



ORIGINAL ARTICLE

Trends in good self-rated health in Germany between 1995 and 2014: do age and gender matter?

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Abstract

Objectives This study analyzes longitudinal trends in self-rated health (SRH) by taking age- and gender-specific differences into account.

Methods Data of 29,251 women and 26,967 men were obtained from the German Socio-Economic Panel between 1995 and 2014. Generalized Estimation Equation analysis for logistic regression was used to estimate changes in odds of (very) good SRH over time. Development of (un)healthy life expectancy was calculated by applying the Sullivan method.

Results While in women, the odds of good SRH increased significantly over time for the ages 41–50 to 71–80 years, improvements among men were most apparent for the ages 61–70 and 71–80 years. By contrast, for both genders, no improvements in SRH were found in the youngest (31–40 years) and eldest age group (81–90 years) and in men aging 51–60 years. Over time, healthy life expectancy at age 31 increased by 3 years in women and 2 years in men, leading to a reduced but not eliminated gender gap in SRH.

Conclusions Our findings support the hypothesis of relative compression of morbidity. However, trends in SRH differed according to age and gender, calling for health promotion efforts that meet diverse needs at different stages of life.

Keywords Self-rated health · Germany · Healthy life expectancy · Sullivan method · Compression · Morbidity

Introduction

As in other industrialized countries, life expectancy in Germany has been constantly rising (Fiedler et al. 2017). However, it still remains unclear whether the additional lifetime is accompanied by an increase in healthy life years. In this context, three hypothetical scenarios with opposing assumptions about future development of morbidity in populations are discussed. The ‘expansion of

morbidity hypothesis’ (Gruenberg 1977) posits that the increased lifetime will entail an increase in years in morbid conditions, while Fries’ (1980) hypothesis of ‘morbidity compression’ assumes that life years spent in morbidity will decrease. A third assumption, termed as ‘dynamic equilibrium’ (Manton 1982), postulates that longer survival is associated with an increase in life years in morbidity, but due to medical advances and improved lifestyle, time spent with severe disability will decline.

Previous studies draw an inconsistent picture of health trends in the last decades, which in part reflects a considerable variation in study design such as country of assessment, health indicators, time period and sample composition. A review by Parker and Thorslund (2007) revealed that while disability measures often show improvement, there is a simultaneous increase in chronic diseases. More recent studies point toward an increase in healthy and disability-free life expectancy (Clarfield 2018; Luijben et al. 2013; Fries et al. 2011; Storeng et al. 2018).

Self-rated health (SRH) has often been used to study trends in the health of older people as it proved to be a reliable indicator of healthcare services utilization

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(DeSalvo et al. 2005), functional limitations (Idler et al. 2000) and mortality (DeSalvo et al. 2005; Jylhä 2009). While some studies found improvement in SRH over time (Hanibuchi et al. 2016; Parker and Thorslund 2007; Pöld et al. 2016; Roqué et al. 2012), others found no change in SRH or even worsening SRH over time (Galenkamp et al. 2013; Mairey et al. 2014; Zack et al. 2004). Similarly, studies on SRH within Germany have found conflicting results, suggesting relative expansion of morbidity (Gärtner and Scholz 2005) as well as compression of morbidity or dynamic equilibrium (Trachte et al. 2014; Unger and Schulze 2013). Some studies indicate that trends in SRH vary with age. For instance, Johansson et al. (2015) found for the Swedish population that SRH improved between 1980/1981 and 2004/2005 in individuals aged 48 and above, but became poorer or was unchanged in those aged 16–47 years.

Beside a persisting social gradient in health (e.g., European Union 2013; Moor et al. 2018), there is evidence for gender inequalities, indicating that higher life expectancy among women is accompanied by higher rates of morbidity and health complaints (Boerma et al. 2016; Read and Gorman 2010). Some studies suggest that women's health status as compared to men has steadily improved over time (Aguilar-Palacio et al. 2018; Hill and Needham 2006), whereas others found no clear evidence for a narrowing of the gender gap (Galenkamp et al. 2013; Johansson et al. 2015). To our knowledge, for Germany, no current studies exist that have explicitly examined changes in gender inequalities in SRH over the last decades.

When interpreting time-related changes, effects of age, period and cohort can be distinguished. While age effects are related to the aging process of individuals and thus are the effects of differences in the ages of the individuals, period effects are the effects of differences in the time periods of observations that occur at a specific point in time and affect people of all ages. Lastly, cohort effects are the effects of differences in the year of birth or some other shared life events for a group of individuals (Debiasi 2018). The present study addressed the overall time trend and analyzed whether compression or expansion of morbidity occurred in the last decades. In order to clarify which of the hypothetical scenarios on health trends applies, proportions of good SRH were combined with age-specific mortality information using the method proposed by Sullivan (1971). In more detail, the study was guided by the following research questions:

1. Stratified by age and gender, how does the proportion of (very) good SRH develop between 1995 and 2014 in the German population?
2. Does gender inequality in SRH change over time?

3. In terms of (un)healthy life expectancy, do the findings indicate compression or expansion of morbidity?

Methods

The data of this study were drawn from the German Socio-Economic Panel Study (GSOEP V.31), conducted at the German Institute for Economic Research. The GSOEP is a representative annual survey of German individuals in private households conducted from 1984 onward. The GSOEP population is regularly updated with new survey samples to reflect changes in the German population. Our analyses are based on a pooled dataset including all panel waves from 1995 to 2014, allowing for trend analysis on population level. We used cross-sectional weights which are assumed to produce a nationally representative sample. Further information on GSOEP can be derived from Wagner et al. (2007).

