **smoking, alcohol and obesity** are the most important preventable risk factors (WHO 2009)
- Important determinants of mortality differences btwn countries and sexes (e.g. Janssen et al. 2007; Trias-Llimos et al. 2018; GBD 2015 Obesity Collaborators)
- Clear impact on trends in life expectancy, due to specific time-varying nature

Time-varying nature of lifestyle factors

- Smoking epidemic => strong wave pattern (prevalence; mortality); Northwestern European men (Lopez et al. 1994; Thun et al. 2012)
- Obesity epidemic => prevalence tripled since 1980 (WHO 2007); wave-shaped epidemic (Xu & Lam 2018); current signs of stagnation (Rokholm et al. 2010)
- Alcohol => adult men Eastern Europe; high and fluctuating mortality (Rehm et al. 2009); recent declines (Trias Llimós et al. 2018)
- Importance of the birth cohort dimension for describing and explaining past trends in smoking-, alcohol- and obesity-attributable mortality (e.g. Janssen & Kunst 2005, Trias-Llimós et al. 2017; Vidra et al. 2018).

Impact on life expectancy trends - smoking

Life expectancy with and without smoking, 1950-2014



Janssen, F. (2019). Smoking's impact on mortality in Europe. *Population & Societies*, 571, 1-4.

Impact on life expectancy trends - ctnd

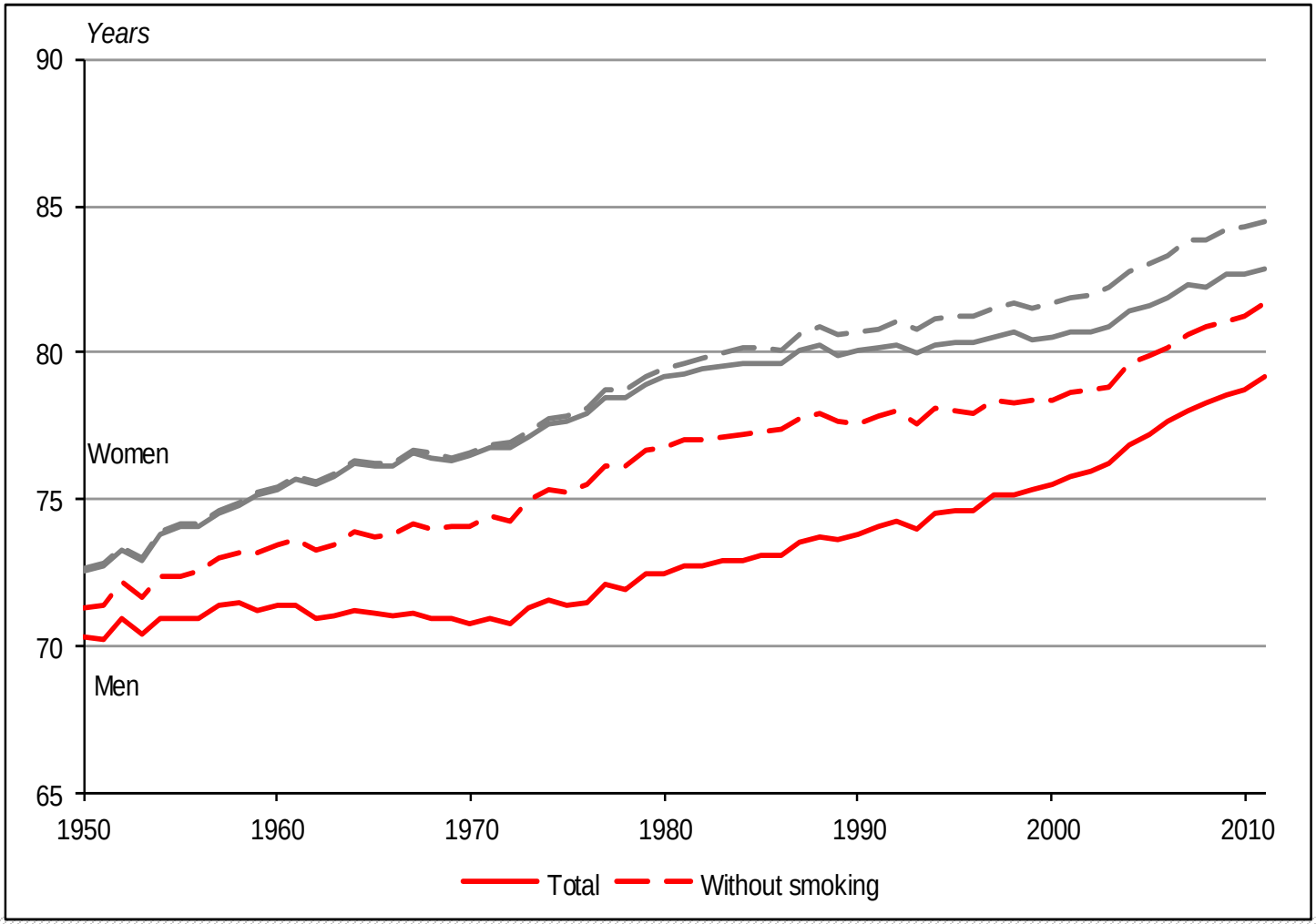
"On average, life expectancy at birth (e_0) increased between 1975 and 2012 by 7.3 years for men and by 6.3 years for women across 26 European countries. **Without obesity, the average increase in e0 would have been 0.8 years higher for men and 0.3 years higher for women."** (Vidra et al. 2019 BMJ Open)

Alcohol contributed substantially to the increase in the East-West life expectancy gap in Europe (1975-2005) and the decline thereafter (Trias-Llimos et al. 2018 IJE)

