The Sensitivity of the Healthy Life Years Indicator: Approaches for Dealing with Age-Specific Prevalence Data

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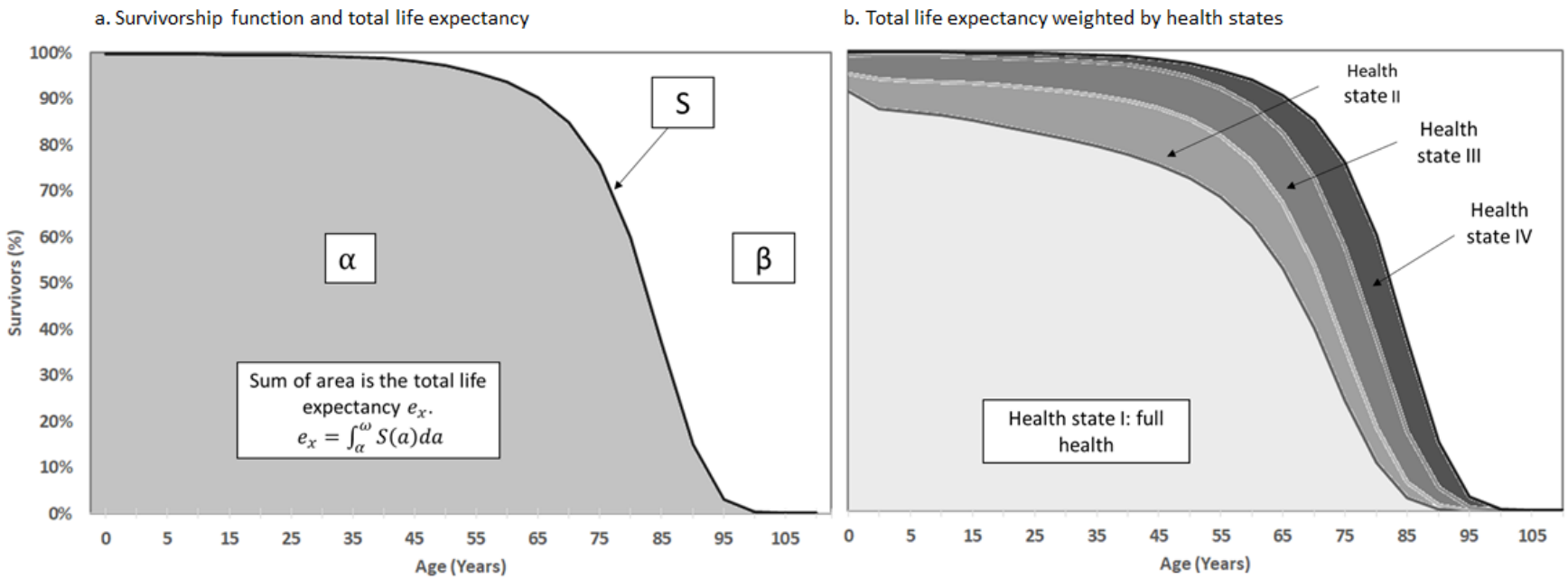
Healthy Life Expectancy(cies): What do They Measure?

1. Different from total life expectancy, there are many different concepts of healthy life expectancy, which vary from health dimension, definition of health and data sources (di Lego et al., 2020).
2. Healthy Life Years (HLY) has been widely acknowledged as the most important indicator for monitoring population health Europe over time and across countries (Jagger et al., 2013; Van Oyen et al., 2013; Nusselder et al., 2019)
3. HLY is used to estimate the proportion of life years spent in good or poor health, its trend over time (the "compression-expansion-debate"), and differences between women and men (Welsh et al., 2021; Füssenich et al., 2019)
4. Official European Union indicator for monitoring health, developing health policies and ranking countries (Eurostat; Nusselder et al., 2019)

Healthy Life Expectancy(cies): What do They Measure?

The same survivorship curve $S_{(x)}$ is divided into health states I to IV, where state I is the state of full health.

Figure 1: A scheme of Total life expectancy and healthy life expectancy



Source: own elaboration; adapated from Mathers et al., 2002

Healthy Life Expectancy(cies): What do They Measure?

1. HLY is within the category of disability-free life expectancy estimates (DFLE).
2. In this case, health expectancy gives a weight of 1 to states of health with no disability and a weight of 0 to states of health with any level of disability above a given threshold.
3. This approach is called dichotomous, since there are only two mutually exclusively health states defined. This means the indicator is usually defined in terms of two shaded areas under curve $S_{(x)}$, with or without a given health state.
4. The definition of health can be various (e.g with/without chronic morbidity, good/bad self-rated health, with/without dementia), and in the case of the HLY the dimension of health analysed is activity limitation (ADL), based on the GALI instrument (EU-SILC).

Healthy Life Expectancy(cies): What do They Measure?

Global Activity Limitation Instrument (GALI): EU-SILC survey question: "For at least the last 6 months have you been limited in activities people usually do, because of a health problem?" (Van Oyen et al., 2006; Jagger et al., 2010; Robine 2003 ;Saito 201).

How is healthy life expectancy estimated?

