Pathways to death by socioeconomic status

Cecilia Potente

University of Oxford, Nuffield College

Christiaan Monden

University of Oxford, Nuffield College

This research was supported by the combined ESRC, Clarendon Fund and Scatcherd European Scholarship, who kindly provided support for the first author.

Abstract

The role of socioeconomic status (SES) in the last years of life is an understudied aspect of health inequalities. This study examines disability patterns preceding death in England using data from the English Longitudinal Study of Ageing. We use repeated measures latent class analysis to identify the most common pathways to death in terms of walking ability, ADL and IADL limitations. Three pathways emerged: one characterised by consistently low disability; a second by a constant high level of functional limitations; and a third by medium impairment. We examine how different SES indicators predict belonging to each disability pattern. Conditional on income, higher wealth is associated with a lower likelihood of belonging to the high disability pathway. Contrary to our expectations we find no gradient in the pathways to death by education. Health inequalities in the last years of life seem to exist especially among individuals with different levels of wealth.

Keywords Ageing - Death - Old Age - Socioeconomic Status - Latent Class - Disability -Time-to-death

Introduction

While the general association between socioeconomic status and mortality and morbidity is well-established—people with higher education, more wealth and higher incomes live longer and in better health—much remains to be understood about the role of socioeconomic status (SES) across the life course. The importance of socioeconomic status for health in the last years of life is one area where much is still to be learned. Most analyses of socioeconomic differences in health during later life are designed around chronological age; that is, they follow people in certain age groups regardless of their eventual age at death. Such designs inform us, for example, about disability patterns among people in their 70s or 80s. However, we lack a detailed understanding of actual disability patterns in the last years before death. What are the most common health pathways in the last years of life? Moreover, we know little about the socioeconomic differences in these pathways to death.

Pathways to death are relevant in at least three ways. First, they have intrinsic meaning for individuals and their loved-ones. Second, they are important from a healthcare policy perspective, insofar as the last years of life are the most expensive ones in terms of inpatient and social care costs (Zweifel et al., 1999; Cutler and Meara, 2001; Bardsley et al., 2010). Thirdly, we can use these pathways to further our understanding of theories about socioeconomic variation in health and disability across the life course.

Our study has two main goals. First, we explore disability pathways to death for older adults in England. We follow deceased respondents from around eight years before their death and map their pathways in terms of ability to walk a quarter of mile, severity of activity of daily living and instrumental activities of daily living difficulties. The second aim is to understand whether, and to what extent, these pathways are shaped by socioeconomic factors. We use data from the first six waves of the English Longitudinal Study of Ageing (ELSA). The analysis proceeds in two steps. First, we use repeated measures latent class analysis to identify the different impairment pathways

preceding death. Next, we study how different socioeconomic indicators help to predict the probability of experiencing a certain disability pathway.

Our study makes three contributions to the literature on SES and health in later life. The first is our focus on disability patterns in the last years of life. Several methods have been suggested to deal with death in conventional longitudinal studies of ageing, such as imputation of expected values, joint models, and exclusion of those dead (Diehr and Patrick, 2003; Rajan and Leurgans, 2010; Murphy et al., 2011). Our design represents a different way to examine the confounding effect of death in late-life trajectories by focusing only on dead individuals and studying disability patterns in the last years of life.

Our second contribution lies in assessing the explanatory power of traditional SES indicators with respect to disability patterns in the last years of life. Socioeconomic status might have a critical role in shaping disability pathways in the last years of life, but few studies have tried to examine this particular socioeconomic gradient in the years before death. Moreover, previous studies have suggested that SES differences in health and disability might widen over the life course (Ross and Wu, 1996; Power et al., 1998), while other studies have suggested that age narrows health disparities (Beckett, 2000; Dupre, 2007). In particular, some studies have emphasized that selective mortality might be responsible for the decreasing association between socioeconomic status and health in old age (Willson et al., 2007). By examining SES differences in the last years of life, we contribute to the empirical investigation of the changing association between SES and health in old age. We also take into account heterogeneity in socioeconomic indicators. It has long been acknowledged that several mechanisms link various measures of socioeconomic positions to health and mortality to different extents (Robert and House, 1996; Torssander and Erikson, 2010; Cutler et al., 2011).