Importance for mortality forecasting

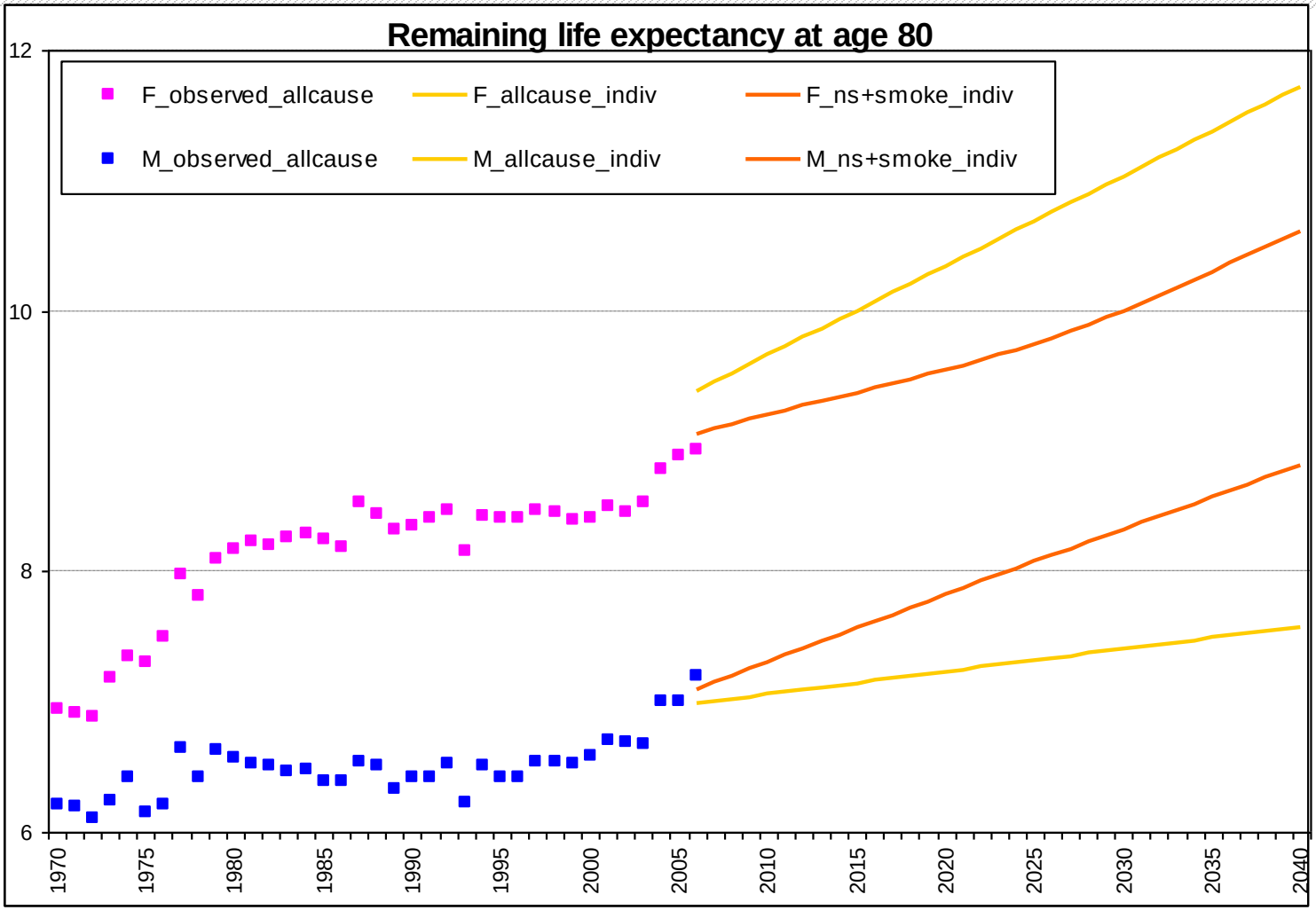
- These changes in lifestyle-attributable mortality are important for mortality forecasting (e.g. Janssen et al. 2013; Bongaarts 2014).
- Mortality projection mostly by extrapolation (Booth & Tickle 2008; Stoeldraijer et al. 2013)
  - When past trends non-linear due to lifestyle factors: different historical period => different outcome (Janssen & Kunst 2007; Stoeldraijer 2019)
  - Unrealistic future differences btwn sexes and countries
  - No non-linearity in the future (no cohort dimension)

Life expectancy with and without smoking, the Netherlands, 1950-2014



Stoeldraijer, L., Van Duin, C., & Janssen, F. (2013). Bevolkingsprognose 2012–2060: Model en veronderstellingen betreffende de sterfte. *Bevolkingstrends*, *61*, 1-27.

Forecast e80 NL taking into account smoking



Janssen et al. (2013) Including the smoking epidemic in internationally coherent mortality projections. *Demography*.

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  - Unrealistic future differences btwn sexes and countries
  - No non-linearity in the future (no cohort dimension)
- Including the mortality experience in other populations (coherent) especially meaningful for non-lifestyle attributable mortality

Objective

- To project all-cause mortality in Europe taking into account the impact of the smoking, obesity and alcohol ‘epidemics’, and the mortality experience in other countries

WP => preliminary results for 6 countries

PPT => approach

Approach to mortality forecasting (I)

Gradual mortality decline	Country and sex specific Deviations / variations
Medical improvements; socio-economic developments	Health-related lifestyle

Predict separately

Other populations

Epidemiological evidence

Approach to mortality forecasting (II)

Separate projection of smoking-, alcohol- and obesity-attributable mortality

Combined with

Coherent projection of non-lifestyle-attributable mortality

Based on: Janssen et al. (2013) Including the smoking epidemic in internationally coherent mortality projections. *Demography*.

Data

- All-cause mortality and exposure from HMD by sex and age, 1950-2016
- Population-level (cause-specific) mortality or prevalence data by age and sex
  - Smoking: Lung cancer mortality from 1950 onwards (WHO)
  - Obesity: Prevalence data from 1975 onwards (NCD Risk Factor Collaboration study 2017)
  - Alcohol: GBD rates + WHO cod info from 1990 onwards

Methods I

- Future smoking-, obesity-, and alcohol-attributable mortality **fractions** (20-100)(up to 2100) by novel methodology that incorporates the wave pattern of epidemics and the cohort dimension

- Future lifestyle attributable mortality by multiplicative approach

$$PAF_{1..i} = 1 - \prod_{i=1}^{n}(1 - PAF_i)$$

Methods II

- Coherent forecast of non-lifestyle-attributable mortality rates (Li & Lee 2005); 1990 onwards; ages 0-100.
- Li & Lee 2005 methodology

- Common = women in France, Spain, Italy.

- kt_i => RW with no drift (non-stationary).