The three most common methods used to estimate healthy life expectancy are:

1. Sullivan
2. Multistate
3. Double decrement method

How is healthy life expectancy estimated by the Sullivan Method?

1. Combines life table information on survivorship with prevalence rates by age.
2. It requires a population life table and prevalence data for the health state or states of interest.
3. The prevalence data is usually derived from cross-sectional surveys.
4. Because of its parcimony and tested consistency, it is the most often used approach (Mathers 1997, Imai et al., 2007; Jagger, C., Van Oyen, H., Robine, J. 2014).

The Sullivan for dichotomous health concept, HLY

1. Developed in the 1970s - still the most widely used approach to estimate a summary measure of population health (Sullivan 1971).
2. Core idea is to combine a period life table with age-specific disability prevalence derived from cross-sectional survey data.
3. The method partitions the total number of person-years lived from the life table (L_x) into disability and disability-free life expectancy, based on the proportion of the population disabled at each age.

Sullivan for estimating Healthy Life Years (HLY)

1. Sullivan inherits period lifetable stationarity assumptions (i.e., constant hazard and birth rates and net migration are 0 at all ages)
2. What´s additional: age-specific disability prevalence is constant over time.
3. Allows for cross-sectional data from different cohorts to be used to infer the age-specific disability prevalence of a hypothetical cohort.

Sullivan for estimating Healthy Life Years (HLY)

From Kosuke Imai and Samir Soneji (2007), we have that:

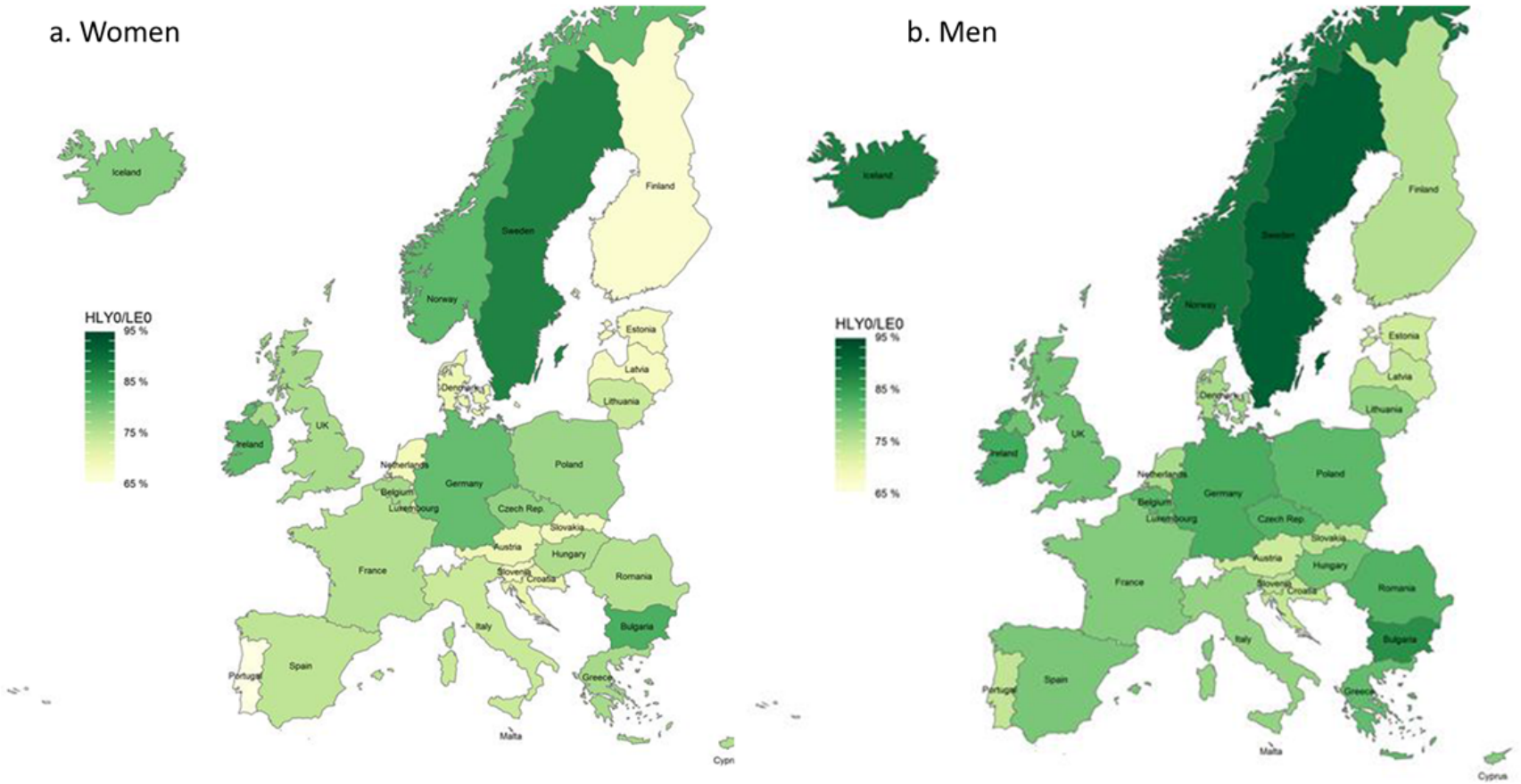
$$\hat{e}_x^{DF} = \frac{1}{l_x} \sum_{i \in x} (1 - {}_{ni}\hat{\pi}_i)_{ni} L_i \tag{1}$$