Panel waves between 1995 and 2014 were classified into four consecutive time periods (1995–1999, 2000–2004, 2005–2009 and 2010–2014). We included individuals aged 31–90 years, and those over 90 years had to be excluded due to small numbers of persons with (very) good health.

Overall, 56,218 respondents (26,967 men/29,251 women) were observed 360,650 (172,712 men/187,938 women) times between 1995 and 2014, corresponding to an average participation in 6 waves for both women and men. The weighted sample characteristics, separated by gender and time period, are presented in Table 1. The proportion of missing values varied between 0 and 2.6%. Respondents with missing information on the variables used for analysis were excluded (Table 1).

Measures

Our outcome variable self-rated health status (SRH) was measured by asking the participants to assess their health with the following question: 'In general, how would you rate your current health status?'. The five original response categories 'very good,' 'good,' 'satisfactory,' 'poor' and 'bad' were transformed into a binary variable by classifying response categories of 'very good' and 'good' into one category which indicates good SRH.

Changes in SRH were assessed with a continuous trend variable, coded 0 for 1995 and 1 for 2014, with the years in between getting fractional values, for example 1996 = 0.05, 1997 = 0.11 and so forth [formula: $(\text{year} - 1995) / (2014 - 1995)$]. This variable reflects the average change for the whole investigation period. In addition, we used a categorical time variable with four categories

Table 1 Weighted sample characteristics in %, Germany, 1995–2014

	Men					Women				
	Time points					Time points				
	1	2	3	4	Total	1	2	3	4	Total
Age groups in years										
31–40	27.0	23.8	19.3	17.1	21.8	22.2	22.0	19.6	17.7	20.4
41–50	22.6	23.3	25.2	23.5	23.7	19.5	21.1	23.4	22.8	21.7
51–60	22.4	19.6	20.1	20.9	20.7	19.3	17.5	19.1	21.5	19.3
61–70	16.7	19.3	19.4	18.2	18.4	17.4	18.9	18.2	16.6	17.8
71–80	8.4	11.3	12.4	15.6	12.0	14.5	14.9	13.3	15.4	14.5
81–90	2.8	2.6	3.6	4.7	3.4	7.1	5.7	6.5	6.0	6.3
Missing (<i>n</i>)	0	0	0	0	0	0	0	0	0	0
Equivalence income										
< 60%	8.5	9.9	11.7	12.4	10.6	13.9	14.3	15.6	15.8	14.9
60 to < 150%	70.8	70.3	67.0	65.1	68.3	69.8	69.5	66.9	65.9	68.0
≥ 150%	20.8	19.8	21.3	22.4	21.1	16.3	16.1	17.5	18.3	17.1
Missing (<i>n</i>)	8	10	13	17	48	42	14	18	7	81
School education										
Primary/no education	50.7	47.0	43.1	38.0	44.6	56.9	49.0	43.4	37.0	46.5
Secondary	22.8	23.1	24.9	25.9	24.2	26.0	28.5	30.3	31.3	29.0
Tertiary	20.2	22.2	23.9	26.5	23.2	12.7	15.5	18.4	21.8	17.1
Other qualification	6.2	7.7	8.1	9.6	7.9	4.4	7.0	8.0	9.9	7.3
Missing (<i>n</i>)	663	1052	1077	775	3567	792	1464	1306	1056	4618
Living with a partner										
Yes	81.0	78.1	75.8	73.5	77.0	63.3	66.0	65.2	64.4	64.8
No	19.0	21.9	24.2	26.5	23.0	36.7	34.0	34.8	35.6	35.2
Missing (<i>n</i>)	302	6	4	139	451	269	2	7	83	361
Self-rated health										
(Very) good	44.1	44.8	41.5	43.5	43.5	36.2	39.2	38.4	40.5	38.6
Fair to poor	55.9	55.2	58.5	56.5	56.5	63.8	60.8	61.6	59.5	61.4
Missing (<i>n</i>)	124	86	168	58	436	184	121	198	83	586

1 = 1995–1999 (men = 41,356, women = 46,343), 2 = 2000–2004 (men = 43,778, women = 47,130), 3 = 2005–2009 (men = 44,039, women = 47,231), 4 = 2010–2014 (men = 43,539, women = 47,234), total (men = 172,712, women = 187,938), *n* = number of observations

(1995–99, 2000–04, 2005–09 and 2010–14) since the time trend was not consistently linear for all ages.

Statistical analyses

Analyses of repeated measures data, as in our study, need to accommodate the statistical dependence among the repeated observations within subjects ('autocorrelation'). GEE (Generalized Estimation Equation) as an extension of standard regression estimation procedures addresses the problem of autocorrelation by robust estimation of the variances of the regression coefficients (Liang and Zeger 1986). We used GEE for estimating population-averaged effects since our aim was to analyze temporal change in the population and not between subjects that would be more accurately estimated by random-effect models (Hu et al.

1998). We calculated different working correlation matrices and finally used the autoregressive correlation matrix (AR1) as this structure represents panel data most adequately. For calculating this matrix, information on at least two time points for each respondent was required. For this reason, individuals only participating in one wave were dropped. Since our outcome 'good SRH' was dichotomous, we calculated logistic GEE by selecting 'binomial' distribution and 'logit' link function using the Huber–White–Sandwich estimator.

Based on this specification, we estimated odds ratios of the chance of reporting good SRH over time by using two different time variables (i.e., a categorical and a continuous trend variable) as the independent variables (Table 2).

