

## Online Appendix

# Healthy Lifespan Statistics Derived From Cross-Sectional Prevalence Data Using the Sullivan Method are Informative Summary Measures of Population Health\*

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\* This Online Appendix contains additional information regarding the article:  
<https://comparativepopulationstudies.de/index.php/CPoS/article/view/555/404>.

## 1 Additional Tables

**Tab. A1:** List of chronic conditions included in the study

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1. A heart attack including myocardial infarction or coronary thrombosis or any other heart problem including congestive heart failure
  2. High blood pressure or hypertension
  3. High blood cholesterol
  4. A stroke or cerebral vascular disease
  5. Diabetes or high blood sugar
  6. Chronic lung disease such as chronic bronchitis or emphysema
  7. Cancer or malignant tumour, including leukaemia or lymphoma, but excluding minor skin cancers
  8. Parkinson disease
  9. Alzheimer's disease, dementia, organic brain syndrome, senility or any other serious memory impairment
  10. Other affective or emotional disorders, including anxiety, nervous or psychiatric problems
  11. Rheumatoid arthritis
  12. Osteoarthritis, or other rheumatism
  13. Chronic kidney disease
- 

Notes: Based on question *PH006* of wave 7 SHARE questionnaire. Conditions not included in the study but mentioned in the question and that might be reversible: Stomach or duodenal ulcer, peptic ulcer, cataracts, hip fracture, other fractures, other conditions that have not yet been mentioned. For the transition rates between health states required for the microsimulation model for the attrited individuals, health status was defined on the basis of the same list of conditions in waves prior to wave 7 (where possible, only small exceptions apply).

**Tab. A2:** Sample size by country, total\* and observed, all countries in SHARE wave 7

Country	Women		Men	
	Total	Observed	Total	Observed
Belgium	5518	2720	4472	2153
France	4868	1930	3581	1378
Italy	4739	2514	3763	2043
Czech Republic	4631	2523	3204	1679
Germany	4309	2024	3605	1777
Spain	4169	2619	3273	2063
Estonia	3953	3113	2497	1945
Sweden	3469	1724	2803	1463
Greece	3209	1768	2498	1292
Slovenia	3121	2127	2413	1532
Austria	3117	1876	2168	1297
Poland	3056	2595	2391	2071
Denmark	2742	1760	2320	1474
Switzerland	2452	1311	1927	1079
Croatia	1533	1336	1200	1056
Hungary	1372	921	968	599
Lithuania	1294	1294	724	724
Luxembourg	1230	676	1031	563
Romania	1200	1200	880	880
Bulgaria	1153	1153	830	830
Slovakia	1108	1108	934	934
Latvia	1093	1093	629	629
Finland	1077	1077	920	920
Cyprus	727	727	492	492
Malta	706	706	548	548

\* Total sample consists of respondents observed in wave 7 and respondents who were not observed in wave 7 because they had dropped out of the panel sample prior to this wave.. The health state at wave 7 of attrited respondents is derived in a microsimulation model as described in *Muszyńska-Spielauer and Spielauer (2022)*.

Countries are ranked by the size of the total sample of female respondents.

Source: Own estimations based on data from SHARE (*Börsch-Supan 2020; Börsch-Supan et al. 2013*)

