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

Impact on life expectancy trends - ctned

“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 $e_0$ 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

Remaining life expectancy at age 80

- F_observed_allcause
- F_allcause_indiv
- F_ns+smoke_indiv
- M_observed_allcause
- M_allcause_indiv
- M_ns+smoke_indiv

Importance for mortality forecasting

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- 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)
- 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)

<table>
<thead>
<tr>
<th>Gradual mortality decline</th>
<th>Country and sex specific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical improvements; socio-economic developments</td>
<td>Deviations / variations</td>
</tr>
<tr>
<td>Health-related lifestyle</td>
<td></td>
</tr>
</tbody>
</table>

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.

- $k_t \Rightarrow RW$ with no drift (non-stationary).
Methods III

› **Combining:**

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

(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 of all-cause mortality vs trends of non-lifestyle attributable mortality.
Projected lifestyle-attributable mortality fractions
Comparisons of different projections in Hungary

- **men**
- **women**
- **All cause mortality**
- **Life style and non-life style mortality**

Life expectancy at birth vs. Year (1990 to 2065)
Effect lifestyle when individually forecasting mortality (LC)

Belgium women

Spain
Effect lifestyle when coherently forecasting mortality (LiLee)

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Projected eo 2065</td>
<td>Projected eo 2065</td>
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<tr>
<td></td>
<td>Li and Lee</td>
<td>Li and Lee</td>
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<td></td>
<td>eo 2014 Allcause</td>
<td>eo 2014 Allcause</td>
</tr>
<tr>
<td></td>
<td>direct</td>
<td>indirect</td>
</tr>
<tr>
<td>Belgium</td>
<td>78.6</td>
<td>88.6</td>
</tr>
<tr>
<td>France</td>
<td>79.3</td>
<td>89.4</td>
</tr>
<tr>
<td>Spain</td>
<td>80.1</td>
<td>89.4</td>
</tr>
<tr>
<td>Finland</td>
<td>78.1</td>
<td>88.4</td>
</tr>
<tr>
<td>Poland</td>
<td>73.7</td>
<td>85.8</td>
</tr>
<tr>
<td>Hungary</td>
<td>72.3</td>
<td>84.4</td>
</tr>
</tbody>
</table>
Summary of results

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


References (2)


References (3)


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

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Data

- six European countries, by sex and age, 1950-2016
- Age and sex-specific lifestyle-attributable mortality fractions
  - Alcohol (1990-2016; 20-100) => rates from Global Burden of Disease Study 2017 (20-64) and age pattern at highest ages using cause-specific mortality data from WHO.
  - Obesity (1975-2016; 20-100) => PAF formula applied to prevalence data (NCD Risk Factor Collaboration study 2017) and RR of dying from obesity (DYNAMO-HIA Consortium, 2010).
  - Smoothing over age
  - Three lifestyle factors combined => multiplicative approach
- 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

Eo 1950-2011 NL + other countries - women

Source: Statistics Netherlands  
West European countries  
The Netherlands

Stoeldraijer, van Duin and Janssen (2013)