Gender differences in SRH were analyzed by estimating the chance of (very) good SRH in women as compared to

Table 2 GEE logistic regression: effect of time on the chance of (very) good SRH in men and women by age groups, Germany, 1995–2014

31–40 years		41–50 years		51–60 years		61–70 years		71–80 years		81–90 years		Overall (31–90 years)	
(n = 33,550)		(n = 37,219)		(n = 29,956)		(n = 26,120)		(n = 15,164)		(n = 3595)		(n = 140,684)	
OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Men													
Model 1: Time (cat.)													
1995–1999	1	1	1	1	1	1	1	1	1	1	1	1	1
2000–2004	1.08*	1.00–1.17	1.07	0.99–1.16	1.11*	1.02–1.21	1.21***	1.10–1.34	0.90	0.76–1.07	0.81	0.54–1.14	1.10***
2005–2009	1.12*	1.02–1.23	1.01	0.92–1.10	0.98	0.89–1.08	1.30***	1.16–1.46	0.93	0.77–1.13	0.76	0.51–1.13	1.06**
2010–2014	1.05	0.96–1.16	1.15**	1.04–1.26	1.08	0.97–1.19	1.42***	1.26–1.60	1.18	0.97–1.43	0.91	0.61–1.36	1.16***
Model 2: Time (cont.)													
1.07	0.95–1.20	1.19**	1.06–1.33	1.09	0.96–1.23	1.64***	1.41–1.91	1.60***	1.27–2.01	1.03	0.64–1.67	1.21***	1.15–1.28
31–40 years		41–50 years		51–60 years		61–70 years		71–80 years		81–90 years		Overall (31–90 years)	
(n = 39,775)		(n = 41,999)		(n = 31,583)		(n = 26,898)		(n = 17,745)		(n = 5976)		(n = 159,246)	
OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Women													
Model 1: Time (cat.)													
1995–1999	1	1	1	1	1	1	1	1	1	1	1	1	1
2000–2004	1.13**	1.05–1.21	1.18***	1.10–1.28	1.32***	1.21–1.44	1.17**	1.05–1.31	0.95	0.82–1.11	0.92	0.68–1.25	1.17***
2005–2009	1.12**	1.03–1.23	1.25***	1.15–1.37	1.35***	1.22–1.49	1.43***	1.27–1.61	1.05	0.89–1.25	0.95	0.69–1.32	1.22***
2010–2014	1.05	0.97–1.15	1.29***	1.18–1.41	1.43***	1.29–1.58	1.63***	1.44–1.85	1.40***	1.18–1.66	1.16	0.83–1.61	1.29***
Model 2: Time (cont.)													
1.02	0.92–1.12	1.31***	1.18–1.46	1.42***	1.26–1.60	1.98***	1.70–2.30	1.78***	1.43–2.20	1.18	0.77–1.82	1.32***	1.25–1.39

Adjusted for age, *GEE* Generalized Estimation Equation, *SRH* self-rated health, *n* number of observations, the continuous time variable 'Trend (cont.)' is coded 0 for 1995 and 1 for 2014. Reference group in model 1: 1995–1999 and in model 2: 1995. *OR* odds ratio, *95% CI* 95% confidence interval

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

men, calculating separate models for each time period. In order to investigate whether gender inequality in SRH changed between 1995 and 2014, gender was tested for interaction with time. We displayed the interaction of women by time periods in relation to the development in men, using the interaction among men as reference category (Table 3).

All analyses were controlled for age, taking possible shifts in age composition within the 10-year age intervals into account. In addition to odds ratios (OR), we reported predictive margins (predicted probabilities) (Fig. 1) and conditional marginal effects at the means (MEMs), making the results more intuitive and easier to interpret (Supplementary Table 1).

According to Fries (1980), compression of morbidity occurs if the onset of disability is postponed toward the end of life. In order to test this hypothesis, we calculated changes in healthy life expectancies by applying the method introduced by Sullivan (1971). The data on further life expectancies were derived from period life tables of the Federal Statistical Office (Destatis 2017). Different from the 5-year intervals of our time variable, the life tables cover 3 years as standard. Hence, we selected life tables from the last 3 years of each 5-year interval for calculating healthy life expectancies (1997–99, 2002–04, 2007–09 and 2012–14).

We calculated further ‘healthy life expectancy’ by applying the age- and gender-specific prevalence of (very) good health to further life expectancy. This indicator can be interpreted as the number of remaining years, at a particular age, which an individual can expect to live in good SRH. Furthermore, we determined the health ratio as the proportion of remaining life expected to be spent in good health to the total remaining life time (Jagger et al. 2007). In our study, relative compression of morbidity could be confirmed when this ratio increased over time. For meeting the condition for absolute compression, in addition, also the total number of life years expected to live in poor SRH needed to decrease (Kreft and Doblhammer 2016). Therefore, we additionally calculated expected ‘life expectancy in poor health’ as the number of remaining years with less than good SRH (fair, poor and very poor). Microsoft Excel version 2010 was used for life table analysis, and GEE analyses were performed using STATA 11.1.

Results

Changes in good SRH over time across ages

GEE analyses revealed a significant overall improvement in chances of good SRH in men (ORTrend = 1.21) and

women (ORTrend = 1.32) (Table 2), corresponding to a rise in predicted probabilities of good health of 4.8%-points in men and of 6.7%-points in women (Supplementary Table S1). Compared to the continuous trend variable (Trend_cont), the effects of the categorical time variable were somewhat smaller, with predicted probabilities of good SRH rising in men from 44.0% (1995–99) to 47.6% (2010–14) and in women from 38.3 to 44.5% (Supplementary Table S1).