**Tab. A3:** Healthy survival in selected European countries in 2017, by sex and age

Country	Age						
Average	50-55	55-60	60-65	65-70	70-75	75-80	80-85
	52.7	57.7	62.7	67.6	72.6	77.6	82.6
	Women						
Austria	0.72	0.48	0.37	0.26	0.20	0.21	0.19
Belgium	0.44	0.29	0.27	0.22	0.15	0.18	0.13
Czech Republic	0.36	0.34	0.19	0.13	0.06	0.06	0.10
Germany	0.41	0.35	0.22	0.24	0.18	0.15	0.08
Denmark	0.57	0.46	0.34	0.30	0.18	0.16	0.11
Estonia	0.54	0.42	0.34	0.28	0.17	0.17	0.12
Greece	0.71	0.48	0.32	0.19	0.11	0.07	0.07
Spain	0.37	0.38	0.30	0.28	0.21	0.16	0.09
France	0.50	0.44	0.29	0.21	0.19	0.17	0.08
Italy	0.53	0.60	0.39	0.32	0.18	0.18	0.07
Poland	0.50	0.36	0.30	0.20	0.09	0.10	0.06
Sweden	0.56	0.47	0.44	0.32	0.29	0.16	0.11
Slovenia	0.52	0.50	0.33	0.23	0.18	0.10	0.16
	Men						
Austria	0.53	0.48	0.34	0.27	0.17	0.15	0.09
Belgium	0.38	0.29	0.22	0.18	0.10	0.09	0.06
Czech Republic	0.43	0.33	0.17	0.14	0.08	0.06	0.03
Germany	0.45	0.38	0.23	0.23	0.12	0.12	0.08
Denmark	0.60	0.48	0.39	0.30	0.23	0.10	0.07
Estonia	0.51	0.39	0.29	0.21	0.10	0.06	0.03
Greece	0.67	0.48	0.28	0.16	0.13	0.05	0.04
Spain	0.63	0.38	0.23	0.18	0.09	0.08	0.03
France	0.49	0.37	0.27	0.19	0.14	0.13	0.05
Italy	0.60	0.52	0.41	0.30	0.14	0.13	0.04
Poland	0.46	0.29	0.21	0.14	0.10	0.06	0.03
Sweden	0.61	0.55	0.43	0.30	0.22	0.15	0.06
Slovenia	0.54	0.36	0.33	0.26	0.16	0.08	0.09

Age is the average age at death within a corresponding age interval ( $x + a_x$ ).

Source: Own estimations based on data from SHARE (Börsch-Supan 2020; Börsch-Supan et al. 2013) and Eurostat (2022)

**Tab. A4:** Standard deviation in healthy lifespan (Sh') conditional on being healthy at age 50 by sex in selected European countries in 2017

Country	Women	Men
Austria	9.2	9.2
Belgium	9.5	10.3
Czech Republic	8.2	7.1
Denmark	9.2	9.1
Estonia	8.6	8.7
France	9.3	8.7
Germany	9.2	9.6
Greece	7.4	7.0
Italy	8.0	8.3
Poland	8.6	7.6
Slovenia	9.4	7.7
Spain	7.7	8.7
Sweden	8.4	9.3
Mean	8.7	8.6
Standard Deviation	0.7	0.9

The statistics are estimated at age  $50 + a_{50} \in [52.7 - 52.8]$ , with the value of  $a_{50}$  differing between the countries.  $50 + a_{50}$  is the average age at death within the age interval  $[50, 55]$ .

Source: Own estimations based on data from SHARE (Börsch-Supan 2020; Börsch-Supan et al. 2013) and Eurostat (2022)

## 2 Step-by-step Instructions

### 2.1 A single-age life table

This part of the guide is a continuation of the guide from Jagger, Van Oyen, and Robine (2014) on pages 6-11 for estimating disability-free life expectancy. The guide from Jagger et al. (2014) is available free online at [http://www.eurohex.eu/ehleis/pdf/Sullivan\\_guide\\_pre%20final\\_oct%202014.pdf](http://www.eurohex.eu/ehleis/pdf/Sullivan_guide_pre%20final_oct%202014.pdf). Table A5 reproduces columns [1],[6],[10] of the table on p.11 in the original source, and adds columns [15]-[19].

1. In a single-age life table, the exact age at which half of the persons who die in the age interval  $[x, x + 1)$  are dead is assumed to be  $x + 0.5$ . This age is given in column [15] and the number of persons alive at that age is given in column [16]. It is estimated by deducting from the number of persons alive at the exact age  $x$ , given in the same row in column [1], half of the difference between the number of persons alive at the exact age  $x$ , in the same row in column [1], and the number of persons alive at the exact age  $x + 1$ , given in the next row in column [1].