While for life expectancy we have that :

$$e_x = \frac{1}{l_x} \sum_{i \in x} {}_{ni} L_i \tag{2}$$

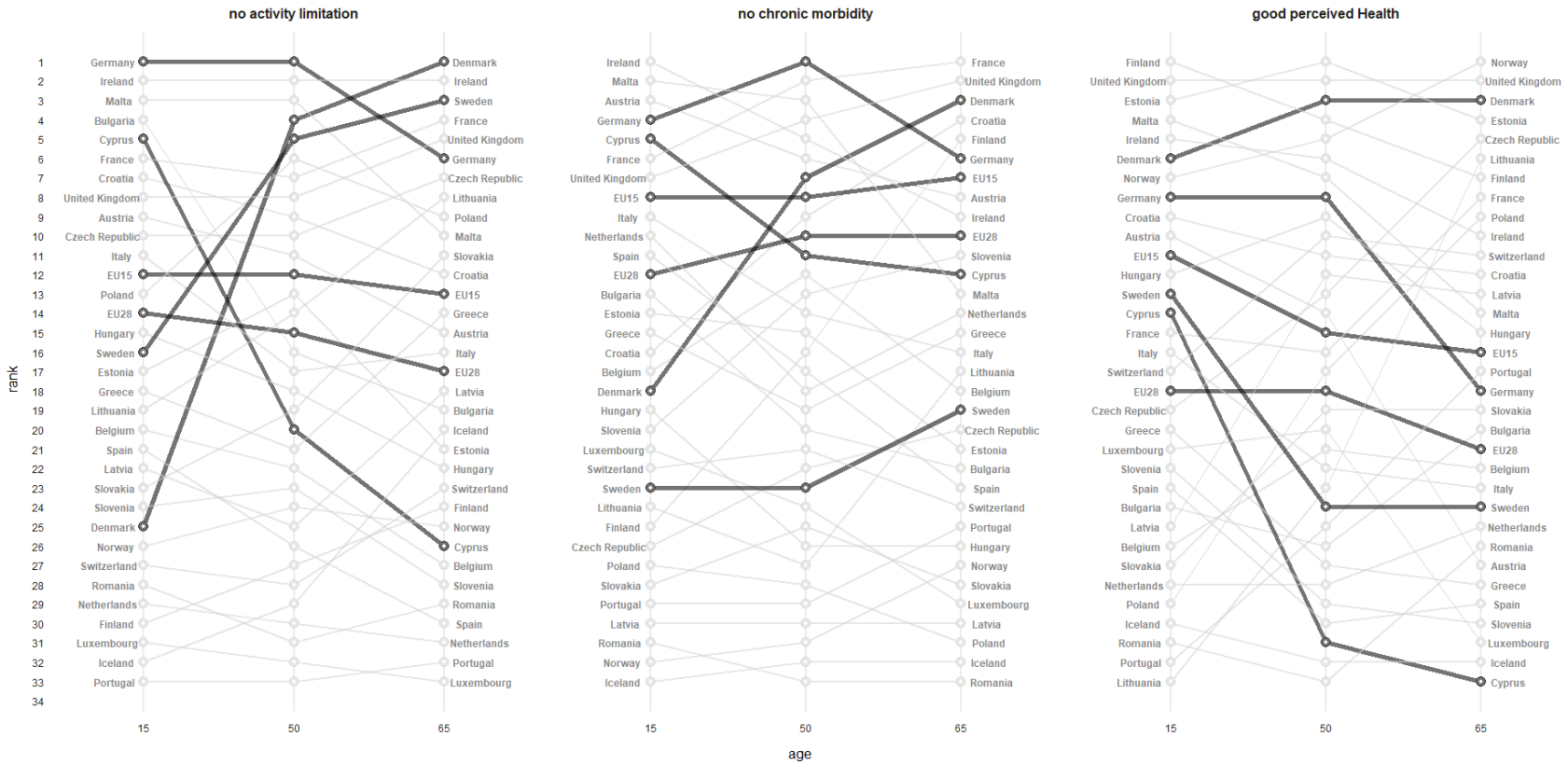
The Distribution of HLY in EU countries

Figure 2: Proportion of Healthy Life Years (HLY), EU countries



Not so simple!