In both genders, changes in the predicted probability of good SRH were most pronounced for the age group 61–70 years with an average increase of 11.0%-points in men and 14.3%-points in women (ORTrend men = 1.64, women = 1.98) (Fig. 1 and Supplementary Table S1). Significant changes over time were also observed for the age group 71–80 (ORTrend men = 1.60, women = 1.78) and less pronounced for those aging between 41 and 50 years (ORTrend men = 1.19, women = 1.31). In women only, a significant rise in the predicted probability of good SRH could be found for the age group 51–60 years, indicating an average increase by 8.2%-points over time. By contrast, the youngest (31–40 years) as well as the oldest age group (81–90 years) showed no significant change over time in both genders. As the odds ratios of the categorical time variable indicate, the chance of reporting good SRH between 41 and 60 years of age increased more steadily in women than in men.

Changes of gender inequalities in good SRH

At baseline (1995–99), women as compared to men showed significant lower odds of good SRH in all age groups (OR = 0.61 to 0.85) (Table 3). The most obvious gender difference at that time was found in the age group 51–60 years, where the predicted probability of good SRH was 39.5% in men but only 31.7% in women (Supplementary Table S1). At the end of observation, gender differences decreased, but remained largely significant (OR = 0.72 to 0.94). The only exception was the age group 51–60 years, where differences between men and women were initially largest but failed to reach statistical significance in 2010–14 (OR = 0.94). As illustrated in Fig. 1 and Supplementary Table S1, predicted probabilities of good SRH increased in this age group by 8.2%-point in women, while only slightly rising by 2.0%-point in men, indicating a more favorable development in women as compared to men. Accordingly, a significant interaction effect between time and gender on good SRH could be established in this age group (Table 3, model 2). For the 41–50 years age group, a significant interaction could be determined in 2005–09 (OR = 1.24), where women’s predicted probability of good SRH increased by 5.7%-point, while in men

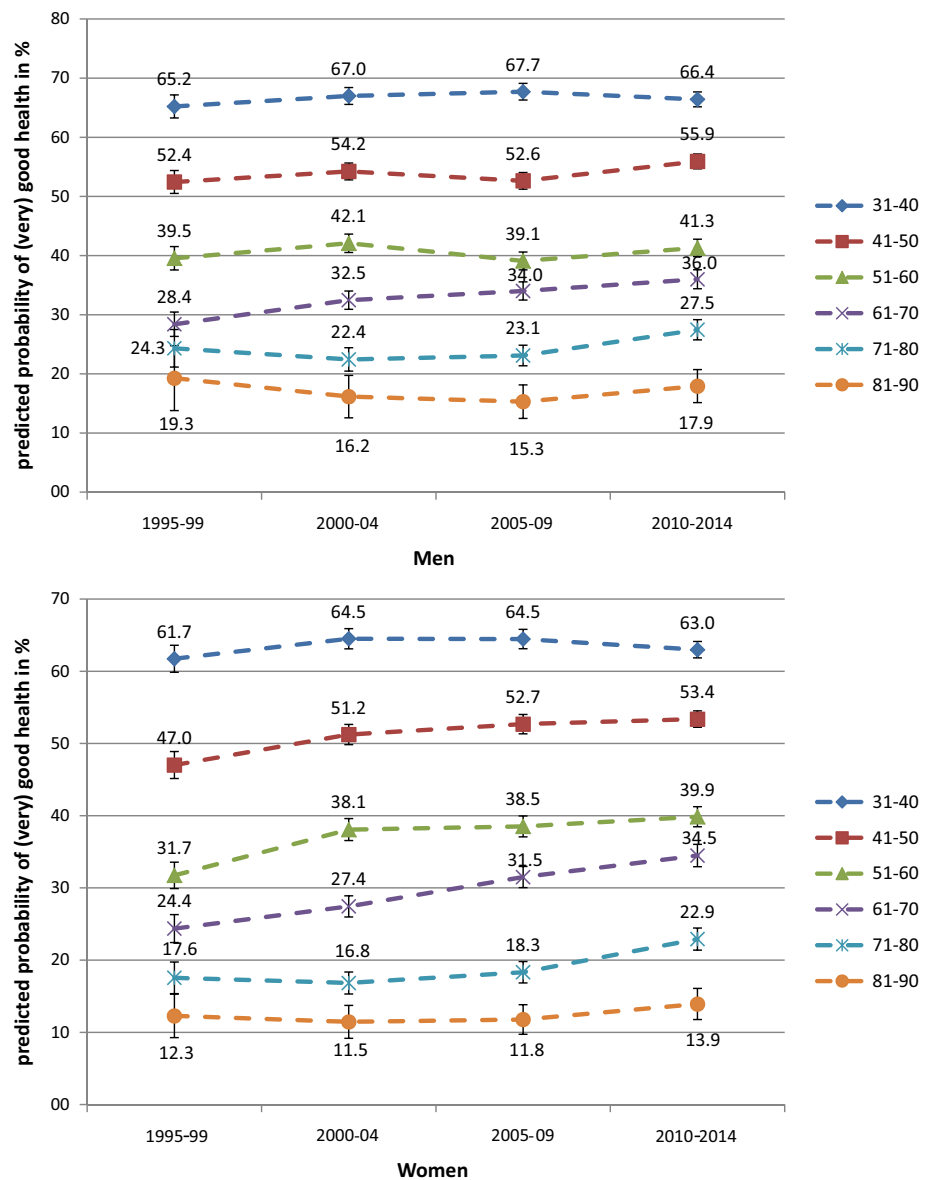
Table 3 GEE logistic regression: chance of (very) good SRH in women as compared to men by time period and age groups, Germany, 1995–2014