2. The number of healthy persons at the middle of the age interval (column [17]) is obtained by multiplying the number of persons alive at the middle of the age interval (column [16]) by the proportion of persons without disability at that age (one minus column [10]).

3. Health expectancy conditional on being healthy at the radix age (here age 0) is derived by dividing the total number of years lived without disability (sum of column [12] in the original table in *Jagger et al.* (2014)) by the number of healthy persons at age 0.5 (given in the first row in column [17]).

Next, we demonstrate the steps necessary to estimate the standard deviation of healthy years lived by persons who are healthy at age 0. Because no information is provided for the life-table statistics for ages 6-73 in the original table in *Jagger et al.* (2014), we cannot provide the value of this statistic.

4. The number of persons who cease to be in full health between ages  $x + 0.5$  and  $x + 1.5$  is derived for each row in column [18] as the difference between the number of healthy persons in the middle of the age interval in that row (at age  $x + 0.5$ ) and the number of healthy persons in the middle of the age interval in the next row (at age  $x + 1.5$ ), both in column [17].

5. To calculate the average age at death between ages  $x + 0.5$  and  $x + 1.5$ , which is also assumed to be the average age at which an individual ceases to be healthy, we first determine the number of deaths that occurred at each age  $x$ , as indicated in column [19]. This is achieved by subtracting the value in each row of column [2] from the value in the same column in the subsequent row. Next, we calculate the average age at death between ages  $x + 0.5$  and  $x + 1.5$  in column [20]. This computation involves multiplying the value in a given row of column [15] by the value in the corresponding row of column [19]. Then, we add the value in the next row of column [15] multiplied by the value in the next row of column [19]. Finally, we divide the sum of these values by the sum of the values in column [15] for the given row and the next row.

6. To estimate the variance in the healthy years lived, we follow these steps: First, we calculate the squared difference between the age in column [19] and the health expectancy at age 50 (in this example:  $e'_{50} = 66.69$ ). Next, for each row, we weight this squared difference by the number of individuals who cease to be in full health within this age interval, as provided in column [18]. The result of this calculation is recorded in column [20]. To obtain the variance in the healthy years lived by persons who are healthy at the radix age, we aggregate all the values in column [20] and then divide the sum by the number of healthy persons at age  $x + 0.5$  (the value found in the first row of column [17]). Finally, the standard deviation of the healthy years lived by persons who are healthy at age 0 can be found by taking the square root of the calculated variance.

**Tab. A5:** Calculation of disability-free survival and its selected statistics in a single-age life table

Age	Number of persons Surviving to age $x$	Proportion with disability	Age when half dead in $x$	Number surviving to $x + 0.5$	Number of persons healthy at $x + 0.5$	ceasing to be healthy in $[x + 0.5, x + 1.5]$	Number of deaths at age $x$	Average age at death in $[x + 0.5, x + 1.5]$	Squared difference
[1]	[6]	[10]	[15]*	[16]	[17]	[18]	[19]	[20]	[21]**
$x$	$\ell_x$	$\pi_x$	$x + 0.5$	$\ell'_{x+0.5}$	$\ell'_{x+0.5}$	$d'_{x+0.5}$	$d_x$	$z$	$(x - e'_0)^2 d'_{x+0.5}$
0	100000.0	0.000	0.1	99819.7	99819.7	4981.2	360.6	0.3	21974915.4
1	99639.4	0.048	1.5	99620.3	94838.5	27.5	38.2	1.8	115784.9
2	99601.2	0.048	2.5	99591.4	94811.0	16.1	19.7	2.9	65640.6
3	99581.5	0.048	3.5	99574.4	94794.8	17.0	14.2	4.1	66457.6
4	99567.3	0.048	4.5	99556.6	94777.9	7460.9	21.4	-	-
5	99545.9	0.030	5.5	-	-	-	-	-	-
74	80489.1	0.345	74.5	79637.8	52162.8	7852.4	1702.7	75.0	544518.0
75	78786.4	0.431	75.5	77874.0	44310.3	1183.6	1824.8	76.1	103950.8
76	76961.6	0.431	76.5	75793.8	43126.7	1452.0	2335.6	77.0	155615.9
77	74626.0	0.431	77.5	73241.9	41674.7	1629.9	2768.1	78.0	209116.2
78	71857.9	0.431	78.5	70377.4	40044.7	1740.1	2961.0	79.0	264376.8
79	68896.9	0.431	79.5	67319.1	38304.6	1801.2	3155.5	80.0	319171.9
80	65741.4	0.431	80.5	64153.5	36503.4	1740.7	3175.6	81.0	355497.6
81	62565.7	0.431	81.5	61094.4	34762.7	1565.3	2942.7	82.0	365231.1
82	59623.1	0.431	82.5	58343.4	33197.4	1310.9	2559.2	82.9	346360.0
83	57063.8	0.431	83.5	56039.5	31886.5	1483.2	2048.6	84.1	449929.3
84	55015.2	0.431	84.5	53432.9	30403.3	-	3164.7	-	-
85+	51850.5	0.513	-	-	-	-	-	-	-