Figure 3: Ranking of EU countries by gender gap and health dimensions



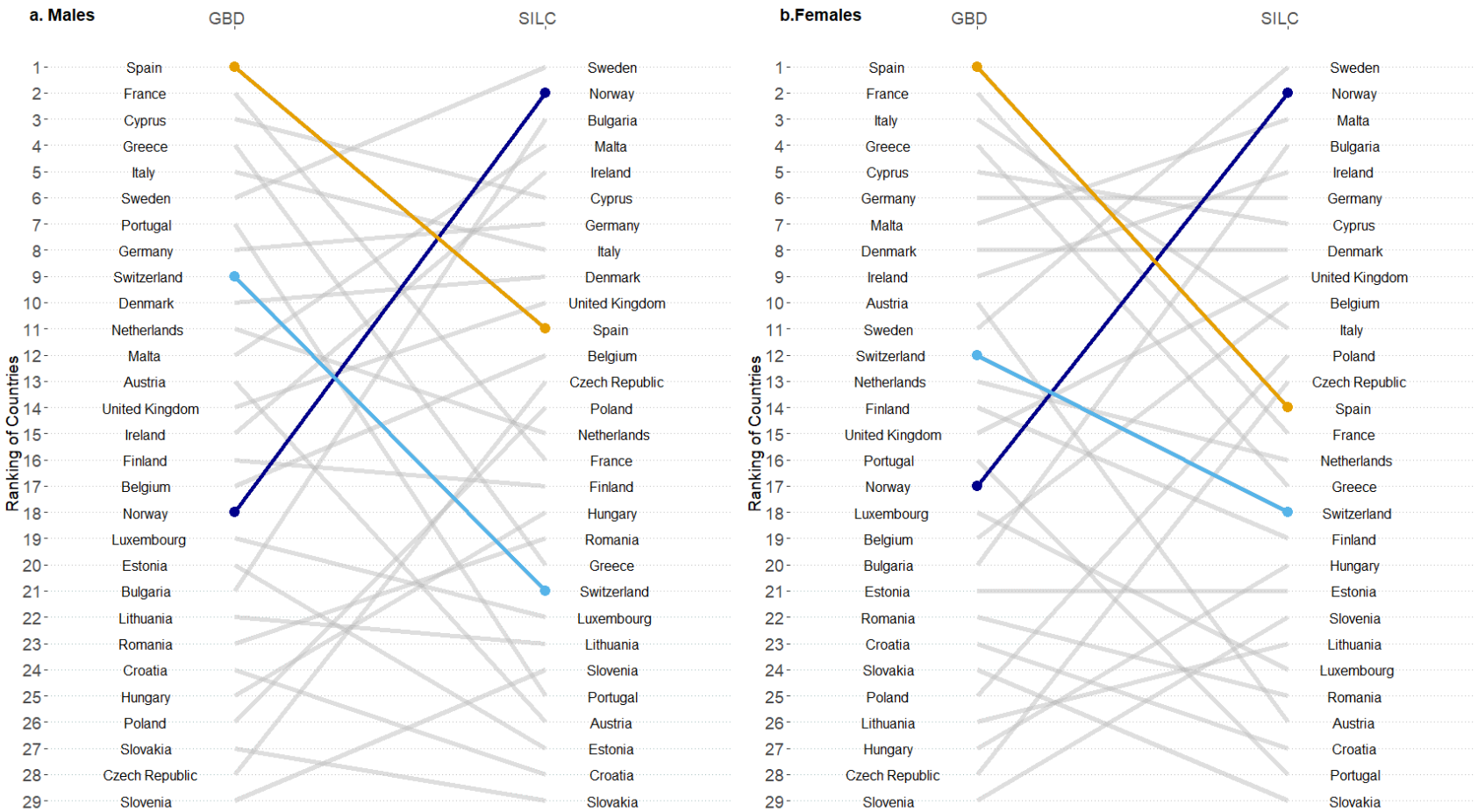
Source: SILC/MEHM. Statistics of Living and Income Survey

Gender differences on HLY

Figure 4: International Handbook on Health Expectancies

Not so simple!