	31–40 years (<i>n</i> = 73,325)		41–50 years (<i>n</i> = 79,218)		51–60 years (<i>n</i> = 61,539)		61–70 years (<i>n</i> = 53,018)		71–80 years (<i>n</i> = 32,909)		81–90 years (<i>n</i> = 9571)		Overall (31–90 years) (<i>n</i> = 299,930)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Models 1a–d														
(a) 1995–1999	0.83***	0.75–0.92	0.79***	0.70–0.88	0.70***	0.61–0.80	0.85*	0.72–1.00	0.72**	0.56–0.92	0.61*	0.38–0.99	0.80***	0.75–0.85
(b) 2000–2004	0.92	0.84–1.01	0.89**	0.82–0.97	0.85***	0.77–0.94	0.80***	0.93–0.96	0.72***	0.61–0.85	0.62*	0.43–0.89	0.85***	0.82–0.90
(c) 2005–2009	0.88**	0.79–0.97	0.99	0.90–1.08	0.97	0.88–1.07	0.89*	0.80–1.00	0.71***	0.61–0.84	0.80	0.56–1.12	0.91***	0.86–0.95
(d) 2010–2014	0.85***	0.79–0.92	0.90**	0.83–0.97	0.94	0.86–1.03	0.90*	0.80–1.00	0.79***	0.70–0.90	0.72*	0.54–0.95	0.88***	0.85–0.92
Model 2														
1995–1999 * women	1		1		1		1		1		1		1	
2000–2004 * women	1.04	0.94–1.16	1.10	0.98–1.23	1.18*	1.05–1.34	0.96	0.83–1.11	1.05	0.84–1.32	1.14	0.69–1.88	1.05	0.99–1.11
2005–2009 * women	1.01	0.89–1.15	1.24*	1.09–1.40	1.36***	1.19–1.57	1.06	0.90–1.25	1.12	0.87–1.45	1.26	0.75–2.11	1.13***	1.06–1.21
2010–2014 * women	1.00	0.89–1.14	1.12	0.99–1.27	1.32***	1.14–1.52	1.11	0.94–1.32	1.17	0.90–1.50	1.26	0.76–2.11	1.10**	1.03–1.18

Adjusted for age, GEE Generalized Estimation Equation, SRH self-rated health, *n* number of observations based on model 2, reference for model 1a–d: men, reference for interaction in model 2: 1995–1999 * women and each interaction for men (1995–1999 * men, 2000–2004 * men, 2005–2009 * men and 2010–2014 * men) (main effects of gender and time not displayed). OR odds ratio, 95% CI 95% confidence interval

p* ≤ 0.05; *p* ≤ 0.01; ****p* ≤ 0.001

Fig. 1 Predicted probabilities of (very) good health from 1995 to 2014 in Germany in different ages (years) by gender and period with 95% CI, adjusted for age



with a rise of 0.2%-point hardly any improvement could be found (Supplementary Table S1).

Changes in healthy and unhealthy life expectancy

Life expectancy (LE) as well as healthy life expectancy (H-LE) increased significantly over the study period (Table 4). For example, in 1997–99, a man aged 31 years could expect to live another 44.7 years of which 18.8 years are expected to live in good health. In 2012–14, LE and H-LE increased to 47.9 and 20.8 years, respectively. At baseline, a woman of that age could expect a longer further life (50.4 years) but a shorter further time in good health (17.6 years) as compared to men. In 2010–14, LE and H-LE increased in women to 52.6 and 20.6 years,

respectively. In women, the confidence intervals between the first and last time period did not overlap except for the oldest age group, indicating significant improvements in H-LE over time for these ages. Among men, a significant rise over time could be determined up to the age of 76 years. As indicated by the non-overlapping confidence intervals between women and men, in 1997–99 significantly lower levels of H-LE in younger age groups (31–46 years) could be observed in women as compared to men. At the end of observation, gender differences with respect to H-LE disappeared for all ages.

Among men, not only H-LE but also life expectancy in poor SRH (P-LE) increased over time for all ages. By contrast, in women, P-LE decreased slightly between the ages 31 and 56 years, but marginally increased from 61 years on (Supplementary Table S2).

Table 4 Calculation of life expectancy in (very) good health by the Sullivan method, Germany, 1995–2014

