Wealth and occupation determine health deficit accumulation onset in Europe – results from the SHARE study.

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Abbreviations:

CI = Confidence interval

DA = deficit accumulation

DAG = directed acyclic graph

FI = Frailty Index

HR = Hazard Ratio

ISCED = international standard classification of education

SHARE = Survey of Health, Aging and Retirement in Europe,

Abstract

While socio-economic characteristics have been shown to be associated with health deficit accumulation (DA) trajectories, their effect on the age at DA onset remains unclear. The objective of this study was to compare the median age at DA onset across nine European countries and to investigate the effects of income, occupation and wealth on DA onset after age 50. We used population samples aged 50 years and older from the SHARE (Survey of Health, Aging and Retirement in Europe) study. Participants from nine European countries with longitudinal data from at least three of the 2004/05, 2006/07, 2010/11, 2012/13 and 2014/15 waves were included in the analysis. A Frailty Index (FI, range 0-1) was constructed from 50 health deficits. DA onset was defined as having FI values >0.08 in at least two consecutive measurements following an initial FI value ≤0.08. We investigated the effect of income, occupation and wealth on DA onset using a random effects model for time-to-event data. Potential confounding variables were identified using directed acyclic graphs. Out of 8,616 (mean age 62 years, 49.0% female) participants initially at risk, 2,640 (30.6%) experienced a subsequent DA onset. Median age at onset was 71 years overall, ranging from 66 years (Germany) to 76 years (Switzerland). Wealth and occupation were found to have significant effects on DA onset which decreased with age. In sum, the median age at DA onset differs between European countries. On an individual-level, wealth and occupation, but not income influence the age at DA onset.

Key Words: Health Status Disparities, Socioeconomic Factors, Aged, Healthy Aging, Frailty, Health Deficit Accumulation

1. **Introduction**

Socio-economic characteristics such as education, income, wealth, and occupation are among the most powerful determinants of health. They may act both as direct (Kondo 2012) and indirect determinants of health, e.g. by creating environmental hazards related to employment and housing, or by influencing health care utilization and less favourable health behaviours (Adler and Newman 2002).

Deteriorating health in older age can be summarized using the concept of deficit accumulation (DA) (Mitnitski and others 2001). Health effects of socio-economic risk factors may accumulate over the course of a lifetime (Ben-Shlomo and Kuh 2002), possibly until they surmount a threshold after which the impact of external stressors is no longer as easily compensated by regenerative processes as in younger adulthood (Kondo 2012). Failure to compensate the impact of external stressors leads to the accumulation of what is generally perceived as “age-related” chronic health deficits. Although it was recently found that a targeted intervention may reduce the number of accumulated deficits at any age (Theou and others 2017), ageing populations outside of intervention studies experience mostly stable or deteriorating health patterns (Mitnitski and others 2007; Stephan and others 2017). Socio-economic characteristics are associated with the onset of various degenerative health processes in older adults, such as functional limitations (Matthews and others 2005), heart problems, diabetes, cancer, stroke (Herd and others 2007), and depression (Koster and others 2006). Thus, investigating the social determinants of DA onset is of high relevance.

Both socio-economic status and health expectancy vary considerably across Europe. For instance, average wealth ranges from below 40.000 Euro (Netherlands) to over 280.000 Euro (Switzerland) (Christelis and others 2009), and healthy life expectancy at the age of 50 ranges from 14 years in Germany to 24 years in Denmark (Jagger and others 2009). The difference in health expectancy between the lowest and highest educational level has been reported to vary between 2 years in Italy and 5.3 years in Austria (Mäki and others 2013). For other constituents of socio-economic position, such as income, wealth, or occupation, comparative studies between countries are largely missing.

Therefore, the objective of this study was to investigate the effect of socioeconomic characteristics, especially income, wealth, and occupation on DA onset in people aged 50 years and older in nine European countries.