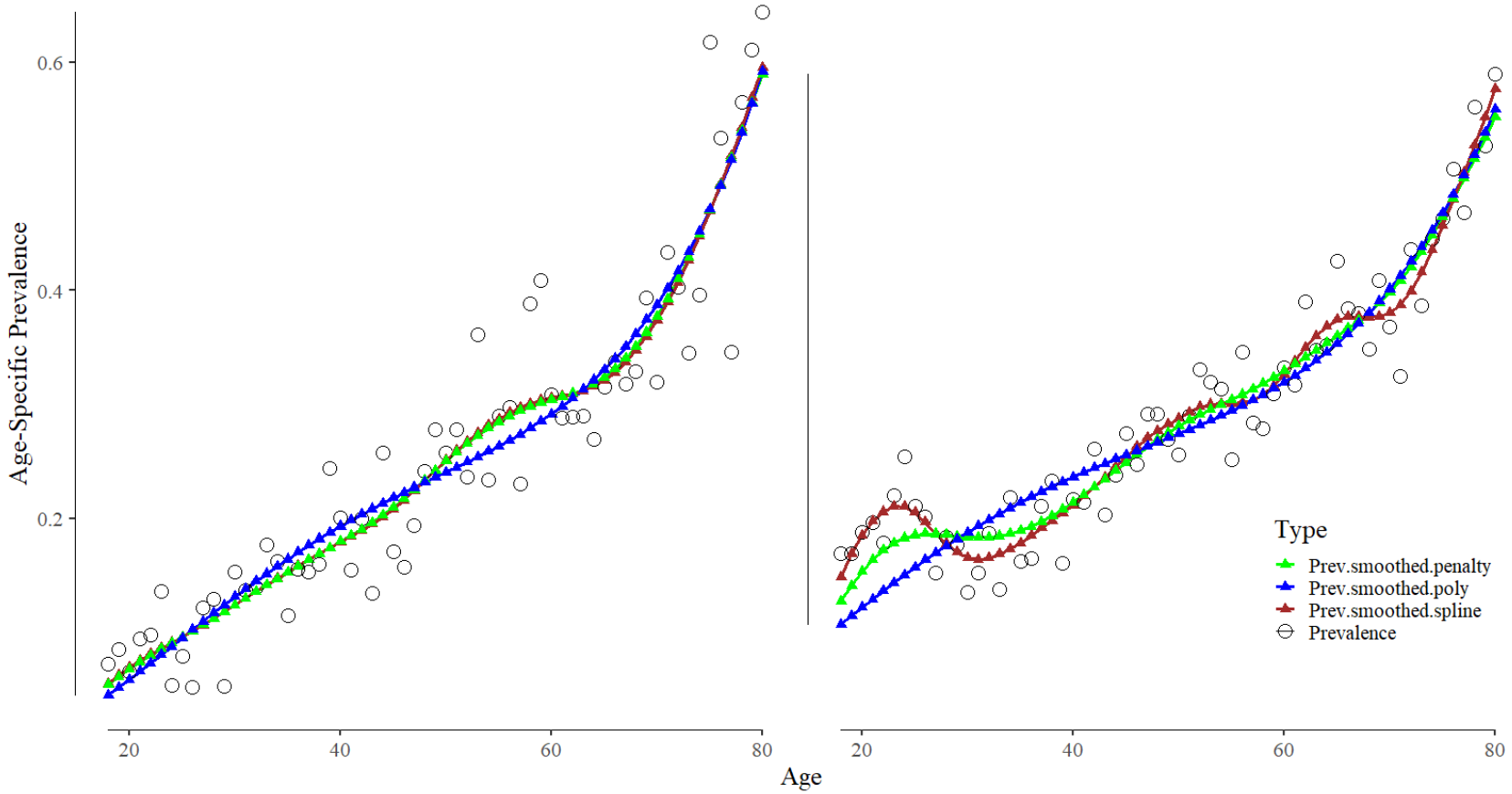
Figure 5: Ranking of EU countries, GBD x SILC



Source: SILC/MEHM. Statistics of Living and Income Survey, (GBD 2017)

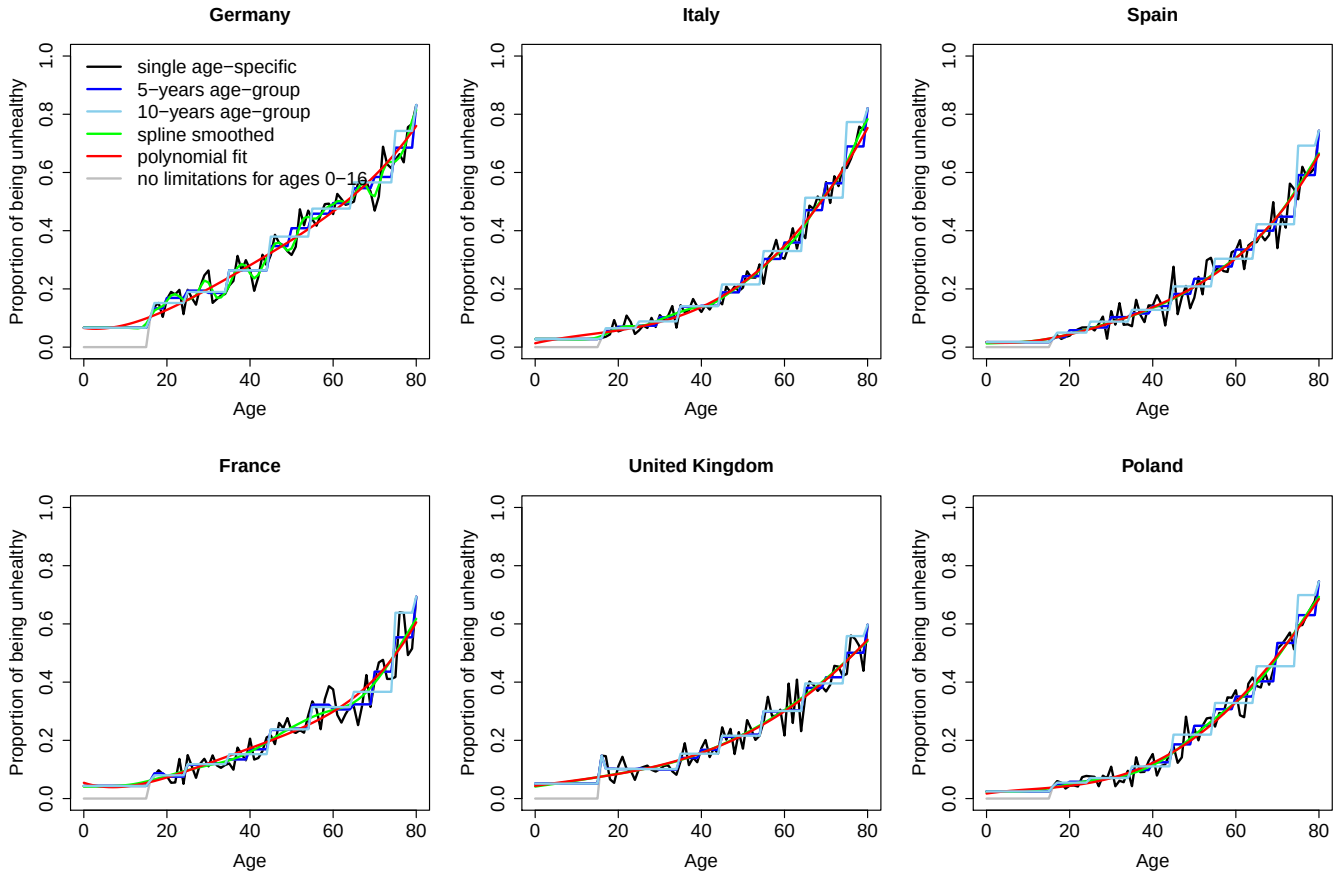
Problem: Age-Specific Prevalence is Complex (Noise or Reality?)

