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Dörte Heger and Ingo W.K. Kolodziej[1]

Changes in Morbidity over Time – Evidence from Europe

Abstract

The elderly are the main beneficiaries of recent gains in life expectancy in the EU. Whether the additional life time is spent in good or in poor health will drastically influence the development of health care costs as morbidity status rather than age per se determines an individual's need for health care services. However, empirical evidence on whether the prolonged lifespan is associated with a compression or an extension of morbidity is still sparse and inconclusive. In this paper, we analyse disability levels in the population 50+ in Europe by age and by proximity to death over time using longitudinal data from the Survey of Health, Ageing, and Retirement in Europe (SHARE).We find that disability levels in Europe have increased due to population ageing and an increase in the prevalence of diseases. The disabling effect of health conditions remained constant over time.

JEL Classification: I10, J11, J14

Keywords: Ageing; compression of morbidity; Blinder-Oaxaca decomposition

September 2016

1 Dörte Heger, RWI; Ingo W.K. Kolodziej, RUB and RWI. – *The authors gratefully acknowledge financial support from the European Investment Bank under the EIB-Universities Research Action Programme. Any errors remain those of the authors. The findings, interpretations and conclusions presented in this article are entirely those of the authors and should not be attributed in any manner to the European Investment Bank.**– All correspondence to: Ingo W.K. Kolodziej, RWI, Hohenzollernstr. 1-3, 45128 Essen, Germany, e-mail: ingo.kolodziej@rwi-essen.de*

1 Introduction

Life expectancy in Europe is increasing with most of the increase occurring at older ages. In times of tight government budgets, the pressing question is how much this development will lead to an increase in health care costs. Since morbidity rather than age per se determines an individual's need for health care services, the answer to this question heavily depends on whether the increase in life expectancy comes with a delayed onset of diseases.

Several theories concerning ageing over time and the associated trends in morbidity have been proposed. Gruenberg (1977) argues that, due to limited prevention of illness and the resulting increase in prevalence of non-fatal but non-curable diseases, the increase in life expectancy is the result of an increase in unhealthy years. Olshansky et al. (1991) points to two processes that are driving this extension of morbidity. For one, medical progress improves the survival probability of individuals with disabilities; for another the declining mortality from fatal diseases leads to higher rates of disability caused by nonfatal diseases. Contrary, Fries (1980) argues that morbidity is compressed into a shorter period before death as a result of a change in the prevalence of chronic diseases due to changes in life style. For a biologically predetermined length of life, this results in a longer time in good health. Manton (1982), however, questions a predetermined life span or that people will change their life styles in favour of prevention of chronic diseases. Instead, he describes a "dynamic equilibrium" where the survival probability is improved but the incidence of disease remains unchanged. However, decreases in the severity of chronic diseases lead to a higher quality of life and social participation, including the ability to work. Higher health care expenditures might then be justified with greater economic productivity.

Empirical evidence on this issue remains inconclusive.[1] Studies that report evidence for a compression of morbidity include, for example, Doblhammer and Kytir (2001);

[1] See Lindgren (2016), Chatterji et al. (2015), and Rechel et al. (2013) for an overview of recent empirical work.

Manton et al. (2008); Liu et al. (2009), and most recently Chernew et al. (2015) in the U.S. for the time between 1992 and 2008. Contrary, Parker et al. (2005); Karlsson et al. (2008) and Walter et al. (2016) find an increase in morbidity for particular European countries in the nineties and early 2000s. Similarly, results by Crimmins and Beltrán-Sánchez (2010) suggest a decrease in years without disease and an increase in life expectancy with disease in the U.S. between 1998 and 2008. Again other studies find mixed results or no change in disability over time (Lafortune and Balestat, 2007; Robine et al., 2009; Jagger et al., 2009). Possible reasons for the diverging results are the different time periods and different countries analysed in the studies. For example, while earlier studies (see, e.g. Freedman et al., 2004) find evidence of a compression of morbidity in the 1980s and 1990s in the U.S., Freedman et al. (2013) find the share of elderly with disability limitations to be constant since 2000. Moreover, Robine et al. (2009) relate the time spent in good health to longevity and find that healthy life expectancy increases most in countries with a low overall life expectancy at age 65. Hence, the authors conclude that the compression of morbidity observed in some countries is rather a catching up in terms of population health than changes in disability patterns.

To shed more light on the issue, we analyse the developments in disability levels in the elderly population between 2004 and 2011 in ten European countries and relate these changes both to age and proximity to death. After presenting the raw change in disability of the elderly over time, we decompose this change into changes of demographic, clinical and socioeconomic endowments as well as in changes of the impact of these endowments on disability status to identify possible drivers of the observed change. While we find a slight increase in disability levels in Europe over time, this change can largely be explained by population ageing and an increase in the prevalence of health conditions. The disabling effect of health conditions, however, remained constant over time. Thus, our results indicate a slight extension of morbidity for the population 50 plus in Europe in recent years.