Methods III

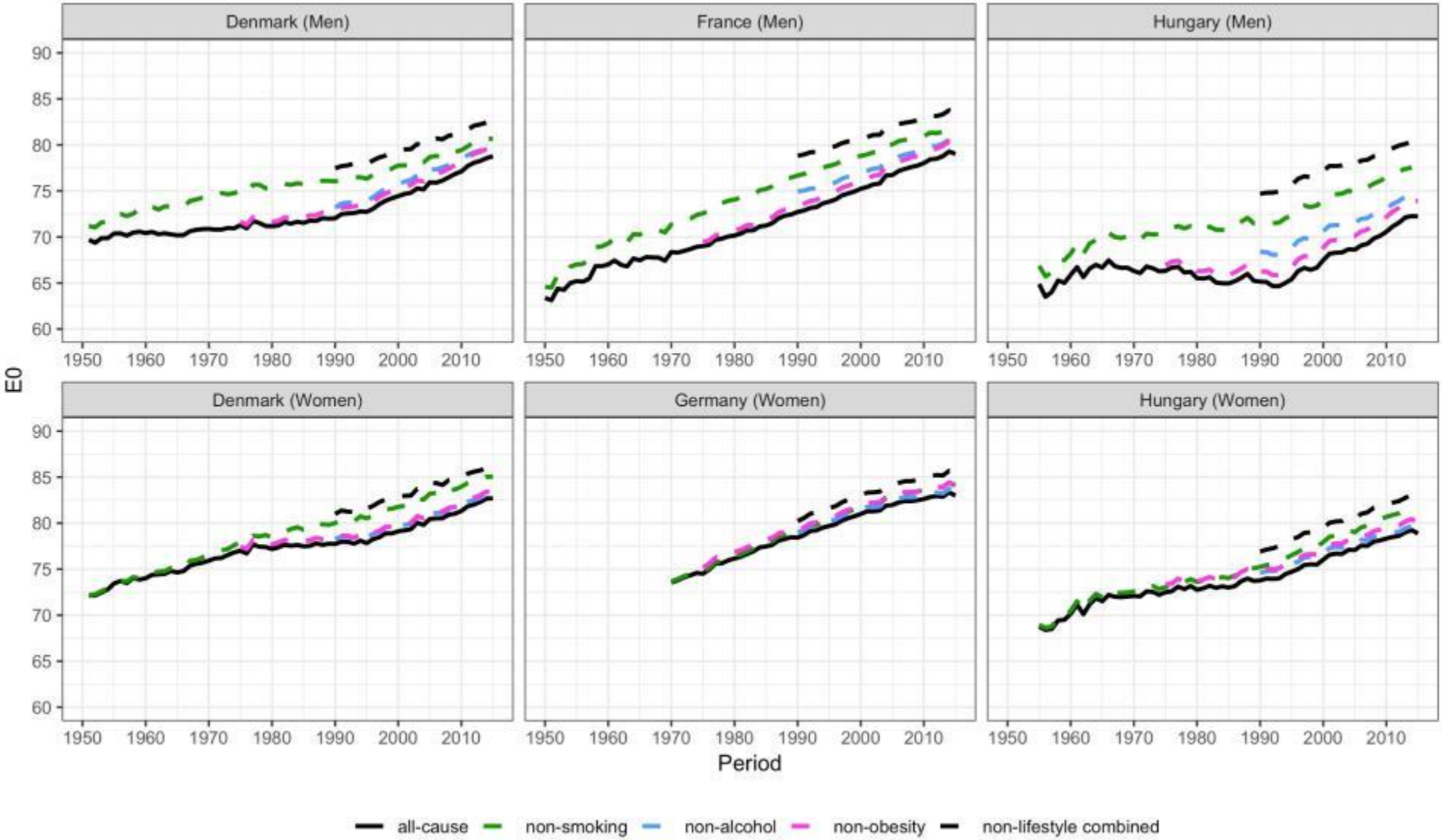
- Combining:

  $$m(x,t)^{allcause} = m(x,t)^{non-lifestyle} \cdot \left(\frac{1}{1-LAMF(x,t)}\right)$$

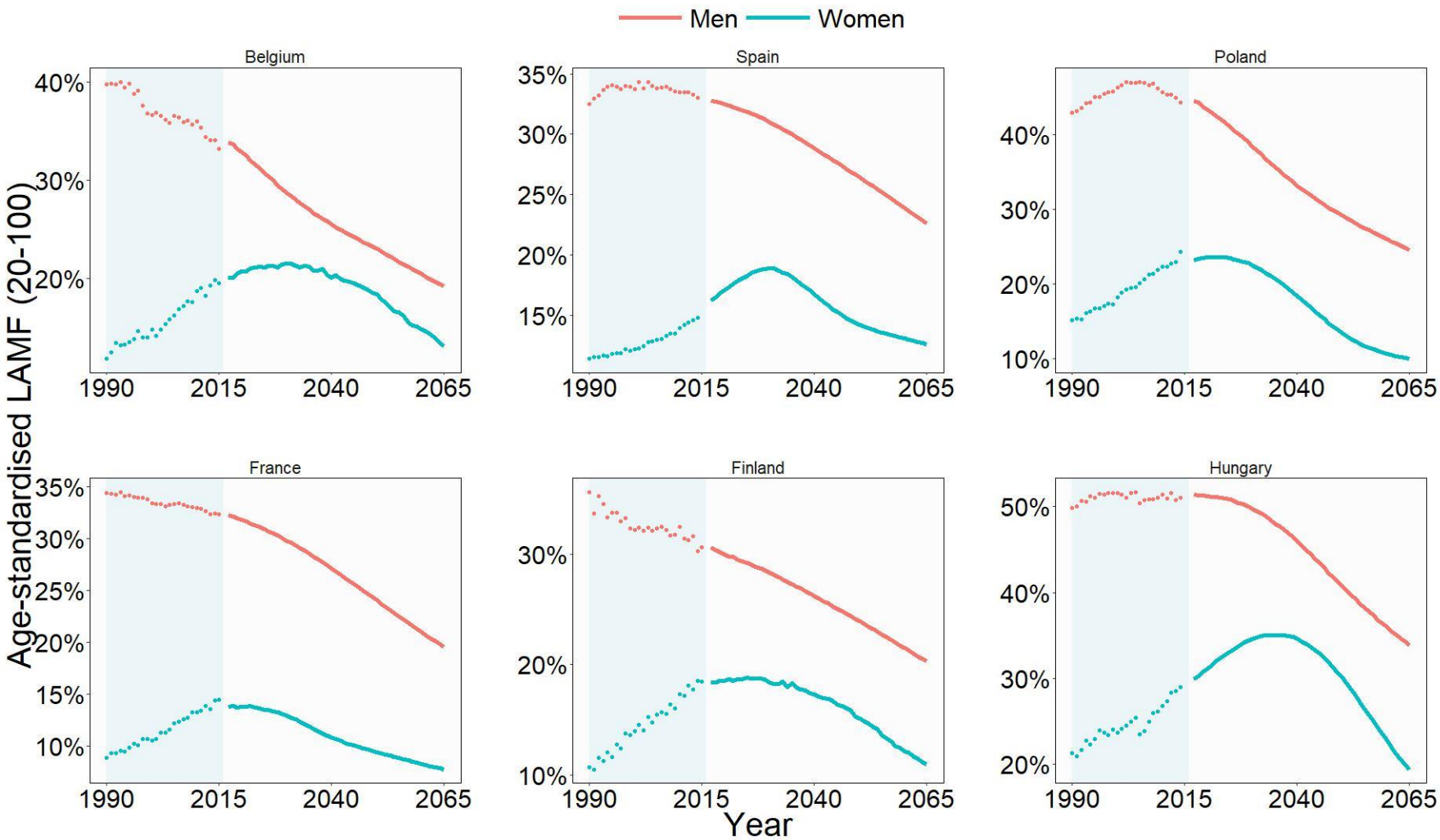
  (Janssen et al. 2013)
- For ages 100+ => Kannisto model of old-age mortality (Thatcher et al. 1998)
- Comparison with direct forecast of all-cause mortality (individual LC and coherent Li-Lee) and with individual LC forecast of non-lifestyle-attributable mortality