Age	1997–99				2002–04				2007–09				2012–14			
	LE	H-LE	95% CI		LE	H-LE	95% CI		LE	H-LE	95% CI		LE	H-LE	95% CI	
			Lower	Upper			Lower	Upper			Lower	Upper			Lower	Upper
Men																
31	44.7	18.8	18.5	19.0	46.0	19.7	19.5	19.9	47.2	19.1	18.9	19.4	47.9	20.8	20.6	21.0
36	39.9	15.5	15.2	15.8	41.2	16.3	16.1	16.5	42.4	15.8	15.6	16.0	43.1	17.6	17.4	17.7
41	35.3	12.5	12.2	12.7	36.4	13.3	13.1	13.5	37.6	12.9	12.7	13.0	38.3	14.4	14.2	14.6
46	30.7	9.8	9.6	10.0	31.8	10.6	10.4	10.8	33.0	10.3	10.2	10.5	33.6	11.7	11.5	11.8
51	26.4	7.6	7.3	7.8	27.5	8.4	8.2	8.6	28.5	8.2	8.0	8.4	29.0	9.3	9.2	9.5
56	22.2	5.7	5.5	5.9	23.3	6.5	6.3	6.6	24.3	6.6	6.4	6.7	24.8	7.4	7.3	7.6
61	18.2	4.3	4.1	4.5	19.3	4.8	4.7	5.0	20.3	5.1	4.9	5.2	20.7	6.0	5.9	6.2
66	14.7	3.2	3.0	3.4	15.5	3.5	3.4	3.7	16.5	3.7	3.6	3.8	17.0	4.6	4.5	4.7
71	11.5	2.4	2.2	2.6	12.2	2.3	2.2	2.5	13.0	2.5	2.3	2.6	13.4	3.2	3.0	3.3
76	8.8	1.6	1.4	1.8	9.3	1.6	1.4	1.7	9.8	1.5	1.3	1.6	10.1	2.0	1.9	2.1
81	6.5	1.2	1.0	1.5	6.8	1.0	0.8	1.1	7.2	1.0	0.8	1.1	7.3	1.2	1.1	1.3
86	4.8	0.9	0.6	1.1	4.8	0.6	0.5	0.8	5.1	0.7	0.5	0.9	5.0	0.8	0.6	0.9
Women																
31	50.4	17.6	17.3	17.9	51.2	19.1	18.9	19.3	52.1	19.0	18.8	19.2	52.6	20.6	20.4	20.8
36	45.5	14.4	14.1	14.7	46.3	15.7	15.6	15.9	47.2	15.9	15.7	16.1	47.7	17.3	17.1	17.5
41	40.7	11.6	11.3	11.8	41.5	12.9	12.7	13.1	42.3	12.9	12.7	13.1	42.8	14.3	14.2	14.5
46	35.9	9.2	9.0	9.5	36.7	10.4	10.2	10.6	37.6	10.4	10.2	10.6	38.0	11.7	11.6	11.9
51	31.3	7.1	6.9	7.4	32.1	8.2	8.0	8.4	32.9	8.4	8.2	8.5	33.3	9.5	9.3	9.6
56	26.8	5.5	5.3	5.7	27.6	6.3	6.1	6.5	28.4	6.6	6.4	6.7	28.7	7.6	7.4	7.7
61	22.4	4.2	4.0	4.4	23.2	4.7	4.5	4.8	23.9	5.1	4.9	5.2	24.3	6.0	5.9	6.2
66	18.2	3.1	2.9	3.3	18.9	3.3	3.2	3.4	19.7	3.5	3.4	3.6	20.1	4.5	4.3	4.6
71	14.3	2.2	2.1	2.4	14.9	2.1	2.0	2.2	15.5	2.3	2.2	2.4	16.0	3.1	2.9	3.2
76	10.8	1.5	1.3	1.7	11.2	1.3	1.2	1.5	11.7	1.5	1.4	1.6	12.1	2.0	1.9	2.2
81	7.8	1.0	0.8	1.1	8.1	0.8	0.7	0.9	8.4	0.9	0.8	1.1	8.6	1.3	1.2	1.5
86	5.4	0.6	0.4	0.8	5.5	0.5	0.4	0.6	5.8	0.6	0.5	0.7	5.9	0.8	0.7	1.0

Data on SRH refer to 5-year interval (1995–99, 2000–04, 2005–09 and 2010–14) while information on life table is based on 3-year interval (1997–99, 2002–05, 2007–09 and 2012–14)

LE total life expectancy, H-LE healthy life expectancy (categories: very good and good SRH), 95% CI 95% confidence interval of H-LE

As displayed in Table 5, the proportion of life spent in good health ('health ratio') increased over time, indicating a higher increase in healthy compared to unhealthy life expectancy. For example, in 1997–99 a woman aged 31 years could expect to live 34.9% of her remaining lifetime in good health, and in 2012–14, this proportion increased to 39.1%. In men of the same age, the health ratio increased from 41.6 to 43.5% over time. Confidence intervals between the first and last time period do not overlap up to age of 71 years in men and 81 years in women, indicating significant changes in the health ratio over time until these ages. At baseline, women spend less time of their remaining life in good health in all age groups as compared to men. Different to healthy life expectancy,

gender differences in the health ratio up to the age of 76 years remained significant over time.

Discussion

The aim of this study was to add empirical evidence regarding the question whether compression or expansion of morbidity occurred over the last decades in Germany. For this purpose, we analyzed changes in the proportions of good SRH in men and women between 1995 and 2014 following an age-specific approach.

Table 5 Proportion of remaining life spent in (very) good health by gender and time period, Germany, 1995–2014