Our paper contributes to the literature in several ways. First, it extends the previous evidence on changes in population health by providing evidence on very recent patterns of the development of population health for a large sample of European countries. Second, while several large scale studies use administrative data, we complement their findings using survey data, which has the benefit of providing detailed information on morbidity, disability, and socioeconomic variables. Third, we use data from the Survey of Health, Ageing, and Retirement in Europe (SHARE)[2] in an innovative way by using the rich information provided in the regular interviews in waves 1 and 4 and combining it with exit interviews from following available waves to obtain information on proximity to death.

The remainder of the paper is organized as follows. Section 2 describes the data, Section 3 introduces the estimation strategy, Section 4 provides an overview of morbidity and disability patterns over time by age and proximity of death, and Section 5 presents the decomposition results. Section 6 concludes.

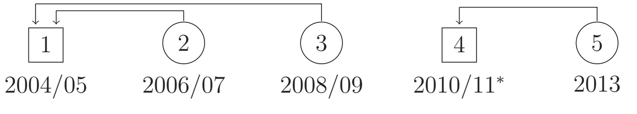
2 Data

The data used for the empirical analysis is drawn from SHARE, which provides rich information on the health, socioeconomic, and demographic situation of the population 50+ on a pan-European level. Since changes in population health probably occur slowly and hence are only observable over a long time span, the aim is to observe changes in health status at two distant points in time. For the comparison of disability and

[2]This paper uses data from SHARE Wave 5 release 1.0.0, as of March 31st 2015 (DOI: 10.6103/SHARE.w5.100) or SHARE Wave 4 release 1.1.1, as of March 28th 2013 (DOI: 10.6103/SHARE.w4.111) or SHARE Waves 1 and 2 release 2.6.0, as of November 29th 2013 (DOI: 10.6103/SHARE.w1.260 and 10.6103/SHARE.w2.260) or SHARELIFE release 1.0.0, as of November 24th 2010 (DOI: 10.6103/SHARE.w3.100). The SHARE data collection has been primarily funded by the European Commission through the 5th Framework Programme (project QLK6-CT-2001-00360 in the thematic programme Quality of Life), through the 6th Framework Programme (projects SHARE-I3, RII-CT-2006-062193, COMPARE, CIT5- CT-2005-028857, and SHARELIFE, CIT4-CT-2006-028812) and through the 7th Framework Programme (SHARE-PREP, N° 211909, SHARE-LEAP, N° 227822 and SHARE M4, N° 261982). Additional funding from the U.S. National Institute on Aging (U01 AG09740-13S2, P01 AG005842, P01 AG08291, P30 AG12815, R21 AG025169, Y1-AG-4553-01, IAG BSR06-11 and OGHA 04-064) and the German Ministry of Education and Research as well as from various national sources is gratefully acknowledged (see www.share-project.org for a full list of funding institutions).

morbidity over time, we thus use data from waves 1 and 4 collected in 2004/05 and 2010/11, respectively. We use wave 4 data, rather than the latest currently available data from wave 5, since we want to link the available information on health status with information on whether an individual is still alive or whether she has died within one year after the interview. Hence, we supplement our data with information from additional waves of SHARE. Specifically, we use exit interviews for individuals who have died before the next SHARE interview and regular follow-up interviews to learn about the subsequent life status of the respondents. During the exit interview, a proxy – usually a close relative – answers questions about a deceased SHARE respondent's last year of life. To obtain information on a respondent's living status one year after their interview in wave 1 or 4 we use exit and follow-up interviews from waves 2, 3, and 5 of SHARE[3], which have been collected in 2006/07, 2008/09, and 2013, respectively. The exit interviews contain information on time and cause of death, which we link to the respondents' data from previous waves to determine the proximity to death. Hence, we can observe a time span of approximately seven years (see Figure 1 for a graphical representation). Restricting our sample in this way allows us to analyse morbidity and disability status over time between individuals close to death and individuals who are still alive after one year.

Figure 1: Data waves used for comparison and information on life status



Note: Boxes denote waves used for comparison. Circles denote waves used for information on life status. *After data cleaning, only observations from 2011 remain.

We define our dependent variable, the disability status (AL) of an individual, by a composite measure that runs from 0 to 13 and summarizes the number of limitations with activities of daily living (ADL) and limitations with instrumental activities of daily living

[3]For some respondents, the wave 2 interview was conducted less than one year after the wave 1 interview. Hence, we also include information from wave 3. Wave 5 interviews have been conducted at least one year after wave 4 interviews for all respondents.

(IADL) an individual experiences. ADL limitations include having problems concerning dressing, walking across a room, bathing or showering, eating, getting out of bed, and using the toilet, while IADL limitations include having problems concerning orientation using a map, preparing a hot meal, shopping for groceries, making telephone calls, taking medications, doing work around the house or garden, and managing money. Spector and Fleishman (1998) show that adding both measures represents a meaningful measure of disability.[4] Moreover, limitations with ADL and IADL are often used to assess the need for long-term care (LTC) services and thus the eligibility for LTC payments (see, for example, Colombo et al., 2011). The measure is therefore also relevant from a policy perspective.