Preliminary results

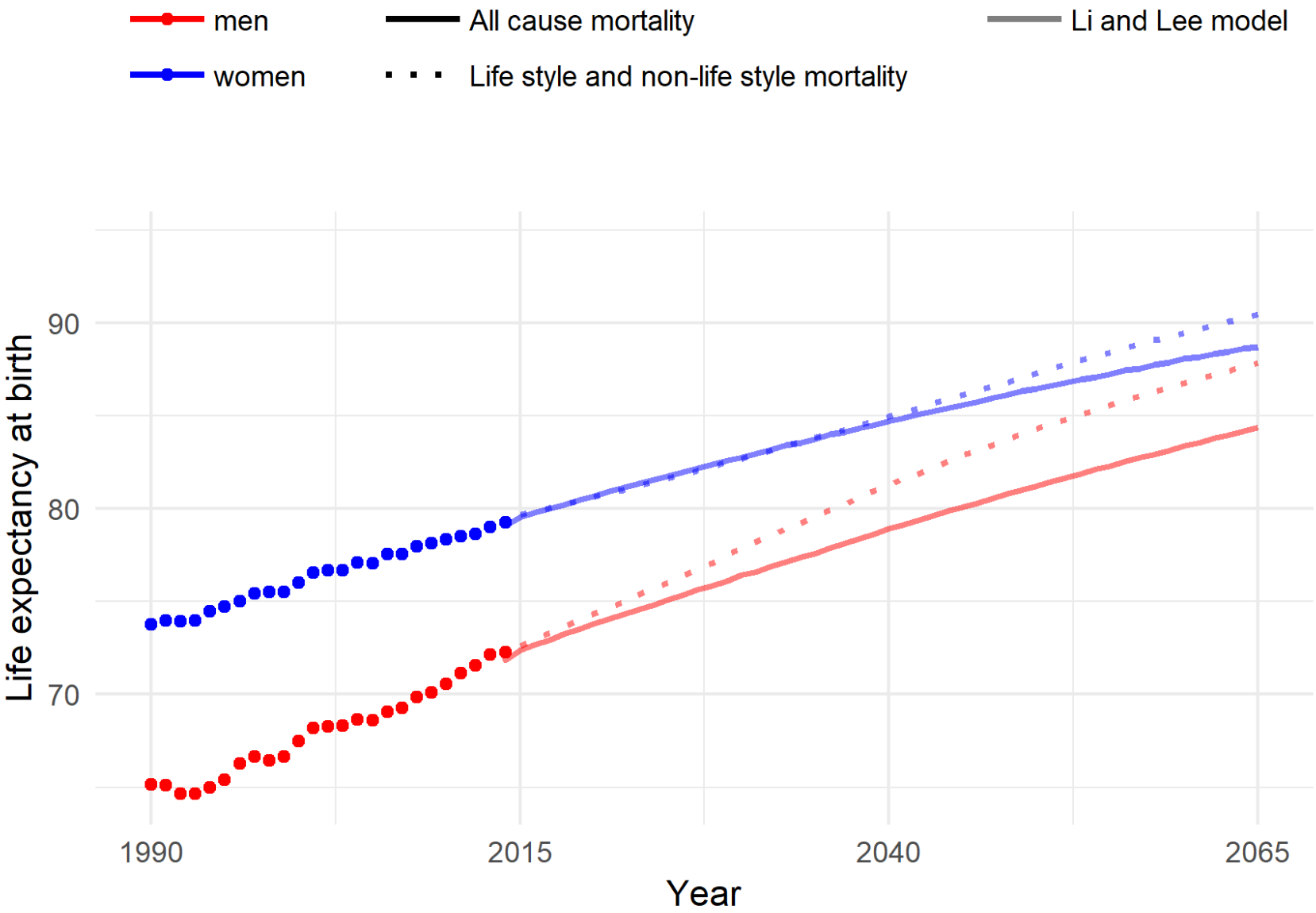
Comparison trends e0 all-cause mortality vs trends e0 non-lifestyle attributable mortality



Projected lifestyle-attributable mortality fractions

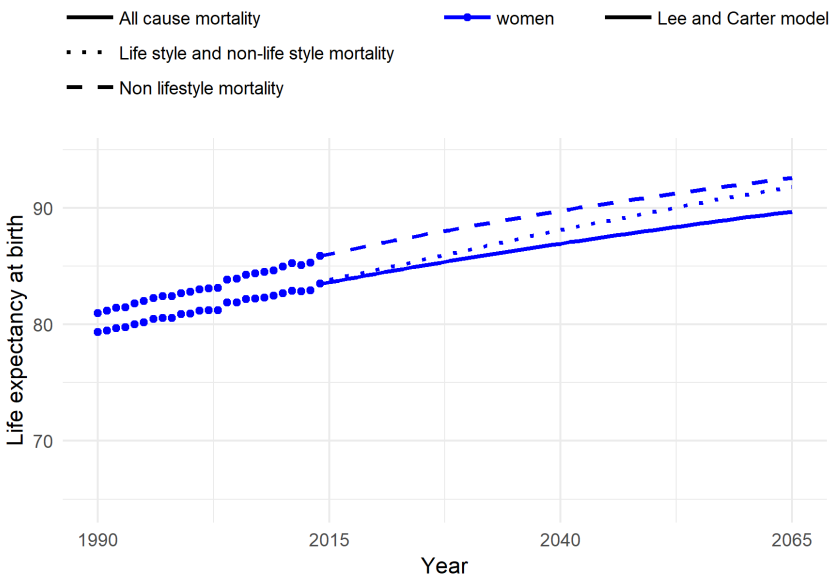


Comparisons different projections Hungary

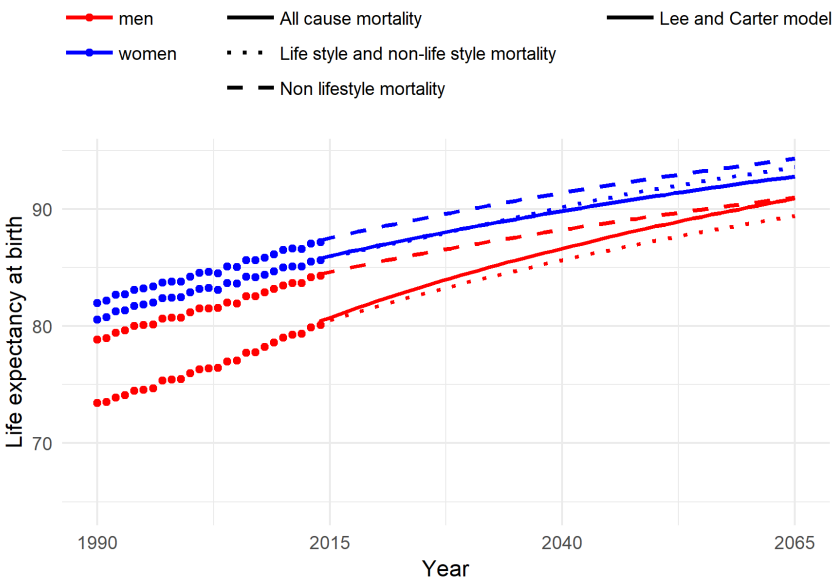


Effect lifestyle when individually forecasting mortality (LC)