2. **Methods**

2.1 Study Design, Participants and Data Collection Procedures

Data originates from the Survey of Health, Ageing and Retirement in Europe (SHARE), which includes representative samples of the populations aged 50 years and older from 20 European countries and Israel.

All SHARE participants are asked to complete a multi-module computer-assisted personal interview. Details about study design, sampling methods and data collection for SHARE can be found elsewhere (Alcser and others 2005; Börsch-Supan and others 2013; Börsch-Supan and others 2008; Malter and Börsch-Supan 2013; Malter and others 2015). Approval for SHARE was obtained from the Ethics Committee of the University of Mannheim until 2011 and from the Ethics Council of the Max-Planck-Society for the Advancement of Science from 2011 onwards. Written informed consent was obtained from all participants.

To obtain a sample with a maximum of follow-ups for longitudinal analysis, we used data from those nine countries (Austria, Belgium, Switzerland, Germany, Denmark, Italy, Spain, France, and Sweden) participating in all five SHARE waves conducted in 2004/05 (wave 1), 2006/07 (wave 2), 2010/11 (wave 4), 2012/13 (wave 5) and 2014/15 (wave 6) [dataset](Börsch-Supan 2017a; Börsch-Supan 2017b; Börsch-Supan 2017c; Börsch-Supan 2017d; Börsch-Supan 2017e) and only from participants who had participated in at least three out of the five waves.

2.2 Outcome

2.2.1 Frailty Index

To measure deficit accumulation, we constructed a Frailty Index (FI) following established methods and procedures (Searle and others 2008). The FI for this study includes in total 50 items, covering 10 diseases, 21 measures of functioning and 19 signs and symptoms. Candidate item were taken into consideration based on two criteria: Use in earlier FIs created for analyses of SHARE data (Romero-Ortuno 2014; Theou and others 2013) and being available in all five SHARE waves used for the current analysis. This approach was chosen as previously developed SHARE FIs were based solely on the first two waves of SHARE. As a consequence, neither all items used in the previously published 40-item nor all items used in the previously published 70-item SHARE FI were available in all five SHARE waves used in this analysis. Definite item selection was based on the following standard inclusion criteria: Prevalence increase with age, late saturation (i.e. no prevalence >80% in any age group) and coverage of different body structures and systems (Searle and others 2008). The FI for a person results as the number of the person-specific deficits divided by the total number of listed deficits, ranging from 0 (= no deficits present) to 1 (= all deficits present). If information on more than 10 items (20%) were missing for a participant, the FI value was set to missing (Yang and Lee 2009). For a list of the included and excluded FI candidate items and details on the item selection process see Appendix A.

2.2.2 Definition of onset of DA

Onset of the DA process was defined as having a FI value ≤0.08 followed by FI values >0.08 in at least two consecutive measurements. Thus, to establish a confirmed DA onset, at least three measurements were needed.

The threshold of ≤0.08 corresponds to a maximum of four health deficits. It was chosen following published FI thresholds (Song and others 2010).

2.3 Exposures: Income, wealth and (last) occupation

The total annual household income before tax in euros (Alcser and others 2005) was adjusted for the square root of household size (OECD 2013). This adjusted value was then dichotomized using country-specific poverty thresholds according to Eurostat (Eurostat 2017). Where poverty thresholds for a specific year were unavailable, the threshold of the next available year for this country was applied.

Wealth was measured in euros as the sum of all financial and real household assets minus debts, adjusted for OECD purchasing power parity exchange rates (Organisation for Economic Co-operation and Development 2012) and recoded into tertiles.

Occupation was measured as the respondent's last job according to the International Standard Classification of Occupations (ISCO-88) by the International Labour Organization (International Labour Office 1990) in ten major groups of occupation. Under the assumption that elementary occupations include physical strain and may specifically increase the risk for DA onset, we dichotomized the groups into those indicating elementary occupations as compared to all others (International Labour Office 1990).