In addition, the existence of a wide set of health conditions is used to measure morbidity. Health conditions include, for example, high blood pressure, arthritis, diabetes, and cancer. While the information is self-reported, only conditions diagnosed by a doctor or conditions for which the respondent takes medications are considered.[5] The information on depression further uses information from the EURO-Depression scale (EURO-D). Since a score greater than three has been shown to be a good predictor for depressive disorders, we count everyone with a depression score of four or more as depressed (Prince et al., 1999b,a). Further, we observe socio-demographic variables such as age, sex, marital status, education, and wealth.[6][7]

In the analysis, we consider only individuals from countries that participated in all waves, i.e. Austria, Germany, Sweden, the Netherlands, Spain, Italy, France, Denmark, Switzerland and Belgium. After cleaning the data for age eligibility, country participation

[4] Results stay comparable if we use an indicator on whether an individual has any activity limitations.

[5] The information on health conditions is derived from the question "Has a doctor ever told you that you had ..." and "Do you currently take drugs at least once a week for ...".

[6] Education is grouped into lower (0-2), medium (3), and higher (4-6) education based on the ISCED-97 classification (OECD, 1999). Wealth is measured as household net worth and is adjusted for household size by division by the square root of the number of household members.

[7] We do not standardize the two samples by age and sex to avoid the impression that the two samples are easily comparable beyond the comparison of general population health. While the population in wave 4 is on average older, many other factors, such as e.g. the education level or the share living with a partner, have also changed and are likely to have an influence on disability and mortality. Instead, we control for these differences in our multivariate analysis and confirm in a sensitivity analysis that age standardization would not have changed our main findings.

in all waves, and missing values, our sample includes 57,690 observations. For 12,924 observations the subsequent life status is unknown due to attrition. Since missing follow-up information of, in particular, deceased individuals might bias our results, we consider three categories to describe a person's life status: alive, deceased, and life status unknown. Still, overall mortality might be underestimated as a result of a positive selection of healthier individuals into the longitudinal sample of SHARE due to the initial exclusion of institutionalized individuals (Schulz and Doblhammer, 2011). Hence, the individuals in our sample are likely to be healthier than the general population and our findings might not be generalizable. However, it seems plausible that health improvements are easier to accomplish for sicker individuals (Heger, 2016). In this case, any observed change in disability level would provide a lower bound of the true effect.

Table 1: Descriptive Statistics by Wave

	(1)		(2)	
	Wave 1		Wave 4	
	Mean	Std. Dev.	Mean	Std. Dev.
Disability				
Numb. of activity lim.***	0.611	1.798	0.700	2.007
Prox.death.				
Less than 12 months	0.010	0.098	0.010	0.102
At least 12 months	0.709	0.454	0.706	0.456
Time to death unknown	0.281	0.450	0.284	0.451
Demographics				
Age 50-59***	0.364	0.481	0.339	0.473
Age 60-69	0.306	0.461	0.303	0.459
Age 70-79	0.221	0.415	0.225	0.418
Age 80+***	0.109	0.311	0.133	0.339
Male	0.451	0.498	0.457	0.498
Married***	0.643	0.479	0.674	0.469
Lower Education***	0.344	0.475	0.264	0.441
Medium Education***	0.474	0.499	0.510	0.500
Higher Education***	0.182	0.386	0.226	0.418
Net Worth (in 100k)***	2.080	5.723	1.645	2.735
Clinical conditions				
Cancer*	0.055	0.229	0.061	0.240
Chronic Lung Disease***	0.061	0.238	0.074	0.262

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	(1) Wave 1		(2) Wave 4	
	Mean	Std. Dev.	Mean	Std. Dev.
Parkinson's Disease	0.007	0.083	0.007	0.084
Heart Attack	0.119	0.324	0.115	0.319
Stroke	0.036	0.187	0.039	0.194
Hip or Femoral Fracture***	0.018	0.133	0.028	0.164
High Blood Pressure***	0.434	0.496	0.479	0.500
High Blood Cholesterol***	0.230	0.421	0.281	0.449
Diabetes***	0.115	0.320	0.137	0.344
Asthma***	0.050	0.218	0.040	0.197
Arthritis***	0.223	0.417	0.248	0.432
Osteoporosis***	0.098	0.298	0.059	0.236
Ulcer***	0.054	0.227	0.038	0.192
Cataracts***	0.078	0.268	0.095	0.294
Pain	0.244	0.430	0.250	0.433
Sleep Problems	0.089	0.285	0.087	0.282
Anxiety or Depression***	0.296	0.457	0.320	0.467
Stomach Burns***	0.055	0.228	0.081	0.274
Other Condition***	0.273	0.445	0.292	0.455
Countries				
Austria***	0.022	0.147	0.026	0.160
Germany	0.288	0.453	0.283	0.450
Sweden	0.031	0.173	0.030	0.170
Netherlands	0.049	0.216	0.051	0.219
Spain	0.133	0.340	0.138	0.345
Italy*	0.209	0.406	0.197	0.398
France	0.194	0.395	0.198	0.398
Denmark	0.018	0.131	0.017	0.131
Switzerland***	0.022	0.148	0.025	0.155
Belgium	0.034	0.182	0.035	0.183
Observations	23,738		33,952	

Note: Summary measures using calibrated weights. ***, ** and * denote differences between wave 1 and wave 4 at the 1%, 5% and 10% significance level.