Belgium women



Spain



Effect lifestyle when coherently forecasting mortality (LiLee)

	Men			Women		
		Projected e0 2065 Li and Lee			Projected e0 2065 Li and Lee	
	e0 2014	Allcause direct	Allcause indirect	e0 2014	Allcause direct	Allcause indirect
Belgium	78.6	88.6	90.6	83.5	91.4	92.7
France	79.3	89.4	91.3	85.4	93.0	94.2
Spain	80.1	89.4	91.2	85.6	92.9	93.6
Finland	78.1	88.4	90.0	83.9	91.7	92.7
Poland	73.7	85.8	89.1	81.4	90.5	92.0
Hungary	72.3	84.4	87.8	79.2	88.7	90.4

Summary of results

- Past increase e0 nonlifestyle less strong compared to e0 all-cause among men; slightly stronger among women
- Future LAMF: M decline; F wave shape
- When adding lifestyle to individual projections => e0 (eventually) moving back to e0 non-lifestyle
- When adding lifestyle to coherent projections => higher future e0 and more convergence btwn sexes

Overall conclusion

- Mortality projections that take into account likely future changes in smoking, alcohol and obesity result in higher future e0 and - when projecting coherently - in larger convergence between sexes

Discussion

- Preliminary results
- Only data (for alcohol) from 1990 onwards
- Recent stagnations in life expectancy and its causes are not taken into account
- Dependent on projections lifestyle-attributable mortality (particularly lower bounds used)
- LC and Li-Lee => illustration of the effects

Thank you

www.futuremortality.com

References (1)

Bongaarts, J. (2014). Trends in causes of death in low-mortality countries: Implications for mortality projections. *Population and Development Review, 40*(2), 189-212.

Booth, H., & Tickle, L. (2008). Mortality modelling and forecasting: A review of methods. *Annals of Actuarial Science, 3*(1-2), 3-43. doi:10.1017/S17484

Cairns A.J., Blake D., Dowd K., Coughlan G.D., Epstein D., Ong A., et al. (2009) A quantitative comparison of stochastic mortality models using data from England and Wales and the United States. *North American Actuarial Journal* 13: 1-35.

DYNAMO-HIA Consortium. (2010). Workpackage 7: Overweight and obesity. report on data collection for overweight and obesity prevalence and related relative risks. Retrieved from www.dynamo-hia.eu

GBD 2015 Obesity Collaborators (2017). Health effects of overweight and obesity in 195 countries over 25 years. *The New England Journal of Medicine, 377*, 13-27.

Janssen, F., van Wissen, L. J., & Kunst, A. E. (2013). Including the smoking epidemic in internationally coherent mortality projections. Demography, 50(4), 1341-1362.

Janssen, F., Kunst, A. E., & Mackenbach, J. P. (2007). Variations in the pace of old-age mortality decline among seven European countries, over the period 1950 to 1999: The role of smoking and factors earlier in life. *European Journal of Population, 23*(2), 171-188.

Janssen, F., & Kunst, A. E. (2007). The choice among past trends as a basis for the prediction of future trends in old-age mortality. Population Studies, 61(3), 315-26Janssen & Kunst 2005

Li, N., & Lee, R. (2005). Coherent mortality forecasts for a group of populations: An extension of the lee-carter method. Demography, 42(3), 575-594.

References (2)

Lopez, A. D., Collishaw N.E., & Piha. T. (1994). A descriptive model of the cigarette epidemic in developed countries. *Tobacco Control*, 3(3), 242-247.

NCD Risk Factor Collaboration (NCD-RisC)(2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *The Lancet* 390(10113):2627-2642.

Peto, R., Boreham, J., Lopez, A. D., Thun, M., & Heath, C. (1992). Mortality from tobacco in developed countries: Indirect estimation from national vital statistics. *The Lancet, 339*(8804), 1268-1278.

Rehm, J., Mathers, C., Popova, S., Thavorncharoensap, M., Teerawattananon, Y., & Patra, J. (2009). Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders. *Lancet, 373*(9682), 2223-2233. doi:10.1016/S0140-6736(09)60746-7

Rokholm, B., Baker, J. L., & Sørensen, T. I. A. (2010). The levelling off of the obesity epidemic since the year 1999? A review of evidence and perspectives. *Obesity Reviews, 11*(12), 835-846. doi:10.1111/j.1467-789X.2010.00810.x

Stoeldraijer, L. (2019). Mortality forecasting in the context of non-linear past mortality trends: An evaluation. PhD thesis. University of Groningen, the Netherlands.

Stoeldraijer, L., van Duin, C., van Wissen, L., & Janssen, F. (2013). Impact of different mortality forecasting methods and explicit assumptions on projected future life expectancy: The case of the Netherlands. Demographic Research, 29, 323-354.

Thatcher, A. R., Kannisto, V., & Vaupel, J. W. (1998). The force of mortality at ages 80 to 120. Odense: Odense University Press.

References (3)

Thun, M., Peto, R., Boreham, J., & Lopez, A. (2012). Stages of the cigarette epidemic on entering its second century. *Tob Control, 21*(2), 96-101. doi:10.1136/tobaccocontrol-2011-050294

Trias-Llimos, S., Kunst, A. E., Jasilionis, D., & Janssen, F. (2018). The contribution of alcohol to the east-west life expectancy gap in Europe from 1990 onward. International Journal of Epidemiology, 47(3), 731-739. doi:10.1093/ije/dyx244