Figure 6: Age-Specific Prevalence, Single Ages and Different Smoothing Methods, France and UK



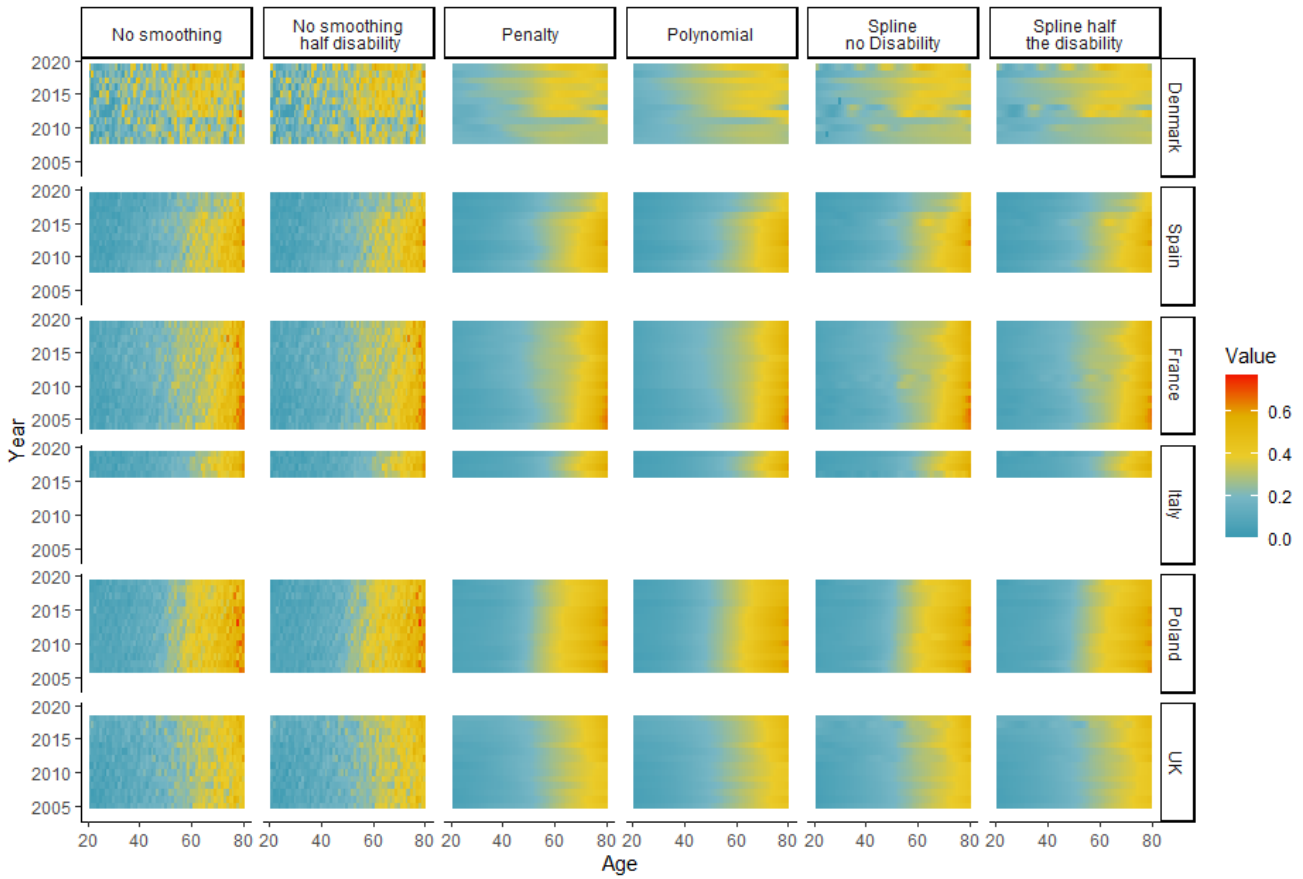
Problem: Age-Specific Prevalence is Complex (Noise or Reality?)