2.4 Covariates

2.4.1 Covariate selection

While it is widely known that neglecting important covariates can induce spurious associations in regression analysis (confounding), it is less well-known that covariate over-adjustment in turn increases the risk for collider bias (Shrier and Platt 2008), i.e. increasing bias by adjustment instead of decreasing it. To avoid both types of bias, we used directed acyclic graphs (DAGs) as covariate selection method. DAGs are constructed based on existing literature and contain the known or assumed associations among all covariates considered for a specific analysis. Ultimately, the DAG also gives the minimal adjustment set, i.e. the most parsimonious set of covariates needed for estimating an unbiased effect(Stang and Knüppel 2010). Covariates which were entered into the DAG were selected based on their reported association with the exposures or the outcome of interest in the literature. The resulting minimal adjustment set for estimating the total effect of income, wealth and occupation on hazard of DA onset, identified through the program DAGitty, a browser based environment for creating, editing, and analyzing causal models (Textor and others 2011), included sex, education, marital status, place of living, welfare regime and two interaction terms of income with welfare regime and wealth, respectively. The interaction terms were chosen based on the assumption that both the country-specific welfare regime and individual wealth might buffer the effect of income on DA (see Appendix B for the DAG and its references).

2.4.2 Covariate measurement

Education was measured according to the international standard classification of education (ISCED) (UNESCO 1997). We collapsed the seven categories into three levels: lower secondary education or less (ISCED levels 0–2), upper secondary education (ISCED level 3) and post-secondary education (ISCED levels 4–6).

Welfare regimes were defined as "conservative" (Germany, Belgium, France, Switzerland, Austria), "Scandinavian" (Sweden, Denmark), or "southern" (Italy, Spain) (Dragano and others 2010).

2.4.3 Missing Values

For income, wealth, marital status and education, five imputed data sets based on multivariable fully conditional specification are provided by the SHARE team. This allows using the available information from incomplete cases and thus increases precision, while the uncertainty of the imputed values is reflected by the variance between imputed values in the different data sets (White and others 2011).

While imputing missing covariate values increases precision of model estimation, it is generally not recommended to impute outcomes, as this increases noise in the data (White and others 2011). Thus, we did not impute items used for construction of the FI.

2.5 Statistical Methods

Dealing with left truncation

For all time-to event analyses, we used age as opposed to time under observation as time variable. This is generally recommended for time-to-event analyses if study entry does not represent a meaningful predictor of risk (Sperrin and Buchan 2013).

To avoid bias by left-truncation while simultaneously keeping age as time variable, study participants contributed only time at risk for those age intervals to the likelihood estimation during which they were actually observed in SHARE (Foreman and others 2008).This was necessary because not all participants entered the study at the same age (Cain and others 2011) and can be ensured with the entry option in SAS proc phreg (Foreman and others 2008). For an explanatory example how bias by left-truncation would have affected the analysis if it had not been controlled for, see Supplemental Appendix C.

2.5.1 Non-parametric analysis: Median age at DA onset

The median age at DA onset including 95% confidence intervals was estimated for the overall sample, and stratified by all selected covariates, respectively. For details on estimation of confidence intervals see Appendix C. Estimates for age-specific hazards of DA onset were generated using the procedures phreg and mianalyze in SAS Version 9.3 for Windows (Copyright © SAS Institute Inc., Cary, NC). Plots of age at DA onset and median estimates were based on these results and generated using the procedure sgplot. Log-rank tests for difference in the distributions of age at DA onset between subgroups were calculated separately for each imputed data set.

2.5.2 Regression Models and Predictors

We investigated the effect of income, wealth and occupation on hazard of DA onset using a Cox-proportional hazards model with country as random effect and controlling for the minimal sufficient covariate adjustment set as identified by the DAG. All predictors were included as time-independent variables, using values of the first available wave, as we wanted to be able to draw causal inferences with a longitudinal perspective and avoid introducing unnecessary complexity (for details see Appendix C).