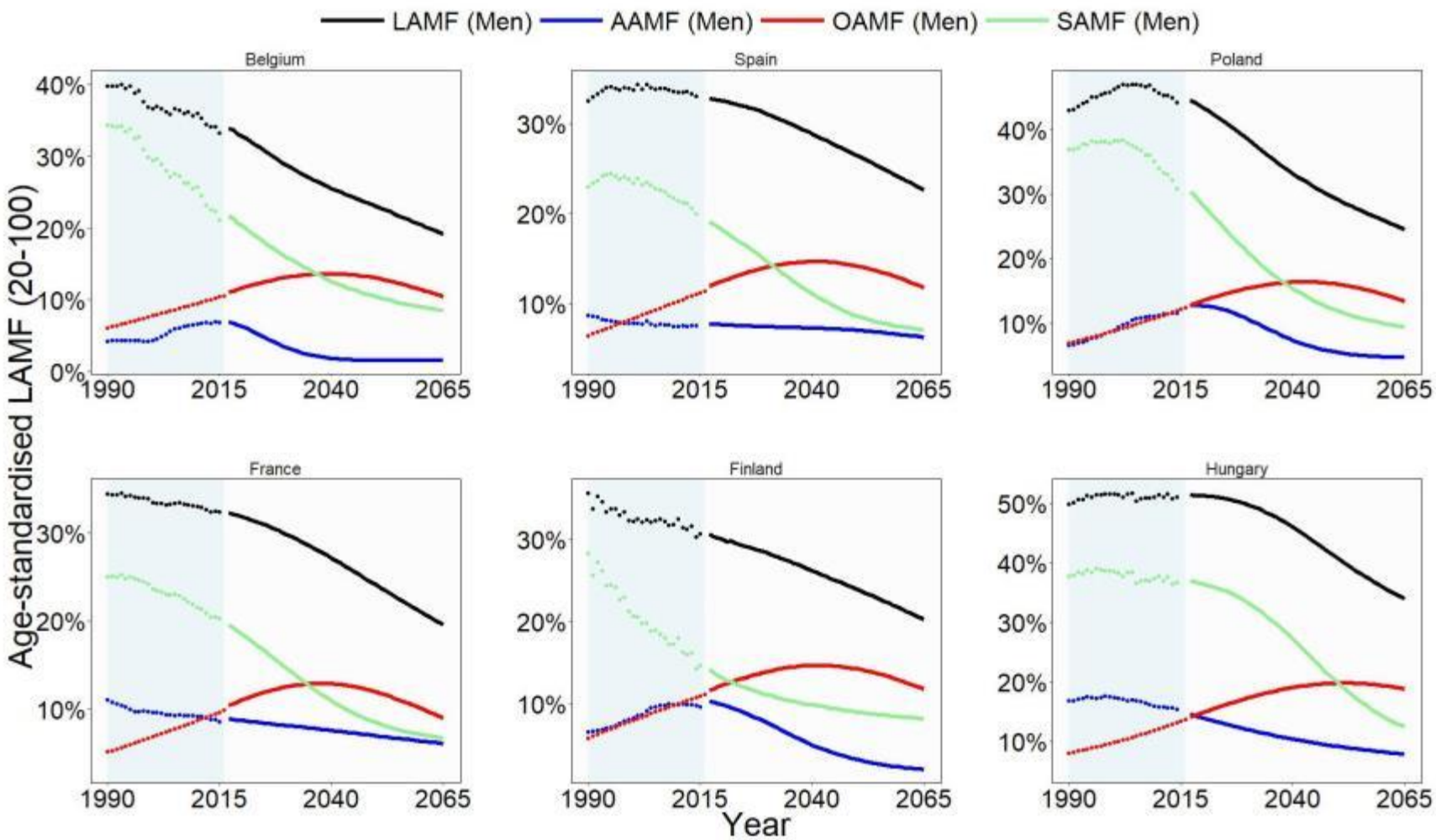
Trias-Llimos, S., Bijlsma, M. J., & Janssen, F. (2017). The role of birth cohorts in long-term trends in liver cirrhosis mortality across eight European countries. Addiction, 112(2), 250-258. doi:10.1111/add.13614

Vidra, N., Bijlsma, M. J., Trias-Llimos, S., & Janssen, F. (2018). Past trends in obesity-attributable mortality in eight European countries: An application of age–period–cohort analysis. International Journal of Public Health, 63(6), 683-692.

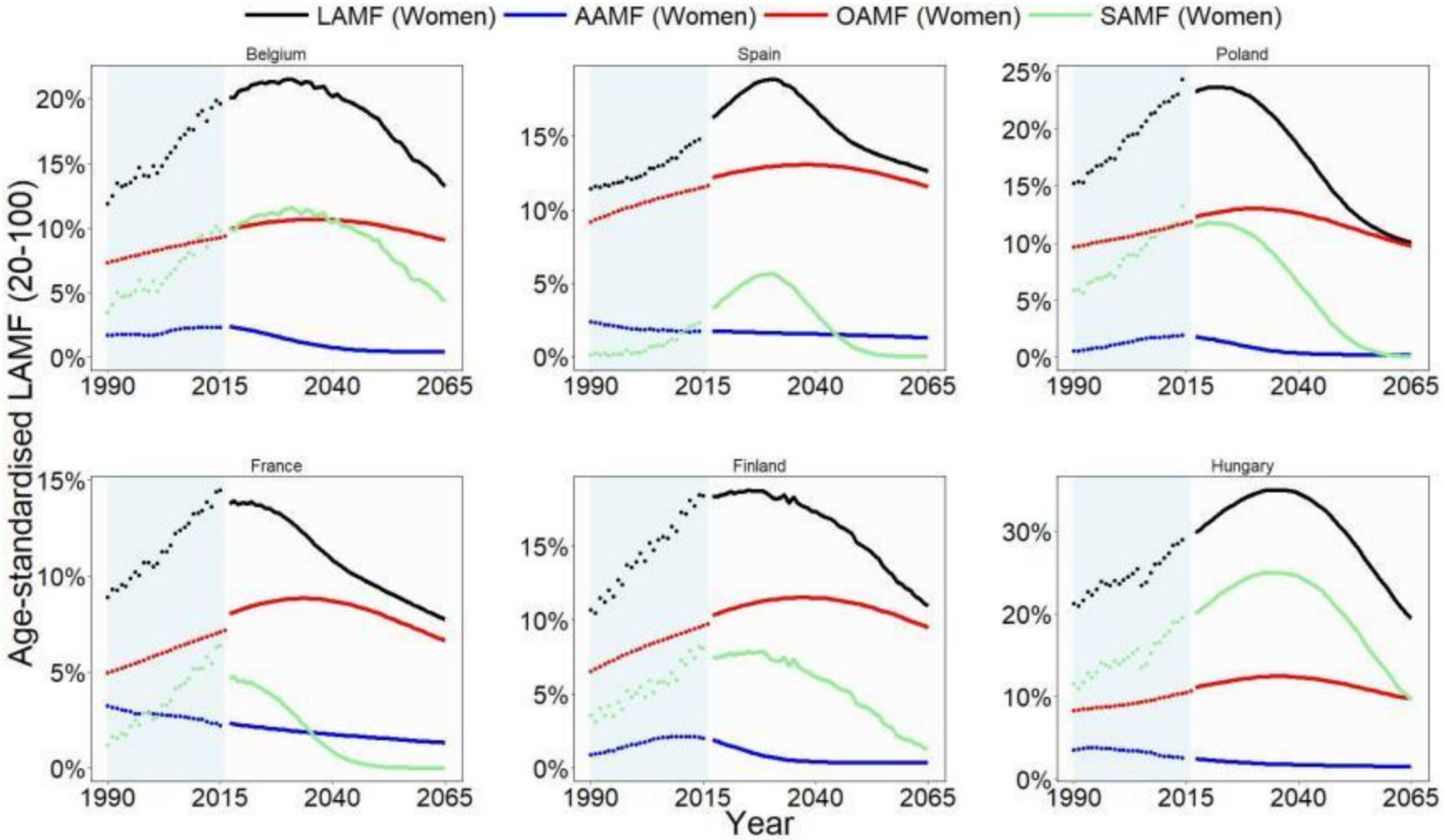
WHO Regional Office for Europe (2007). *The challenge of obesity in the WHO European Region and the strategies for response. Geneva:* World Health Organization.