Figure 7: Age-Specific Prevalence, Single Ages and Different Smoothing Methods, Selected EU countries



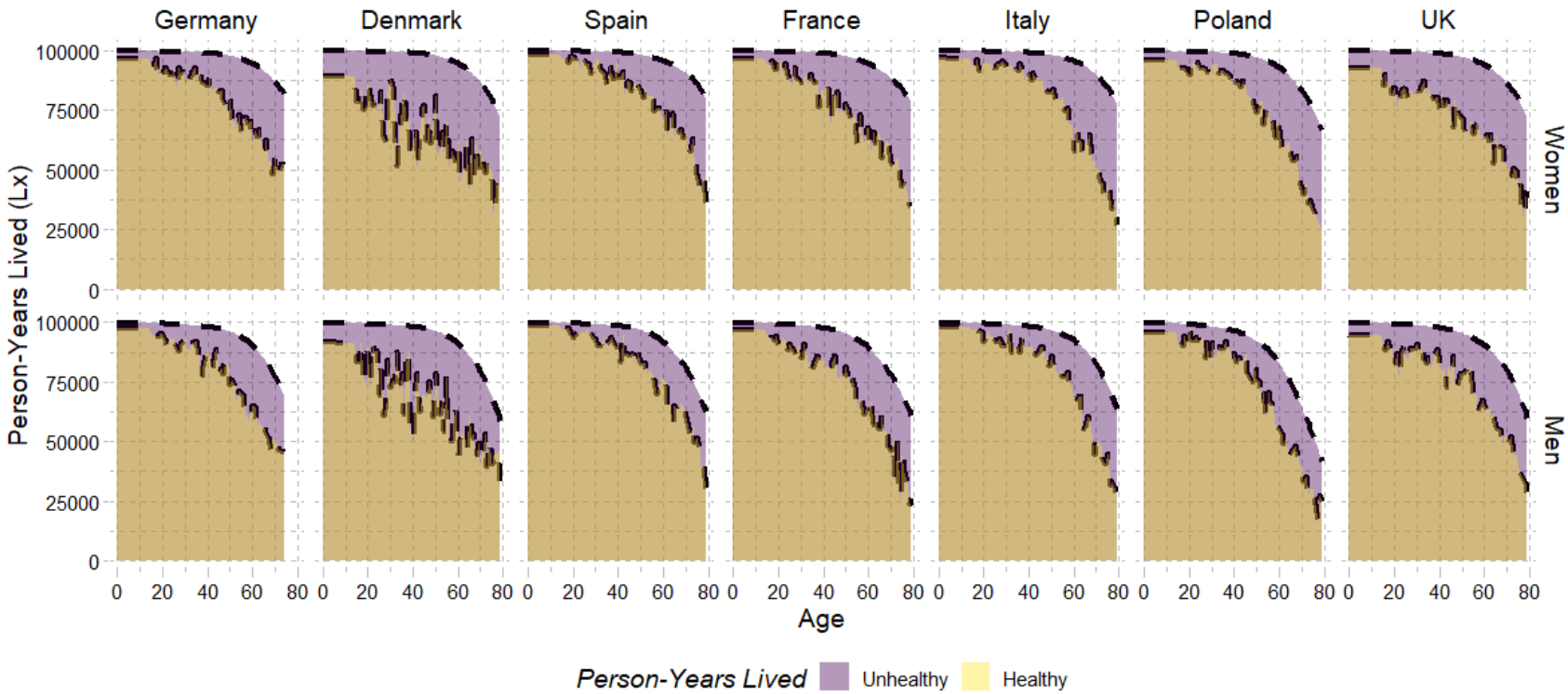
Problem: Age-Specific Prevalence is Complex (Noise or Reality?)

Figure 8: Age-Specific Prevalence, Single Ages and Different Smoothing Methods for Years 2005-2015, Selected EU countries