Age	1995(7)–99			2000(2)–04			2005(7)–09			2010(2)–14		
	H-ratio	95% CI		H-ratio	95% CI		H-ratio	95% CI		H-ratio	95% CI	
		Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
Men												
31	41.6	41.3	41.9	42.9	42.4	43.3	40.5	40.1	41.0	43.5	43.1	43.9
36	38.8	38.5	39.1	39.7	39.2	40.1	37.3	36.8	37.7	40.8	40.3	41.2
41	35.4	35.2	35.7	36.6	36.1	37.1	34.1	33.7	34.6	37.6	37.1	38.0
46	31.9	31.6	32.1	33.2	32.7	33.8	31.4	30.8	31.9	34.8	34.3	35.3
51	28.7	28.5	29.0	30.6	30.0	31.2	28.7	28.2	29.3	32.0	31.5	32.6
56	25.7	25.5	25.9	27.9	27.2	28.5	27.1	26.5	27.7	29.9	29.3	30.5
61	23.4	23.2	23.6	24.9	24.2	25.7	25.1	24.3	25.8	29.0	28.4	29.7
66	21.7	21.5	21.9	22.7	21.8	23.7	22.4	21.6	23.3	27.1	26.4	27.9
71	20.6	20.4	20.8	19.1	17.9	20.2	18.9	17.9	20.0	23.5	22.6	24.5
76	18.1	17.9	18.3	16.7	15.2	18.3	15.0	13.6	16.3	19.5	18.3	20.7
81	18.8	18.6	19.1	14.3	11.9	16.6	13.4	11.4	15.3	16.5	14.8	18.2
86	18.0	17.7	18.3	13.1	9.3	17.0	13.3	10.0	16.6	15.5	12.7	18.4
Women												
31	34.9	34.4	35.5	37.3	36.9	37.7	36.4	36.02	36.85	39.1	38.7	39.5
36	31.7	31.1	32.3	34.0	33.6	34.4	33.6	33.17	34.02	36.3	35.9	36.7
41	28.5	27.8	29.1	31.0	30.5	31.4	30.4	29.92	30.83	33.5	33.1	34.0
46	25.6	25.0	26.3	28.4	27.9	28.8	27.7	27.23	28.20	30.9	30.4	31.3
51	22.7	22.0	23.5	25.6	25.0	26.1	25.4	24.89	25.94	28.4	27.9	28.9
56	20.6	19.8	21.4	22.8	22.3	23.4	23.2	22.66	23.80	26.4	25.8	26.9
61	18.9	18.0	19.8	20.1	19.4	20.7	21.1	20.45	21.71	24.8	24.1	25.4
66	16.8	15.8	17.8	17.5	16.8	18.2	17.8	17.09	18.48	22.2	21.5	22.9
71	15.5	14.3	16.7	14.2	13.3	15.0	14.7	13.92	15.56	19.2	18.4	20.0
76	13.9	12.3	15.4	11.9	10.9	12.9	12.9	11.87	13.89	16.9	15.9	18.0
81	12.5	10.4	14.5	10.2	8.9	11.6	11.2	9.84	12.51	15.4	14.0	16.8
86	10.9	7.9	13.9	9.2	7.2	11.3	10.3	8.21	12.40	14.1	12.0	16.2

Data on SRH refer to 5-year interval (1995–99, 2000–04, 2005–09 and 2010–14) while information on life table is based on 3-year interval (1997–99, 2002–05, 2007–09 and 2012–14)

H-ratio proportion of life spent in (very) good health ('health ratio'), *95% CI* 95% confidence interval of H-ratio

Changes in good SRH over time across ages

In women, prevalence of good SRH increased significantly for all ages between 41–50 and 71–80 years while improvements among men were most apparent for the ages 61–70 and 71–80 years. Both women and men showed the largest increase in good SRH at ages just before and after official retirement age, which in Germany is currently reached at the age of 65 year. By contrast, no improvement in SRH could be found among men at older working age (51–60 years). This finding is consistent with a previous German study conducted by Wolff et al. (2017) who found—however, for both genders—functional health between 2008 and 2014 is increasing only for ages above 65 years while decreasing in younger individuals. A recent study by Clause-Verdreau et al. (2019) revealed similar

results for France, indicating that health-related quality of life between 1995 and 2016 substantially decreased among men aged 45–54 years, while improved for both genders in the age group 65–84 years. The unfavorable development of health among men at older working age is of importance in view of national government policy, aiming to increase the number of older adults in work and to extend working life. Germany as many other countries has responded to increasing life expectancy by raising the retirement age to improve the fiscal stability. However, if 'healthy working life expectancy,' which defines the number of years lived between the ages of 50 and 70 years both in good health and employment (Lievre et al. 2007), does not increase linearly with overall life expectancy, longer working life would be difficult to realize. Evidence suggests that working conditions in Germany became harder in the last

decades due to increasing mental and physical stress on employees which may account for the poorer development in SRH in male senior workers (Franke and Wetzel 2017). Our findings indicate that particularly men who are close to retirement age constitute an important target group for health promotion that aims at enhancing well-being and may also positively affect healthy working life expectancy.

In addition, for both genders, no health improvement could be established for the youngest age group (31–40 years). This finding is consistent with results from a Swedish study by Johansson et al. (2015) who found SRH improving in individuals aged 48 years and above but becoming poorer or remaining unchanged in those aged 16–47 years. The authors discuss several possible reasons for the worsening trend in younger age groups such as lower rise in economic prosperity among younger ages, increasing BMI, mental health complaints and stress. Further research is needed to analyze whether these influencing factors may also act as barriers for health improvement among younger cohorts in Germany.

Furthermore, contrary to the overall positive trend, we found no significant health improvement in the group of the eldest (81–90 years). This finding may suggest that from a certain age onward, proportions of good SRH approached a maximum that cannot be further enhanced. Therefore, the primary goal at older ages would be rather to reduce the share of worse than to expand that of good SRH. However, Lowsky et al. (2014) examining heterogeneity in healthy aging of older Americans found that 28% of those aged 85 years and above reported excellent or very good SRH. This finding suggests that improving good SRH might be a realistic objective for health promotion even for the older population. The absence of health improvement at that age in our study points to the relevance of health promotion targeting the elderly who have long been neglected as an addressee of health promotion activities. Strengthening health promotion activities such as maintaining and increasing functional capacity, self-care and social participation (Golinowska et al. 2016) may contribute to higher proportions of good SRH for future cohorts of the elderly.