\*  $a_0 = 0.14$  comes from the life table for women in Belgium in 2004 from the *Human Mortality Database* (2022).

\*\*  $e'_0 = 66.69$ .

Source: Own estimations, numbers in columns [1],[6] and [10] and notations as in Table 1.5 in *Jagger et al.* (2014)

## 2.2 Abridged life table

This part of the guide is a continuation of the guide of *Jagger et al.* (2014) on pages 16-20 for estimating disability-free life expectancy. Table A6 reproduces selected columns from the table on p. 19 in the original source. In our instructions, we create additional columns in the table, and so the first column we add is [15]. For this hands-on example, we add information on  ${}_n a_x$  from the abridged [5x1] life table for women in Belgium in 2004 from *Human Mortality Database* (2022) to the original life table in *Jagger et al.* (2014).

1. Age  $x + {}_n a_x$ , which is the age where the number of survivors matches the average number of individuals alive in the age interval  $[x, x + n)$ , can be found in column [15]. Column [15] is the sum of columns [1] and [1a].

2. We calculate the number of deaths that occur in each age interval by subtracting from persons alive at the beginning of a given age interval the number of persons alive at the beginning of the next age interval. The value in column [16] for each consecutive row is obtained by subtracting the value in column [6] of the current row from the value in column [16] of the next row.

3. In column [17] we give the number of deaths in the first sub-interval  $[x, x + {}_n a_x)$ . It is derived by multiplying the number of deaths (in column [16]) by one minus the value in column [1a] and dividing by the length of the entire age interval, namely,  $n$ .

4. The number of persons alive at age  $x + {}_n a_x$  in column [18] is estimated by subtracting the number of deaths that occur between ages  $x$  and  $x + {}_n a_x$  in column [17] from the number of persons alive at age  $x$  in column [6].

5. The number of healthy individuals at age  $x + {}_n a_x$  in column [19] is estimated by multiplying the number of persons alive at age  $x + {}_n a_x$  in column [18] by the proportion of healthy individuals in the corresponding age group ( $1 - \text{column [10]}$ ).

6. To estimate health expectancy conditional on being healthy at each age, first derive the total number of years lived in full health starting from age  $x$ , following the guidelines set out on p. 19 of *Jagger et al.* (2014). Unlike *Jagger et al.* (2014), who assumed  ${}_n a_x = 2.5$  for all age intervals, we propose taking the values from the abridged [5x1] life table for women in Belgium in 2004 from the *Human Mortality Database* (2022). For the open age interval, 85+, we take the values from p. 20 of *Jagger et al.* (2014). The total number of disability-free years starting from age  $x$  is given in column [20]. Health expectancy conditional on being healthy at age 50 in column [21] is derived by dividing the sum of the number of years lived in full health in column [20] by the number of people who are healthy at age 50, given in the first row in column [19].

In the next steps, we derive inequality in healthy lifespans conditional on being healthy at the threshold age.

7. The number of persons who cease to be healthy in each age interval between  $x + {}_n a_x$  and  $x + n + {}_n a_x$  is derived in column [22] by subtracting from the average number of healthy persons in a given row in column [19] the average number of healthy persons in the next row in the same column [19].