Person-Years lived with and Without Smoothing

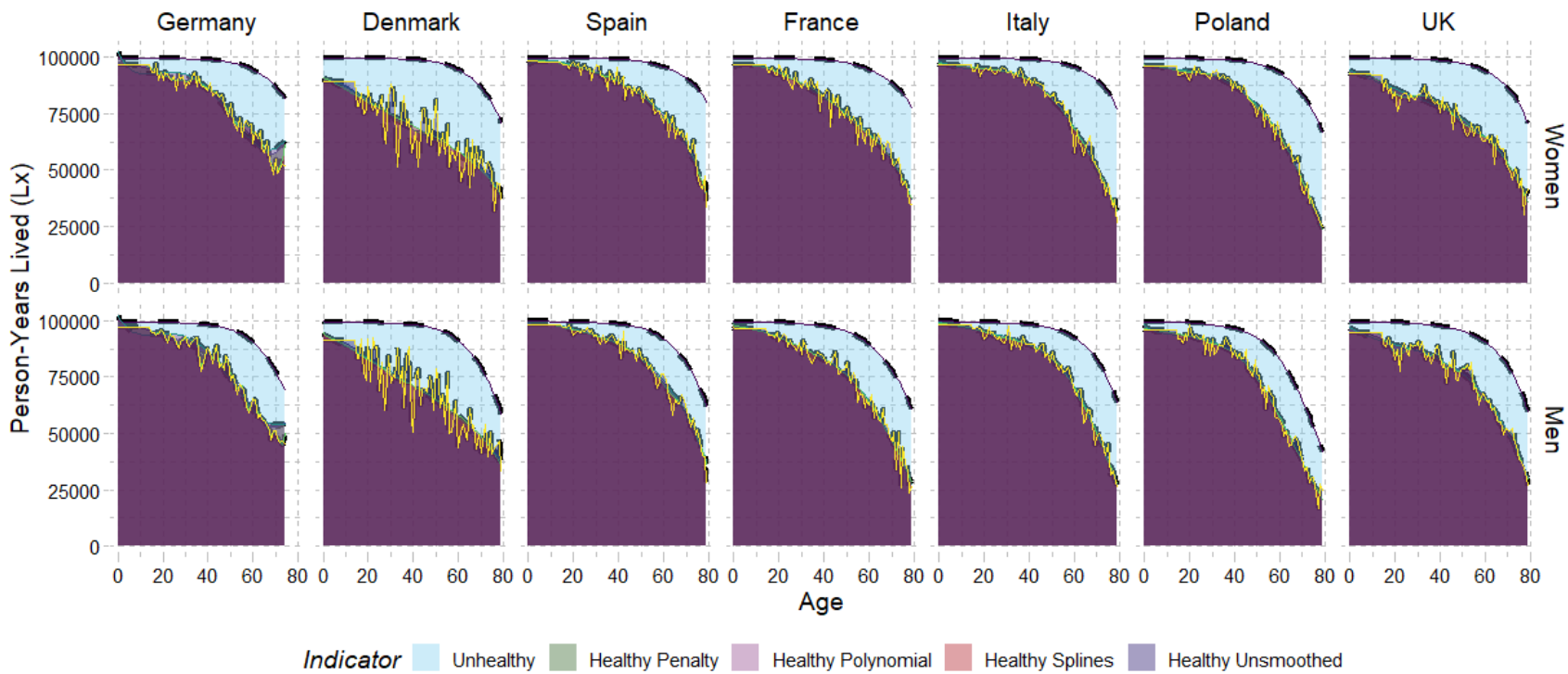
Figure 9: Person-Years Lived, Single Ages, Total and Unsmoothed, Selected EU countries, by sex, year 2017



Source: SILC/MEHM. Statistics of Living and Income Survey and HMD

Person-Years lived with and Without Smoothing

Figure 10: Person-Years Lived, Single Ages and Different Smoothing Methods, Selected EU countries, by sex, year 2017



Source: SILC/MEHM. Statistics of Living and Income Survey and HMD

Implications: Discussion

Table 1: HLY and proportion LE healthy with and without smoothing, selected countries and age, 2017

Country	Age	Sex	LE	HLY				%of LE Healthy						
				half	spline	penalty	poly	half	spline	diff	penalty	diff	poly	diff
Denmark	0	W	83.3	58.4	58.7	58.7	58.7	70.1	70.5	-0.4	70.4	-0.4	70.5	-0.4
	65		21	11.6	11.7	11.9	11.9	55	55.7	-0.6	56.4	-1.4	56.4	-1.3
	0	M	79.4	58.7	58.9	59	59	73.9	74.1	-0.2	74.3	-0.4	74.3	-0.4
	65		18.5	11.3	11.3	11.5	11.6	60.8	61	-0.1	62.2	-1.3	62.4	-1.5
France	0	W	86.1	67.2	66.9	66.9	66.9	78	77.7	0.3	77.7	0.3	77.7	0.3
	65		24	13.2	12.9	12.9	12.8	55.1	53.6	1.5	53.5	1.5	53.4	1.6
	0	M	80	64.2	64	63.9	63.9	80.2	80.1	0.2	80	0.3	79.9	0.3
	65		20	10.9	10.7	10.6	10.5	54.6	53.6	1	53	1.5	52.6	1.9

Source: SILC/MEHM. Statistics of Living and Income Survey

Discussion on the indicators

1. DFLE indicators are not purely cross-sectional
2. Prevalence rates are cumulative, and hence partly dependent on earlier health conditions of each age cohort.
3. The prevalence of disability is a stock variable that depends on the past, while incidence of disability is a flow variable (Mathers 1997, Brouard 1992).
4. Mismatch between stock and flow of health variables. Sudden changes in population health: the Sullivan approach is not appropriate for detecting these changes, nor for monitoring the resultant change (Barendregt 1994b, Mathers1997). (COVID-19?)
5. For further details on how to estimate healthy life expectancy indicators using Sullivan, please refer to (Hauet et al., 2001) and (Jagger et al., 2014).

Research results

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Of General Interest / Viewpoint

Life Expectancy: Frequently Used, but Hardly Understood

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Keywords: Life expectancy · Cohort effects · Heterogeneity · Harvesting effect · Tempo effects

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