Third, this study contributes to a greater integration of life-course analysis in the study of the relationship between socioeconomic status and health. Health-related pathways in the last years of life have been disregarded in favour of age-standardized trajectories. The last part of life can be

conceptualized as a life-stage which could differ among advantaged and disadvantaged socioeconomic groups. In the study of ageing one of the emerging questions is in which way chronological age is useful as a life-stage marker (Morgan and Kunkel, 2016). Lowsky et al. (2014) noted: 'For a surprisingly large segment of the older population, chronological age is not a relevant marker for understanding, measuring, or experiencing healthy aging.' Biological age and life-stages emerge as ways forward to go beyond the limits of considering chronological age as the only life stage indicator (Simm et al., 2008). Simultaneously, in public health and gerontology literature there is an increasing interest in time to death as indicator of ageing (Lynch, 2015; Wolf et al., 2015). Therefore, our study conceptualizes the last years of life in terms of a life-course stage and analyses how socioeconomic status is related to this life phase.

Trajectories in the last years of life

Glaser and Strauss (1968) were the first to draw attention to the longitudinal paths at the end of life. Although they took a caretaker's and medical management perspective, their work highlighted an early interest in disability patterns at the end of life. Most studies of health trajectories in late life so far have focused on age- and cohort-related patterns of health (Lynch, 2003; Zimmer et al., 2012; Rohlfsen and Kronenfeld, 2014). Death is often only considered in terms of attrition bias in research on disability trajectories in later life (Dodge et al., 2006; Liang et al., 2010; Taylor, 2010).

There has been more interest in longitudinal pathways to deaths in studies on cognitive functioning, where the debate is whether these trajectories at the end of life mimic a steady and gradual decline or a more abrupt curvilinear drop (Wilson et al., 2003; MacDonald et al., 2011; Gerstorf and Ram, 2013). Only a small number of studies has explicitly examined physical-health trajectories preceding death (Bradley et al., 2000; Schoeni et al., 2003; Gill et al., 2010). Gerstorf and colleagues (2013) compared the age and time-to-death perspectives for changes in six health domains (i.e. cognitive, sensory, physical, health, social, and perceived control). From their study it emerged that a mortality-related perspective describes changes better than an age-based scale. They

showed that less advantaged socio-demographic circumstances were correlated with lower health conditions at the baseline, but they did not find that SES was associated with differential rates of declines. However, their analysis did not differentiate between socioeconomic indicators (see for instance Herd et al. 2007) but used a composite index. Liao et al. (1999) explored educational and racial differentials in morbidity and disability in the last years of life using a US sample from 1986-1990. They found that more educated individuals were better off in terms of activity limitations, chronic conditions, bed days, and hospital days in the two years prior to death. These findings strongly suggest that health trajectories to death could vary by educational level. Other studies have examined actual health trajectories to death for various indicators of morbidity and disability, but they have not related the observed patterns to socioeconomic differences, or only examined short periods before death (Guralnik et al., 1991; Lunney et al., 2003; Gill et al., 2010; Klijs et al., 2010).

Schoeni and colleagues (2003) explored socioeconomic differences in disability status before death across education and poverty groups. However, due to the limited availability of longitudinal data they used a synthetic approach to estimation using repeated cross-sectional data from National Health Interview Survey. Therefore, they were not able to highlight actual individual trajectories prior to death, which ELSA allows us to do. They concluded that socioeconomic differences in disability present before death fade in proximity to death.

Socioeconomic status and health in later life

Previous research has mostly analysed health conditions and physical barrier as determinants of the onset and progression of disability trajectories in old age (Stuck et al., 1999; Fried et al., 2001). Only a few studies have looked at the association between socioeconomic factors and health-related trajectories (House et al., 2005; Herd et al., 2007), and very limited longitudinal research is available on the socioeconomic gradient in the last years of life.