8. The average age at which a person dies between ages  $x + {}_n a_x$  and  $x + n + {}_n a_x + n$ , in column [23], is assumed to be the average age at which an



**Tab. A6:** Calculation of Disability-Free survival and its statistics in an abridged life table

[1]	[1a]	[6]	[10]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]
$X$	$n^a x^*$	$l_x^{**}$	$\pi_x$	$x + n^a x$	$n^d x$	$d_{x,1}$	$l_{x+n^a x}$	$l'_{x+n^a x}***$	$\sum L'_x$	$e'x$	$d'$	$z^+$	$sqrt^{++}$
50	2.7	100000.0	0.161	52.7	1750.8	815.9	99184.1	83215.5	2252639.6	27.1	3733.7	55.4	1757278.8
55	2.6	98249.2	0.298	57.6	2066.2	983.5	97265.7	79481.7	1837061.6	23.1	6948.3	60.6	1884069.7
60	2.6	96183.0	0.234	62.6	3069.6	1491.8	94691.1	72533.4	1496007.3	20.6	4923.0	65.6	652677.1
65	2.7	93113.3	0.257	67.7	4523.1	2116.8	90996.5	67610.4	1133669.5	16.8	11717.0	70.7	472362.8
70	2.7	88590.2	0.345	72.7	7110.8	3256.7	85333.5	55893.4	796692.8	14.3	13067.2	76.0	15597.6
75	2.7	81479.4	0.431	77.7	13449.6	6213.7	75265.7	42826.2	519181.9	12.1	7940.8	80.3	81164.1
80	2.6	68029.8	0.431	82.7	14297.6	6719.9	61309.9	34885.3	307959.1	8.8	-	-	-
85	6.2	53732.2	0.513	91.2	-	-	-	-	135972.9	-	-	-	-

\*  $n^a x$  comes from the abridged [5x1] life table for women in Belgium in 2004 from *Human Mortality Database* (2022).

\*\*  $l'_x$  is reestimated from the original  $l_x$  in *Jagger et al.* (2014) in Tables on p.18-20, as conditional to survive to age 50, i.e. the original values of  $l_x$  in column [5] are divided by  $l_{50} = 96731.9$ .

\*\*\* As original value of  $l'_{57.6} > l'_{52.7}$ ,  $l'_{57.6}$  was estimated as the average of  $l'_{52.7}$  and  $l'_{62.6}$ .

† consult main text for explanation

††  $sqrt = (x + a_z - e'_{50})^2 d'$

Source: Own estimations, based on Tables on p.18-20 in *Jagger et al.* (2014)

individual ceases to be healthy. This computation involves multiplying the value in a given row of column [15] by the value in the corresponding row of column [17]. Then, we add the value in the next row of column [15] multiplied by the value in the next row of column [17]. Finally, we divide this sum by the sum of the values in column [17] for the given row and the next row.

9. To estimate the variance in the healthy years lived, we follow these steps: First, we calculate the squared difference between the age in column [19] and the health expectancy at age 50 (given as  $e'_{50} = 27.07$  in this example). Next, we weight this squared difference by the number of individuals who cease to be in full health within this age interval, as provided in a given row in column [22]. The result of this calculation is recorded in column [24]. To obtain the variance in the healthy years lived by persons who are healthy at the radix age, we sum up all the values in column [24] and then divide the sum by the number of healthy persons at age 50 (approximated by the value found in the first row of column [19]). Finally, the standard deviation of the healthy years lived by persons who are healthy at age 50 can be found by taking the square root of the calculated variance. In this example, it equals 7.6 years.

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*Date of submission: 17.01.2022*

*Date of acceptance: 30.10.2023*

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## Comparative Population Studies

*www.comparativepopulationstudies.de*

ISSN: 1869-8980 (Print) – 1869-8999 (Internet)

### Published by

Federal Institute for Population Research  
(BiB)  
65180 Wiesbaden / Germany

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2024

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