Descriptive statistics of the variables used in the analysis are shown in Table 1 for waves 1 and 4, respectively.[8][9] Throughout the analysis, observations are weighted using calibrated weights based on the procedure by Deville and Särndal (1992) to make results representative for the population 50 and older in the respective countries at the time of the interview. The average number of activity limitations slightly increased from 0.611 in

[8]Individuals who participated in waves 1 and 4 of SHARE may be included twice.
[9]Missing time constant information is imputed from other waves when available.

wave 1 to 0.700 in wave 4. Likewise, the prevalence of most clinical conditions increased over time or stayed constant. Only the prevalence of heart attacks, asthma, osteoporosis, ulcer, and sleep problems decreased, but the decrease in heart attacks and sleep problems is not significantly different from zero. While the distribution by time to death and the country composition of the sample stayed largely the same, individuals in wave 4 are more educated but own less wealth than individuals in wave 1.

3 Estimation strategy

We consider a linear model of disability, where disability is explained by demographics, i.e. age (DEM), proximity to death (PROX), socioeconomic variables (SOC), clinical conditions (CLIN), and the country of residence (COUN)[10]:

$$AL = \beta_0 + \beta_{dem} * DEM + \beta_{prox} * PROX + \beta_{soc} * SOC + \beta_{clin} * CLIN + \beta_{coun} * COUN + \epsilon. \quad (1)$$

To analyse changes over time, we follow the strategy of Cutler et al. (2013) and decompose drivers of the change in disability into the change in endowments and the change of the impact of the endowments on disability (Cutler et al., 2013; Oaxaca, 1973; Blinder, 1973; Jann, 2008)[11]:

$$\begin{aligned} \Delta AL = & [E(X_{W1}) - E(X_{W4})]' \beta_{W4} + E(X_{W4})'(\beta_{W1} - \beta_{W4}) + \\ & [E(X_{W1}) - E(X_{W4})]' (\beta_{W1} - \beta_{W4}) \end{aligned} \quad (2)$$

where the explanatory variables are subsumed in X with subscripts indicating the

[10]While one could apprehend proximity to death and clinical conditions to be highly correlated, the exclusion of one set of variables leaves our results qualitatively unchanged. Results are available on request.

[11]We follow a three-fold decomposition approach, as – different from a two-fold decomposition – the estimation does not require to assume a value for the unknown nondiscriminatory coefficient vector (Jann, 2008).

data wave, and Δ indicates changes over time. Hence, ΔAL denotes the difference in disability between the individuals in wave 1 and wave 4. The first part of the right hand side of Equation 2 is the endowment effect, which states the difference in disability levels across waves that arises due to different endowments of the explanatory variables in each wave. The second part describes the coefficient effect and captures the difference due to a change in the impact of the explanatory variables on disability. The difference caused by changes in the endowments and changes in the impacts occurring together is captured by the last term of the right hand side, the interaction effect. Rather than determining causal relationships, the decomposition is a statistical method to quantify the relative contribution of endowments and coefficients to the observed difference in disability levels.

4 Disability and morbidity by age, and time to death

As a first comparison, we look at the prevalence of health conditions and disability status by age and by proximity to death. As we are interested in how morbidity and disability patterns change over time, we compare respondents from the first wave of SHARE with respondents from the fourth wave.

Table 2 shows the average number of activity limitations and the prevalence of clinical conditions differentiated by wave and age. The average number of activity limitations increases from 0.19 for those aged 50 to 59 to 2.38 for those aged 80 and older in wave 1 and from 0.23 to 2.59 in wave 4. Disability levels remain relatively stable within each age group over time and the minor differences between the waves are not significantly different from zero in any age group. Similarly, the prevalence of almost all health conditions increases with age. However, the pattern between waves is less clear. While the prevalence of high blood cholesterol and stomach burns increases for all age groups, the prevalence of osteoporosis and ulcer decreases. For the other conditions the prevalence shows no definite pattern over time.

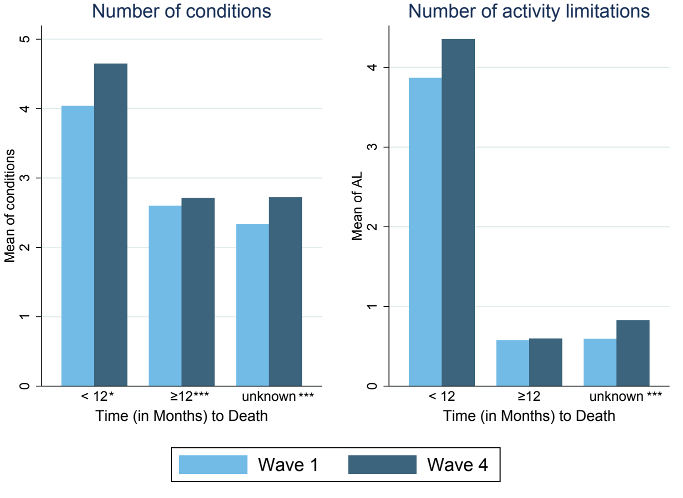
Looking at proximity to death, Figure 2 shows a small increase in the number of