Changes of gender inequalities in prevalence of good SRH

At baseline, we found lower proportions of good SRH in women at all ages, which correspond to previous research, documenting higher numbers of women with functional limitations and disabilities as compared to men (Read and Gorman 2010; Rohlfen and Kronenfeld 2014). Focusing on changes in gender inequalities over time, some studies found no evidence for a narrowing of gender inequalities in health (Galenkamp et al. 2013; Johansson et al. 2015) while other studies pointed to convergence of gender

disparities. For example, Cummings and Jackson (2008) found women's health status steadily improving over a 30-year period, while the trend in men was less pronounced. Pointing in the same direction, Pöld et al. (2016) reported that until 2002, good SRH was slightly more prevalent among men, but thereafter among women. Also Volken et al. (2017) concluded that gender inequalities in SRH have declined over time. In line with these studies, we found stronger improvements in the proportions of good SRH among women as compared to men. According to the differential exposure explanation, gender inequalities in health may result from a stratification system that differentially assigns opportunities to men and women (Denton et al. 2004). Women are more likely than men to have lower levels of education, employment and income, which affect their access to health-promoting resources. During the last decades, the proportion of women in higher education and in paid employment increased in Germany as in other western countries. These improvements might explain the observed health trend toward a narrowing of the gender gap. Supporting this presumption, Hill and Needham (2006) found that the increase in women's health status is largely explained by gains in educational attainment. They conclude that women have benefited more than men in terms of SRH from educational expansion over the past decades. As Aguilar-Palacio et al. (2018) pointed out the increasing presence of women in the labor force might also have contributed to reduce the gender gap in SRH. The authors found that health trends during the economic recession in 2007 differed by gender, with only women slightly improving their SRH. They concluded that promoting women's labor market inclusion might be important, even in economic recession periods. Interestingly, we similarly found significant interaction effects between health trend and gender during the time of economic recession in Germany (2005–09), indicating a sharper decline in proportions of good SRH in men as compared to women. However, further investigations on gender-specific health trends are required in order to place the results in context.

Changes in healthy and unhealthy life expectancy

Based on health expectancy estimates obtained by Sullivan's method, we found life expectancy as well as healthy life expectancy improving over time for both genders and all ages. Not only the numbers of years in good SRH but also the health ratio increased, giving evidence for relative compression of morbidity. However, among men the absolute number of further years expected to live in less than good health increased, too, which argues against absolute compression of morbidity. Among women, the

absolute number of further years expected to live in less than good health slightly increased from the age of 61 years onward, while it decreased up to the age of 60 years, pointing to absolute compression of morbidity until that age (Howse 2006). Overall, it can be stated that at least relative compression of morbidity was observed in both genders. Hence, our findings add evidence for a positive scenario of health improvement in Germany with respect to proportions of (very) good SRH.

Time trends in the light of period and cohort effects

In this study, the temporal change in SRH was discussed as a period effect assuming that the trend can be attributed to sociodemographic changes occurring between 1995 and 2014. We adopted an age-specific approach as it seemed plausible that social change did not have the same health consequences for all ages. However, the observed trend in SRH could also be interpreted as a cohort effect representing the sum of all unique exposures experienced by the different age cohorts from birth (Keyes et al. 2010). This perspective may add to the understanding of health trends by taking into account the sociohistorical and cultural context in which the individual life course unfolds (Kuh et al. 2004). However, in situations where sociodemographic factors gradually changed over a long period of time, it becomes increasingly difficult to separate the effects of past (cohort effects) and contemporary influences (period effects). In this context, Hobcraft et al. (1982) pointed out that ‘period’ and ‘cohort’ effects are just proxies for current and past influences and recommended to use the underlying variables for which they stand for. Detecting these underlying social and behavioral factors and their interactions might pose future challenges for social-epidemiological research.

Limitations

Finally, some important limitations of this study need to be addressed. Since effects are harder to detect in smaller samples, it could be possible that in the oldest age group (81–90 years), deviation from the null hypothesis was not confirmed although such a deviation may exist. Furthermore, the observed gender inequalities at higher ages in favor of the men should be discussed in light of selection bias. In addition, it may be that the time trend in healthy life expectancy is biased by the exclusion of the institutionalized population and persons who could not participate in the survey for health reasons. Hence, we cannot fully rule out that healthy life expectancy is overestimated in our study. However, there is no reason to assume that the proportion of institutionalized population increased over

time. Therefore, the time trend in healthy life expectancy is presumably unbiased by the exclusion of the institutionalized population. In addition, a shift in the perception of health may also have contributed to changes in proportions of good SRH over time. However, since the direction of possible shift in perception is not clear, improvements in good SRH could also be greater than we found in our data. Moreover, the predictive validity of SRH may differ according to gender. For instance, it has been found that poor SRH is a more powerful predictor of short-time mortality for men as compared to women (Assari 2016). One reason for this could be the different meaning of ‘good’ and ‘poor’ SRH for men and women which may have contributed to the gender differences found in our study.

Conclusion

Compression of morbidity in terms of SRH could be found for both genders. However, improvements were more pronounced in women, leading to a narrowing of the gender gap in SRH. The strongest increase in SRH was found in men and women at retirement age (61–80 years). By contrast, male senior workers at age 51–60 years and the youngest (31–35 years) and oldest age group (81–90 years) of both genders could benefit less from the overall positive health trend, calling for health promotion interventions meeting the diverse needs in different life stages.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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