The proportional hazards assumption was checked by successively including time-covariate interaction terms into the model. Covariates whose interaction with time was significant were included as time-varying effects. Analyses were conducted separately in the five imputed datasets and the resulting effect estimates were subsequently combined using the SAS procedure proc mianalyze.

For all analyses significance level was set to 5%. Analyses were performed using SAS Version 9.3 for Windows (Copyright © SAS Institute Inc., Cary, NC).

2.5.3 Sensitivity Analyses

The non-parametric analysis as well as the regression analysis were repeated using FI>0.04, FI>0.06 and FI>0.10 as alternative thresholds for the definition of DA onset. Additionally, we performed a sensitivity analysis which included the baseline FI value as a covariate using the FI>0.08 threshold.

Results

3.1 Study Participants

Longitudinal DA data from at least three waves were available for n=21,154 participants from the nine selected countries. Mean age at study entry was 64.7 years (range: 50-98 years, 55.4% female). Of these, n=8,616 participants (40.7%) had a FI value ≤0.08 and were therefore at risk for DA onset (mean age 61.9 years, range 50-93 years, 49.1% female). Of the initial risk set, 2,640 (30.6%, mean age 63.5 years, 50.5% female) experienced a subsequent confirmed DA onset within a median follow-up time of 7 years (range: 2-11 years). For the study participant flow chart and further descriptive statistics on the study data see Appendices D and E.

3.2 Non-parametric analysis: Median age at DA onset

Log-rank tests showed significant differences in the distribution of age at DA onset between subgroups for countries, wealth, education, occupation, income, sex and welfare regime, but not for marital status and place of living (Appendix F.1-F3).

Median age at DA onset overall was 71 years (95% CI: 70-72 years), with a range between countries from 66 years (Germany) to 76 years (Switzerland).

With regard to the main exposures, the largest univariate differences were found for wealth and occupation: Participants in the lowest wealth tertile (median age at DA onset 68 years, 95% CI [66-70]) experienced a DA onset on average 5 years earlier than persons in the highest wealth tertile (median age at DA onset 73 years, 95% CI [72-74]). Participants with elementary occupations (median age at DA onset 67 years, 95% CI [65-69]) experienced a DA onset 5 years earlier than persons with non-elementary occupations (median age at DA onset 72 years, 95% CI [71-73]).

For further details see Table 1. For plots of time to DA onset see Appendix F.1-F3.

Table 1: Median age at DA onset (in years) after age 50 with 95% confidence limits

		Median	95% confidence limits
Overall		71	(70; 72)
By country	Germany	66	(64; 68)
	Spain	68	(66; 70)
	Austria	69	(67; 71)
	Italy	69	(67; 71)
	Belgium	70	(69; 71)
	France	71	(69; 73)
	Sweden	73	(71; 75)
	Denmark	75	(73; 77)
	Switzerland	76	(74; 78)
By wealth tertile	lowest	68	(66; 70)
	middle	70	(69; 71)
	highest	73	(72; 74)
By income	below poverty threshold	68	(66; 70)
	above poverty threshold	71	(70; 72)
By (last) occupation[a]	elementary	67	(65; 69)
	non-elementary	72	(71; 73)
By sex	female	70	(69; 71)
	male	72	(71; 73)
By place of living[b]	a small town	70	(69; 71)
	a big city	71	(68; 74)
	a rural area or village	71	(70; 72)
	the sub urbs or outskirts of a big city	72	(70; 74)

	a large town	73	(71; 75)
By education	none or primary	67	(65; 69)
	secondary	70	(69; 71)
	post-secondary and tertiary	73	(72; 74)
By marital status	never married	69	(66; 72)
	widowed	70	(67; 73)
	married or in a registered partnership	71	(70; 72)
	Divorced	71	(68; 74)
By welfare regime type	southern	68	(67; 69)
	conservative	70	(69; 71)
	scandinavian	74	(73; 75)

Note. If not indicated otherwise, complete information or imputations were available and the full data set (n=8,616) could be used. Results are then presented for the pooled estimates of median age at DA onset.