Table 2: Disability status and prevalence rates of clinical conditions by age group

	Wave 1 – Age-groups				Wave 4 – Age-groups			
	50-59	60-69	70-79	80+	50-59	60-69	70-79	80+
Disability								
Numb. of activity lim.	0.19	0.35	0.78	2.38	0.23	0.31	0.80	2.59
Conditions								
Cancer	0.04	0.06	0.08	0.07	0.04	0.06	0.08	0.08
Chronic Lung Disease	0.04	0.06	0.08	0.10	0.05	0.07	0.10	0.10
Parkinson's Disease	0.00	0.01	0.01	0.02	0.00	0.00	0.01	0.02
Heart Attack	0.05	0.11	0.18	0.25	0.05	0.09	0.18	0.23
Stroke	0.02	0.03	0.05	0.08	0.02	0.03	0.05	0.10
Hip or Femoral Fracture	0.01	0.01	0.02	0.05	0.01	0.02	0.03	0.08
High Blood Pressure	0.27	0.45	0.59	0.62	0.32	0.45	0.62	0.71
High Blood Cholesterol	0.19	0.26	0.28	0.19	0.21	0.31	0.34	0.29
Diabetes	0.07	0.13	0.15	0.16	0.08	0.13	0.18	0.20
Asthma	0.04	0.05	0.06	0.07	0.04	0.04	0.05	0.04
Arthritis	0.15	0.22	0.29	0.34	0.16	0.22	0.30	0.42
Osteoporosis	0.06	0.09	0.14	0.16	0.03	0.05	0.09	0.11
Ulcer	0.05	0.05	0.06	0.08	0.03	0.04	0.04	0.05
Cataracts	0.02	0.05	0.14	0.23	0.02	0.06	0.16	0.26
Pain	0.18	0.23	0.31	0.36	0.19	0.21	0.30	0.40
Sleep Problems	0.06	0.08	0.11	0.17	0.05	0.07	0.11	0.17
Anxiety or Depression	0.25	0.27	0.33	0.46	0.28	0.29	0.33	0.47
Stomach Burns	0.04	0.05	0.08	0.07	0.06	0.08	0.10	0.11
Other Condition	0.25	0.26	0.30	0.34	0.28	0.28	0.30	0.32
Observations	8,768	7,613	5,173	2,184	10,432	11,458	8,022	4,040

Note: Summary measures using calibrated weights.

Figure 2: Morbidity and disability levels by time to death (in months)



Note: Summary measures using calibrated weights. ***, ** and * denote differences between wave 1 and wave 4 at the 1%, 5% and 10% significance level. Number of conditions summarizes the number of present conditions included in the analysis to a maximum of 19. In wave 1 N = 200/18,116/5,422 and in wave 4 N = 355/26,095/7,502 for $< 12/\geq 12$/unknown.

health conditions and in the disability level over time for individuals that are at least one year away from death, but a much larger increase for those within a year to death. Although this increase is only significantly different at the 10% level for the number of conditions and is not significantly different in the case of disability changes due to the relatively small number of people close to death, it is comparably large in size for both measures. Possibly, these increases close to death are driven by technological progress, which allows individuals to survive with more health conditions at the cost of increased limitations. While the increase in health conditions and in disability levels close to death could suggest a compression of morbidity, i.e. people live longer with disability and disability is compressed into the period before death, the finding that morbidity also increased for individuals further away from death points to an extension of morbidity.

Some differences exist between individuals who dropped out of the survey and whose life status after one year is hence unknown and those that remained in the survey, yet the size of the differences is small. In wave 1, the difference in the number of conditions between those at least 12 months away from death and those whose life status is unknown is significantly different from zero at the 1% level but not significant in wave 4. However, the difference in the number of activity limitations between those at least 12 months away from death and those whose life status is unknown is not significant in wave 1 but in wave 4. To control for possible confounding factors, such as changes in the age and sex composition, a multivariate analysis is necessary, which we turn to now.

5 Results

The regression results explaining the drivers of disability by time to death are shown in Table 3 separately for waves 1 and 4. Old age and proximity to death is correlated with an increase in the number of activity limitations. The estimates are slightly larger in wave 4. While women tend to suffer from more activity limitations than men (OECD, 2015), the coefficient for male is not statistically significant. Being married and of a higher socioeconomic status, i.e. higher educational attainment and higher household net worth, is associated with a lower number of activity limitations. Not surprisingly, most health conditions increase the number of activity limitations. Insignificant coefficients might be an indicator that a health condition can be treated or at least controlled so that the condition has no disabling impact. Significant negative estimates are only found for high blood cholesterol and for ulcer in wave 1. While it is unlikely that these health conditions improve a person's ability level, negative values might be driven by co-morbidities, i.e. suffering from more than one condition increases the number of activity limitations by less than the same condition would on its own.