Previous research in the US has found that education is associated with the onset of health problems, while income is related to the progression rate (House et al., 2005; Herd et al., 2007).

Other socioeconomic status indicators such as wealth and occupation are studied even less often. Nevertheless, Robert and House (1994) showed how liquid assets and home-ownership predict differences in functional health better than both income and education.

We study the association between socioeconomic status and disability patterns in the last years of life for different socioeconomic indicators: education, income, and wealth. The patterns of impairment in the eight years before death reflect the life-course circumstances that have shaped the history of each individual as well as individual coping with increasing impairment during the last year. Different socioeconomic indicators might affect patterns in different ways. Given the explorative nature of our study, and the stepwise procedure for identifying patterns, it does not seem appropriate to formulate specific hypotheses for the socioeconomic factors; instead, we discuss possible mechanisms below.

Education has a well-documented positive impact on status attainment, which is positive for health through material and behavioural factors. Education may be both an important factor for accumulation of health advantage over the life course and a positive moderating element in the presence of health problems. Education seems to increase the ability to manage illness (Goldman and Lakdawalla, 2001) and highly educated people have greater take-up of new medical technologies, which might help to mitigate unfavourable health conditions at the end of life (Lleras-Muney and Lichenberg, 2002).

Although income and wealth might seem to be very similar resources, they have heterogeneous functions and assume different meanings, especially in the context of an older population (Wise, 1998; Poterba et al., 2011, 2013). Income primarily supports daily expenditures and permits a certain standard of living. We can view income as reflecting the short-term and current component of the financial resources. Wealth, on the other hand, reflects the accumulation of advantages over the life course and it also assumes other functions than purchasing or expenditure. It can have an insurance function for unexpected unfavourable events, such as health shocks or unforeseen economic hardships. Moreover, for older individuals wealth can have also a bequest or inter-vivo

transfer purpose: individuals might want to accumulate financial resources in order to transfer them to their loved ones later on. On one hand, for example, income could represent a resource for management of disability which could allow the purchase of the rehabilitative programs after the onset of impairment. Therefore, income might relate to the shape of the pattern of disability. On the other hand, assets could reflect the advantage over the life-course, which might affect the level (i.e. severity of impairment) of the disability pattern in last years of life.

Data and Methods

Research design and data

We used data from Waves 0 to 5 (1998-2011) of the English Longitudinal Study of Ageing (ELSA). ELSA respondents were drawn from households participating in the cross-sectional Health Survey for England. This initial interview is called Wave 0, the subsequent longitudinal waves are Waves 1 to 5. Our sample includes only respondents who died within the two years after Wave 4 or after Wave 5 and for whom information about the previous four waves is available. Therefore, the first subsample includes longitudinal information from Wave 1-4 and the second from Wave 2-5. Mortality follow-up is obtained through the linkage of death records from National Health Service Register Database. Since more than 95% of the sample agreed to the linkage and the database contains high quality data, the reliability of the deaths reported is very high (Banks et al., 2010). Time is coded as distance to death (-1 stands for one period before death, -2 for two periods before death and so on). Consecutive waves are approximately two years apart. Our sample thus allows us to visualize patterns across four periods, or the last eight years, before individuals' death.

This sample included only individuals 65 and older one period before death. Mean age at baseline (i.e. four periods before death) is 75 and 77 for men and women respectively. There are 836 respondents who died in the two years after Wave 4 or Wave 5 for whom we have information four periods earlier. However, many of them did not participate in all four waves due to panel attrition. Table 1 presents the sample size achieved by including only those present in all four