[a]number of participants used: n=7,951

[b]number of participants used: n=5,559

3.3 Regression Model

There were significant interaction effects of observation time with occupation and wealth, respectively, leading to an inclusion of these variables as time-varying effects in the final model.

Out of the 8,616 at-risk observations, 5,242 including 1,596 confirmed onsets had complete covariate information.

After combining estimates from all imputed data sets, income below the poverty threshold had no significant effect on age at DA onset. Persons in the lowest wealth tertile (combined HR: 1.58, 95% CI [1.15; 2.16]), with elementary (last) occupation (combined HR: 1.79, 95% CI [1.20; 2.67]) and women (combined HR: 1.16, 95% CI [1.04; 1.28]) had a significantly higher risk for DA onset. Higher education significantly reduced the risk for DA onset. The effects of wealth and occupation were found to be age-dependent and decreased by a factor of 0.99 (95% CI [0.97; 1.00]) for wealth and 0.97 (95% CI [0.95; 0.99]) for occupation with each additional life year (Table 2).

Table 2: Results of the Cox-proportional hazards model with random effects for country (n=5,242, 1,596 events, pooled results from five imputed datasets)

Covariates		**Hazard Ratio**	**95% confidence limits**	**Significant Type III p-values**[a]
Wealth tertile	lowest	1.58	(1.15, 2.16)	
	middle	1.02	(0.75, 1.38)	5
	highest	Reference		
Interaction lowest wealth rank and age	factor for each additional life year	0.99	(0.97, 1.00)	0
Interaction middle wealth rank and age	factor for each additional life year	1.00	(0.99, 1.02)	0
Income	below poverty threshold	0.77	(0.34, 1.75)	1
	above poverty threshold	Reference		
(Last) occupation	elementary occupations	1.79	(1.20, 2.67)	5
	non-elementary occupations	Reference		
Interaction elementary occupation and age	factor for each additional life year	0.97	(0.95, 0.99)	5
Welfare regime	conservative	1.24	(0.88, 1.74)	
	southern	1.18	(0.77, 1.80)	0
	scandinavian	Reference		
Marital status	divorced	0.96	(0.78, 1.19)	
	married or in a registered partnership	0.94	(0.80, 1.11)	0
	never married	1.08	(0.85, 1.36)	

	widowed	Reference		
Education	post-secondary and tertiary	0.76	(0.65, 0.90)	
	secondary	0.89	(0.78, 1.03)	5
	none or primary	Reference		
Sex	female	1.16	(1.04, 1.28)	5
	male	Reference		
Interaction wealth tertile and income below poverty threshold	lowest wealth tertile	1.10	(0.71, 1.70)	
	middle wealth tertile	1.14	(0.62, 2.11)	1
	highest wealth tertile	Reference		
Interaction welfare regime and income below poverty threshold	conservative	1.42	(0.71, 2.83)	
	southern	1.28	(0.67, 2.47)	0
	scandinavian	Reference		
Place of living	a large town	0.95	(0.79, 1.14)	
	a rural area or village	1.05	(0.88, 1.25)	
	a small town	1.05	(0.88, 1.25)	0
	the sub-urbs or outskirts of a big city	1.00	(0.83, 1.22)	
	a big city	Reference		

[a]Number of imputed data sets with significant p-value according to Type III test of fixed effects (range: 0-5)

3.4 Sensitivity Analyses

3.4.1 Non-parametric analysis: Median age at DA onset

Median age at DA onset increased strictly, but for some countries slightly non-linearly with increased FI threshold values for onset definition. While for the thresholds 0.06, 0.08 and 0.10 most countries retained their relative rank with regard to median age at DA onset, ranks were slightly less stable for the 0.04 threshold. For the threshold 0.04 as compared to 0.06, Belgium (1 rank), Germany (2 ranks) and Spain (3 ranks) changed their relative position. In contrast, for the threshold 0.06 as compared to 0.08, only Austria changed its relative position by two ranks and for the threshold 0.08 as compared to 0.1, only Spain changed its relative position by one rank. For a graphical display see Appendix F.4.