Table 3: Regression explaining the number of activity limitations

	Wave 1		Wave 4	
	Coeff.	Std. Err.	Coeff.	Std. Err.
Demographics				
Age 60-69	-0.012	(0.025)	-0.035	(0.033)
Age 70-79	0.160***	(0.038)	0.165***	(0.051)
Age 80+	1.409***	(0.093)	1.470***	(0.100)
Prox. death				
less than 12 months	2.019***	(0.378)	2.259***	(0.468)
time to death unknown	0.039	(0.035)	0.142***	(0.044)
Soc.-econ. factors				
Male	0.022	(0.030)	-0.037	(0.036)
Married	-0.107***	(0.032)	-0.135***	(0.043)
Lower Education	0.308***	(0.035)	0.282***	(0.053)
Higher Education	-0.074***	(0.027)	-0.024	(0.039)
Net Worth (in 100k)	-0.004**	(0.002)	-0.020***	(0.005)
Conditions				
Cancer	0.068	(0.089)	0.164	(0.106)
Chronic Lung Disease	0.287***	(0.089)	0.192**	(0.090)
Parkinson's Disease	2.148***	(0.438)	3.753***	(0.600)
Heart Attack	0.259***	(0.070)	0.334***	(0.082)
Stroke	1.755***	(0.186)	1.883***	(0.223)
Hip or Femoral Fracture	0.873***	(0.194)	1.084***	(0.180)
High Blood Pressure	0.029	(0.033)	-0.003	(0.039)
High Blood Cholesterol	-0.098***	(0.036)	-0.146***	(0.045)
Diabetes	0.244***	(0.060)	0.315***	(0.068)
Asthma	0.085	(0.085)	0.260*	(0.141)

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	Coeff.	Std. Err.	Coeff.	Std. Err.
Arthritis	0.055	(0.044)	-0.012	(0.056)
Osteoporosis	0.205***	(0.068)	0.055	(0.101)
Ulcer	-0.145*	(0.084)	-0.042	(0.111)
Cataracts	0.017	(0.080)	0.063	(0.091)
Pain	0.374***	(0.047)	0.305***	(0.057)
Sleep Problems	0.228***	(0.076)	0.436***	(0.096)
Anxiety or Depression	0.496***	(0.041)	0.440***	(0.051)
Stomach Burns	0.056	(0.083)	0.166*	(0.092)
Other Condition	0.319***	(0.039)	0.259***	(0.046)
Countries				
Austria	0.035	(0.054)	-0.009	(0.042)
Germany	0.026	(0.048)	0.086	(0.054)
Sweden	-0.107**	(0.050)	-0.084	(0.054)
Netherlands	0.008	(0.049)	0.019	(0.049)
Spain	-0.075	(0.054)	0.192***	(0.066)
Italy	-0.102*	(0.052)	0.078	(0.062)
France	-0.151***	(0.046)	-0.108**	(0.046)
Switzerland	-0.191***	(0.052)	-0.107**	(0.041)
Belgium	-0.038	(0.047)	0.155***	(0.051)
Constant	-0.113**	(0.051)	-0.114*	(0.059)
Observations	23,738		33,952	
R^2	0.287		0.318	

Note: The dependent variable is the number of ALs. Reference groups: Age 50 to 59, at least 12 months away from death, medium education, Denmark. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The decomposition results are shown in Table 4. As seen in the descriptive results, average disability levels increased slightly between wave 1 and wave 4 by 0.088 activity limitations. The difference is significant at the 1% level. Changes in the endowments contribute slightly more to this difference than changes in the coefficients over time, while the size of the interaction effect is negligible. The decomposition is formulated from the viewpoint of wave 4 (Jann, 2008), i.e. Table 4 states the expected change in disability levels in wave 4, if endowments and coefficients had remained at their wave 1 values. The average number of AL in wave 4 would be lower by 0.053, if endowments between waves 1 and 4 had not changed, but only 0.047 lower if the effect of the explanatory variables on disability had remained constant over time. The endowment effect and the coefficient effect occurring together explains only 0.012 of the increase in AL between

Table 4: Decomposition results

	Overall		Endowment effect		Coefficient effect		Interaction effect	
Wave 1	0.611***	(0.018)						
Wave 4	0.700***	(0.024)						
Difference	-0.088***	(0.029)						
Endowments	-0.053***	(0.020)						
Coefficients	-0.047*	(0.025)						
Interaction	0.012	(0.013)						
Agestructure			-0.036***	(0.008)	0.009	(0.016)	0.002	(0.003)
Soc.econ.			0.019***	(0.006)	0.076*	(0.043)	0.010	(0.006)
Prox.death.			-0.002	(0.004)	0.083	(0.194)	0.000	(0.001)
Conditions			-0.035***	(0.013)	0.025	(0.038)	0.000	(0.010)
Countries			0.001	(0.001)	-0.025*	(0.015)	-0.001	(0.001)
Constant					-0.213	(0.205)		
Observations	57,690		57,690		57,690		57,690	

Note: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

waves 1 and 4. To further explore which variables drive the endowment and coefficient effect, we decompose the aggregate effects and look at the contribution of each variable. The detailed decomposition for all variables is shown in Table A1 in the Appendix. For easier interpretation we group the variables into age structure, socio-economic variables, proximity to death, health conditions, and country dummies.