Xu, L., & Lam, T. H. (2018). Stage of obesity epidemic model: Learning from tobacco control and advocacy for a framework convention on obesity control. Journal of Diabetes, 10(7), 564-571.

Projected lifestyle-attributable mortality fractions - men



Projected lifestyle-attributable mortality fractions - women



Descriptive model obesity epidemic

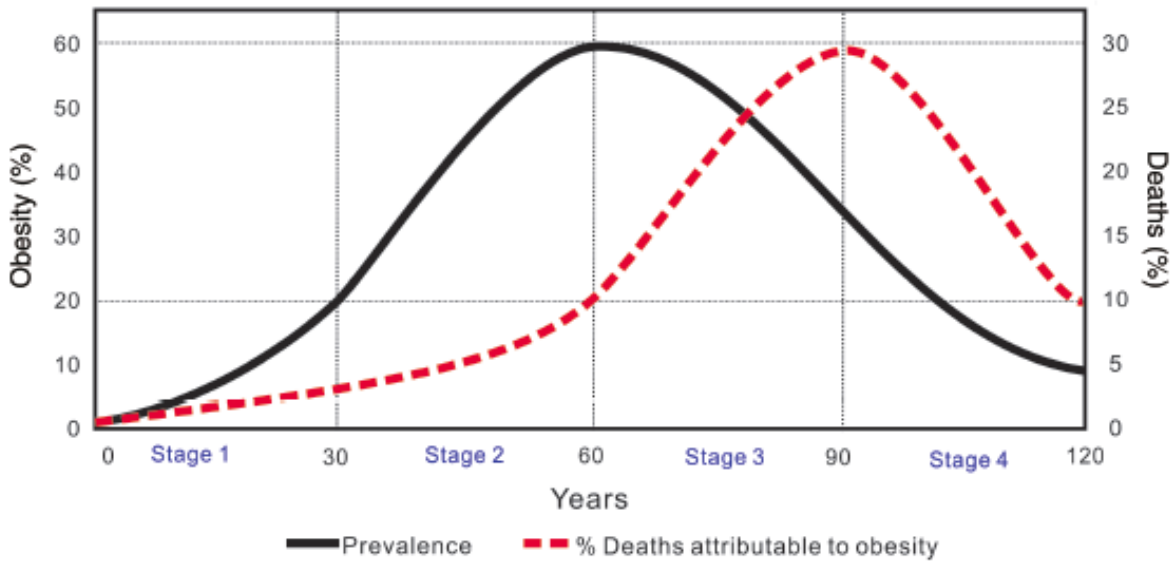
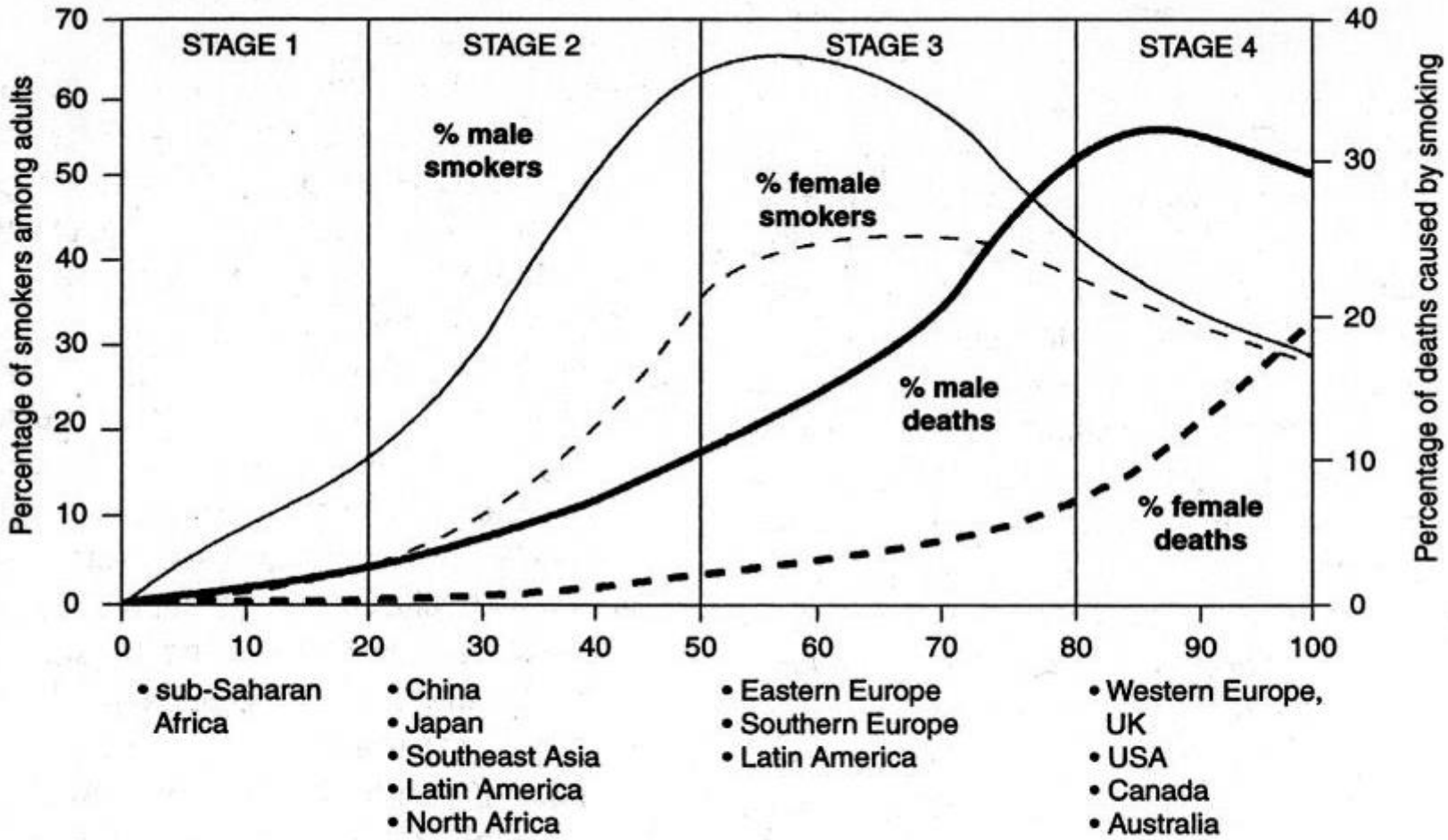


Figure 1 Model of the obesity epidemic: The criteria used to define the stages of the epidemic are based on the level of obesity prevalence and obesity-attributed mortality. Assuming 60 years between the current Stage 1 and Stage 2 to peak at a prevalence of 60%.