3.4.2 Regression Model

The sensitivity analysis using FI> 0.04 and FI>0.06 as thresholds for DA onset resulted in considerably lower numbers of eligible observations (n=1,853 (n=3,564) at risk with full covariate information including n=916 (n=1,394) confirmed onsets for FI>0.04 and FI>0.06, respectively). Point estimates were comparable in size and direction, but only higher education (and, for FI>0.06, elementary occupation) remained a significant predictor (Appendices G and H).

The sensitivity analysis using FI>0.10 as threshold for DA onset resulted in a higher number of eligible observations (n=6,973 at risk including n=1,655 confirmed onsets), and confirmed the results of the main analysis (Appendix I).

Adjustment for baseline FI values resulted in a significant HR for this variable (HR: 1.14, 95% CI [1.01; 1.28]) without changing the estimated effects for any of the other covariates (Appendix J).

3. **Discussion**

Our results show for nine European countries that a person from the highest wealth tertile who was still healthy at the age of 50 could expect to live significantly longer without health deficits than a person from the lowest wealth tertile. The same applied to persons who did not work in elementary occupations. These effects were independent of the country-specific welfare regime, and also independent of individual income and education.

The strength of our study is threefold: one, we included both measures of income (the incoming stream of economic resources) and measures of wealth (the available stock of accumulated economic resources). This is important because, with increasing age and during retirement, accumulated assets may become more relevant for well-being and health than income (Pollack and others). Second, we could rely on longitudinal data from SHARE, a study that has repeatedly proven its value and validity, to define DA onset without major risk of misclassification. The third strength of our analysis was the systematic selection of potential confounders based on directed acyclic graphs. We used DAGs to select an unbiased set of covariates. Interestingly, this set confirms the choice of covariates made for earlier analyses on health effects of socio-economic determinants (Herd and others 2007; Matthews and others 2005).

In our study, wealth and occupation rather than income emerged as significant factors that decelerated the onset of DA. We found that these effects decreased with age. This provides further evidence that health inequalities of groups with different risks are most pronounced in middle and early older age and subsequently level out (House and others 2005).

In conjunction with other studies, our results suggest that different components of socioeconomic position affect different parts of DA trajectories: While education (Herd and others 2007; House and others 2005), and according to our analysis also occupation and wealth, seem to play a role in determining the age at DA onset, income has been found to impact DA progression after DA onset (Herd and others 2007; House and others 2005; Stephan and others 2017). This is also coherent with different suggested pathways: Education and health literacy seem to primarily influence health through health behaviors, wealth through living conditions and psychosocial factors, and occupation through a cumulative effect of strenuous work on homeostasis while income might provide the means to disease control once health deficits are present (House and others 2005).

Being female was an additional independent risk factor for DA onset in our study, adding evidence to the male-female health-survival paradox, with women having a higher life expectancy although experiencing higher prevalence of disease and disability at all ages as compared to men (Oksuzyan and others 2008; Stephan and others 2017). Social and behavioral explanations include earlier help-seeking behavior due to higher social acceptability of disease and disability for women and biomedical explanations such as the protective role of estrogen in the risk for cardiovascular events (Oksuzyan and others 2008).