Not surprisingly, population ageing is one of the main drivers behind the increase in disability levels. The change in the age structure between wave 1 and wave 4 explains 0.036 of the increase in disability. Almost the same amount, 0.035, can be explained by an increase in the prevalence of clinical conditions holding their impact as well as the impact of all other coefficients constant at the level of 2004/2005. Hip or femoral fractures and mental health problems from anxiety or depression contribute almost one third each to this increase (Table A1). Contrary, changes in socioeconomic endowments alone, in particular the increase in educational attainment, would have lowered average disability levels by 0.019. As the share of the population close to death and the country composition of the sample largely stayed the same, differences in these variables do not contribute to the difference in disability levels.

According to Fries' theory of a compression of morbidity (Fries, 1980), the link between ageing and disability would weaken over time as individuals at any given age would be healthier and disability would only occur close to death. However, we observe no change in the impact of age or proximity to death on disability levels over time. Likewise, we find no change in the impact of health conditions on disability, which contradicts the idea of a dynamic equilibrium, in which the prevalence of health conditions increases yet their impact on disability is reduced (Manton, 1982). Only the impact of the socioeconomic variables and of the country dummies changed, though the effects are only significant at the 10% level. Given the same impact of socioeconomic characteristics as in wave 1, the disability level in wave 4 would be higher by 0.076 activity limitations. The detailed decomposition in Table A1 shows that this effect in mainly driven by the influence of household wealth on activity limitations since wealth is associated with a larger reduction in the disability level in wave 4, i.e. socioeconomic inequality in disability levels increased over time. Changes in the coefficients of the country level contribute 0.025 activity limitations to the increase in the disability level, whereas Spain and Italy seem to be the main drivers of this development. Changes in the coefficients of the country variables indicate heterogeneous changes in disability levels across countries over time and might be driven by differences in the quality of the health care systems, macroeconomic factors, as well as by differences in overall life expectancy as countries with a lower life expectancy catch up to countries with a higher life expectancy (Robine et al., 2009).

As a sensitivity analysis, we want to confirm that the increase in the prevalence of conditions, which is associated with a 0.35 increase in the number of ALs, is not just driven by population ageing. To do so, we report standardized morbidity levels in Table 5. While, the first two rows show the raw average number of health conditions, the third row shows the standardized value for wave 4 given the age specific prevalence of conditions as in wave 1.[12] If the age specific prevalence had remained the same across waves, an individual would have suffered from on average 2.61 health conditions in wave 4. Hence, while the increase in the average number of conditions from 2.54 to 2.61 can be attributed

[12] The age standardization is performed for single years up to age 86. Due to sample size restrictions, ages 87 to 89 and 90 and older are combined.

to population ageing, the remaining increase from 2.61 to the actually observed average of 2.73 health conditions is associated with an increase in the prevalence of conditions. Hence, almost two thirds of the increase in the number of health conditions is associated with an extension of morbidity and our results that the increase in AL is not only driven by population ageing is confirmed.

Table 5: Raw and standardized differences in morbidity status

	Mean number of conditions
Wave 1	2.54
Wave 4	2.73
Wave 4* (standardized using age specific prevalence of wave 1)	2.61
Raw difference (wave 4 - wave 1)	0.20
Standardized difference (wave 4* - wave 1)	0.07
Difference not explained by population ageing (wave 4* - wave 4)	0.12

Note: Summary measures using calibrated weights.

6 Conclusion

This paper examines how disability and morbidity changes with age and proximity to death between 2004/2005 and 2011 using a sample of ten European countries covered by SHARE. Our research contributes to the analysis of population health in an ageing population and provides evidence on whether, for Europe, changes in morbidity over time are best described by a compression or an extension of morbidity. Since the elderly make up a quickly increasing share of Europe's population, forecasts of future health care expenditures heavily rely on assumptions about the trend of morbidity. If morbidity is compressed into a shorter period before death, this would imply relatively short periods of extensive health care use, whereas an extension of morbidity would suggest the opposite.

In line with other European studies such as Parker et al. (2005); Karlsson et al. (2008) and Walter et al. (2016), we find disability levels to increase slightly over time. Our results also correspond with Crimmins and Beltrán-Sánchez (2010), but differ from the findings of a compression of morbidity over recent years by Chernew et al. (2015) for the U.S.. While Crimmins and Beltrán-Sánchez (2010) focus on length of life without one of four major diseases or loss of mobility functioning, Chernew et al. (2015) use a similar measure to our approach and define disability as an indicator for whether an individual has impairment with any ADL or IADL. Since, medical progress can attenuate the link between the prevalence of diseases and disability, ability limitations are likely to be the more meaningful measure of morbidity. The diverging findings for Europe and the U.S. hence point to heterogeneous effects between the two regions.[13]

For individuals close to death, we observe a relatively large, albeit insignificant increase in disability status. Decomposing the gross difference in the number of activity limitations over time into the contribution of endowment changes and changes in the impact of different endowments on disability, we find that the slight increase in the average number of disability limitations in the population is partly driven by population ageing but also by an increase in morbidity levels. The impact of health conditions, i.e. the effect of health conditions on disability remained constant over time. Hence, our findings do not support the hypothesis that medical progress reduces the disabling impact of diseases as suggested by Manton (1982), but rather that for Europe population ageing is associated with an extension of morbidity.