Xu & Lam (2018)

Descriptive model smoking epidemic



Source: Lopez AD, Collishaw NE, Piha T. (1994). A descriptive model of the cigarette epidemic in developed countries. *Tobacco Control, 3*, 242-247.

Data

- six European countries, by sex and age, 1950-2016
- Age and sex-specific lifestyle-attributable mortality fractions
  - Smoking (1950-2014; 35-100 M; 40-100 F) => indirectly estimated using lung cancer mortality data from WHO (Peto et al. 1992; Janssen et al. 2013)
  - Alcohol (1990-2016; 20-100) => rates from Global Burden of Disease Study 2017 (20-64) and age pattern at highest ages using cause-specfic mortality data from WHO.
  - Obesity (1975-2016; 20-100) => PAF formula applied to prevalence data (NCD Risk Factor Collaboration study 2017) and RRs of dying from obesity (DYNAMO-HIA Consortium,2010).
  - Smoothing over age
  - Three lifestyle factors combined => multiplicative approach

$$PAF_{1..i} = 1 - \prod_{i=1}^{n}(1 - PAF_i)$$

- All-cause mortality and exposure from HMD (past trends: August 27, 2018; projection: May 1, 2019)

Methods – future fractions I

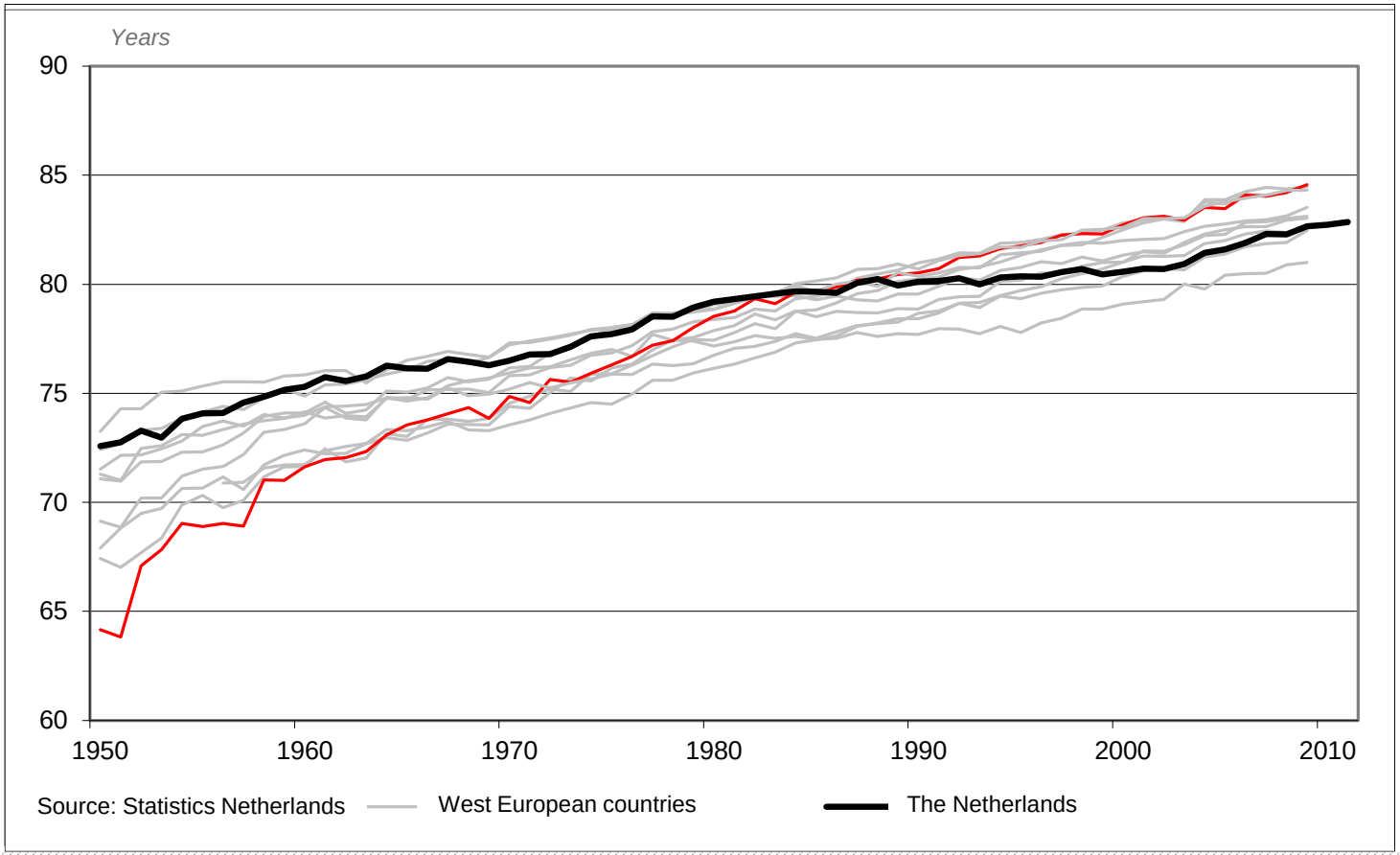
- Novel projections that take into account the wave pattern of epidemics
- Smoking & Alcohol =>
  - APC (Cairns et al. 2009) applied to attributable mortality fractions with a generalized logit link function
  - projection kt by quadratic curve with correlated errors or by decline after peak (best ARIMA)
  - projection gc by extrapolating recent trend (best ARIMA) after burning the outer cohorts
- Obesity
  - Lee & Carter (1992) applied to transformed logit of prevalence
  - projection by linearly extrapolating past trend speed of change over time (1st order diff.)
  - 2000 onwards; 1985 onwards Eastern European women
- Ages up to 84

Methods – future fractions II

- Generalized / transformed => implementing bounds
  - Smoking => men LB 5% smoking prevalence; women UB max level women DK (not Hungary)
  - Alcohol => different LBs by country and sex
  - Obesity => LB age-specific prevalence 1975
- For ages 85 -100 => linear extrapolation of the logit of the fractions/prevalence for ages 75-84
- 500 simulations (for now)
- Multiplicative approach to combine the projected fractions for the three separate lifestyles

Unrealistically large future differences between countries

E0 1950-2011 NL + other countries - women



Stoeldraijer, van Duin and Janssen (2013)