We found considerable differences in median age at health deficit accumulation onset after age 50 between countries, with Germany showing the lowest and Switzerland the highest median age at DA onset. These estimates are well in line with previously published results on differences in healthy life expectancy after age 50 (Jagger and others 2009), which were based on a different methodological approach: the calculation of healthy life expectancy based on cross-sectional data according to the Sullivan method (Jagger and others 1999). Jagger and others 2009 suggested a difference of nine years in healthy life expectancy between Germany and Denmark, a result which was exactly replicated by our time-to event analysis using longitudinal data. This strengthens the face validity of our results, as there is a considerable conceptual overlap between healthy life expectancy and time lived without DA onset, with the advantage that healthy life expectancy can be estimated on a population-level only, whereas age at DA onset can be measured on an individual level.

The order of countries with regard to median age at DA onset was generally stable even when different FI values were used for definition of DA onset, with the threshold 0.04 (corresponding to two health deficits) providing less stable results. This may on the one hand be due to lower numbers at risk (smaller sample size) for this threshold. It may also, on the other hand, suggest that two health deficits are not enough to reliably determine if a DA onset has occurred, because of more frequent recoveries resulting in a rather fluctuating order of countries for very low thresholds. This view is also supported by the fact that the difference in median age at onset between countries was lower for the lowest threshold (8 years) and larger (11 years) and stable for the 0.08 and 0.1 thresholds..

It has to be kept in mind that our results of both the non-parametric and the semi-parametric analyses are to be interpreted as conditional on not having experienced a DA onset before age 50. Although our results cannot necessarily be transferred to the less healthy half of the population, descriptive comparisons suggested that the same factors might play a role in DA onset at earlier ages as well.

Our major challenge was that observational studies currently do not allow for a complete follow-up of an individual's DA trajectory from birth to death. Instead, participants were included in SHARE at different ages. To minimize potential bias introduced by the study design, we took into account age at study entry in all calculations (Cain and others 2011). As over half of all SHARE participants had experienced their DA onset already before their first participation in SHARE, DA onset did not seem to constitute a barrier for study participation. We thus assumed that censoring and DA onset were unrelated (uninformative censoring). Also, the selected cut-off for DA onset (a FI-value >0.08, i.e. at least 4 health deficits) can be criticized as arbitrarily chosen, although it has been previously used in the literature (Song and others 2010; Stephan and others 2017). To account for this, we ran sensitivity analyses with thresholds of 0.04, 0.06 and 0.10, respectively, which essentially confirmed the results of our main analysis, showing that the choice of the exact threshold for DA onset did not exert undue influence. Also, potential improvements or further deterioration after DA onset (i.e. after at least two FI measurements >0.08 over a time period of at least two years) were not further considered for this analysis, as our focus was on DA onset, and not DA trajectories thereafter. This does not preclude improvement.

Last, as most cross-country analyses, we cannot fully exclude cultural differences in subjectively reported health deficits. Further research is required to be able to fully account for it in the future.

The results of our analysis can be interpreted in the context of current European and national-level policies: It is questionable if further increases in retirement age are feasible and desirable for all occupational classes, as this may not only further decrease health expectancy in population groups with elementary occupations, but also increase their subsequent health care costs. Our results also point to the importance of occupational health and safety measures at the work place and corporate health promotion in preventing accumulated health damage during working age, especially for elementary occupations.

In addition, governments should support provisions made in younger age to increase wealth (e.g. through acquisition of residential property and personal pension schemes). In this light, the current low interest rates might be of advantage for future generations, if they encourage people to take on loans for property acquisition.

On the other hand, low interest rates and rising life expectancy have increasingly pushed insurers to shift the risk of financial products to their customers (The Economist 2017). This in turn may decrease consumer confidence in the usefulness of long-term investment strategies and thus dissuade people from accumulating financial assets. Governments might need to consider new incentives to citizens or regulations of the insurance market in order to stimulate the accumulation of wealth.

In conclusion, next to education, also wealth and occupation deserve a more prominent focus in studies and policies targeting DA onset after age 50 in Europe.

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Conflict of Interest:

The authors declare that they have no conflict of interest.

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