[13] Arguably, the heterogeneous effect is declining over time since recent studies suggest no continued compression of morbidity in the 2000s for the U.S. (Fuller-Thomson et al., 2009; Freedman et al., 2013).

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Appendix

Table A1: Detailed decomposition results

	Endowment effect		Coefficient effect		Interaction effect	
Age 50-59	-0.010***	(0.003)	0.004	(0.015)	0.000	(0.001)
Age 60-69	-0.001	(0.003)	0.010	(0.013)	0.000	(0.000)
Age 70-79	0.001	(0.002)	0.001	(0.012)	-0.000	(0.000)
Age 80+	-0.026***	(0.006)	-0.007	(0.013)	0.001	(0.002)
Male	0.000	(0.000)	0.027	(0.021)	-0.000	(0.000)
Married	0.004**	(0.002)	0.019	(0.035)	-0.001	(0.002)
Lower Education	0.016***	(0.003)	0.009	(0.011)	0.003	(0.003)
Medium Education	0.003***	(0.001)	0.004	(0.015)	-0.000	(0.001)
Higher Education	0.005***	(0.001)	-0.009	(0.007)	0.002	(0.001)
Net Worth (in 100k)	-0.009***	(0.003)	0.026***	(0.009)	0.007**	(0.003)
Less than 12 months	-0.001	(0.002)	-0.001	(0.004)	0.000	(0.000)
At least 12 months	-0.003	(0.007)	0.081	(0.142)	0.000	(0.001)
Time to death unknown	0.002	(0.006)	0.003	(0.058)	-0.000	(0.001)
Cancer	-0.001	(0.001)	-0.006	(0.008)	0.001	(0.001)
Chronic Lung Disease	-0.003*	(0.001)	0.007	(0.009)	-0.001	(0.002)
Parkinson's Disease	-0.001	(0.005)	-0.011**	(0.005)	0.000	(0.002)
Heart Attack	0.001	(0.002)	-0.009	(0.012)	-0.000	(0.001)
Stroke	-0.005	(0.006)	-0.005	(0.011)	0.000	(0.001)
Hip or Femoral Fracture	-0.010***	(0.003)	-0.006	(0.007)	0.002	(0.003)
High Blood Pressure	0.000	(0.002)	0.015	(0.024)	-0.001	(0.002)
High Blood Cholesterol	0.007***	(0.002)	0.013	(0.016)	-0.002	(0.003)
Diabetes	-0.007***	(0.002)	-0.010	(0.012)	0.002	(0.002)
Asthma	0.002	(0.002)	-0.007	(0.007)	-0.002	(0.002)
Arthritis	0.000	(0.001)	0.017	(0.018)	-0.002	(0.002)
Osteoporosis	0.002	(0.004)	0.009	(0.007)	0.006	(0.005)
Ulcer	-0.001	(0.002)	-0.004	(0.005)	-0.002	(0.002)
Cataracts	-0.001	(0.002)	-0.004	(0.012)	0.001	(0.002)
Pain	-0.002	(0.002)	0.017	(0.018)	-0.000	(0.001)
Sleep Problems	0.001	(0.002)	-0.018*	(0.010)	-0.000	(0.001)
Anxiety or Depression	-0.011***	(0.003)	0.018	(0.021)	-0.001	(0.002)
Stomach Burns	-0.004*	(0.003)	-0.009	(0.010)	0.003	(0.003)
Other Condition	-0.005**	(0.002)	0.018	(0.018)	-0.001	(0.001)
Austria	0.000	(0.000)	0.003***	(0.001)	-0.001**	(0.000)
Germany	0.000	(0.001)	0.006	(0.014)	0.000	(0.000)
Sweden	-0.000	(0.000)	0.002	(0.002)	0.000	(0.000)
Netherlands	0.000	(0.000)	0.004	(0.002)	-0.000	(0.000)
Spain	-0.001	(0.001)	-0.026***	(0.009)	0.001	(0.001)
Italy	0.001	(0.001)	-0.019*	(0.012)	-0.001	(0.001)
France	0.001	(0.001)	0.008	(0.008)	-0.000	(0.000)
Denmark	-0.000	(0.000)	0.001*	(0.001)	0.000	(0.000)
Switzerland	0.000**	(0.000)	-0.000	(0.001)	0.000	(0.000)
Belgium	-0.000	(0.000)	-0.004**	(0.002)	0.000	(0.000)
Observations	57,690		57,690		57,690	

Note: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$