periods preceding death (444). Our final analytic sample (without missing variables in any of the socioeconomic variables) comprised 437 individuals of whom about 49 per cent are male (214). From Table 1 we observed that the groups of decedents do not differ from the overall sample in terms of attrition rate. The attrition rates between waves were slightly lower in the overall sample than among respondents who died (e.g. from Wave 3 to Wave 4 83.6 % of individuals remain in the sample, but among those dying after Wave 4 78 %). Previous analyses of ELSA data showed that people lost at follow-up between Wave 1 and Wave 5 are older, with higher prevalence of limiting long-standing illness, lower wealth and educational attainment (Steptoe et al., 2013). Similarly, we looked at the characteristics of those lost at follow-up from period -4 to period -1 only among the decedents in this analysis. Table 2 shows that the decedents for which we have information for all four periods are wealthier, more educated and less likely to be married four periods before death compared to those leaving the sample over waves. No significant differences are observed in terms of disability four periods before death. Therefore, our final sample of decedents might be slightly selected in terms of advantaged socioeconomic position—as was already shown for the overall longitudinal ELSA sample (Steptoe et al., 2013)—but not in terms of disability.

<Table 1>

<Table 2>

Our design helps to solve two recognized issues in ageing studies: "healthy survivor" bias and informative censoring due to death (Murphy et al., 2011). The first problem, the so-called "healthy survivor" effect (Murphy et al., 2011), refers to studies observing the healthier individuals in the population at old age due to age-truncated designs and attrition due to death (Kelley-Moore and Lin, 2012). Premature mortality, in particular, could cause selection in those observed reaching old age: for example, a cohort observed in old age could appear more robust because those with higher mortality risk are selected out of the sample. Our study design does not suffer from the "healthy

survivor" bias since it includes only dead individuals dying at different ages. In this way, we eliminate the bias caused by the selection happening in age-based groups (Hoffmann, 2008).

The second problem which our design avoids is the non-randomness of missing data due to death. Non-random attrition due to death could bias the study of longitudinal patterns of health and disability in old age. Missing data caused by participants' death are associated with the longitudinal outcomes under examination. Therefore, it is necessary to take into account the dependence between longitudinal outcomes and death. Our design considers only dead individuals and follows their disability pathways preceding death. Studies that simply exclude those dying from the longitudinal analysis might reach biased results (Biering et al., 2015). Alternative strategies that help to deal with non-random missingness due to death, such as imputation of the expected values, transformation of the outcome variable, competing risk models and joint models have other drawbacks (Murphy et al., 2011). First, the imputation of expected values that the person would have, if still alive, treats death as non-informative censoring and produces bias estimates. Second, incorporating death in the disability score by transforming the variable would result in an underestimation of the mean scores for the population which is still alive (Biering et al., 2015). Competing risk models—despite being able to deal with the informative censoring—do not prevent the "healthy survivor" effect and produce biased estimates. The joint modelling of longitudinal outcome and time to death is one approach that could handle both the "healthy survivor" bias and informative censoring. However, these models are computationally complex and the current softwares available have limited applicability to different problems (Tsiatis and Davidian, 2004; Diggle et al., 2008). By looking only at dead individuals we do not have to take care of the non-random attrition due to death. Our design therefore represents a different approach to the described difficulties in longitudinal studies of ageing offering a viable solution of limited computational complexity.

Dependent variables

Being able to function independently is crucial for old people and represents an extremely important public health issue: later-life functioning provides a valuable indicator for the effect of chronic diseases on quality of life and long-term care use in old age (Guralnik et al., 1996). Chronic conditions, as well as the severity of diseases, greatly affect later-life functioning, making disability a valid and useful indicator of functional health. We used three different variables to measure the disability status of individuals. The first two are frequently used indicators of difficulties in activities of daily living (Martin et al., 2010; Montez and Hayward, 2014). The Activities of Daily Living indicator (ADL) refers to the physical dimension of everyday activities. It includes six activities such as: walking across a room, dressing, bathing or showering, eating, getting in or out of bed, and using the toilet, including getting up and down (Freedman et al., 2008). The Instrumental Activities of Daily Living (IADL) refers to everyday tasks which are not necessarily physically intense but require a good level of cognition as well. Five questions are asked in order to measure difficulties in instrumental activities of daily living: the ability to prepare a hot meal, to shop for groceries, to make phone calls, to take medications, and managing your money, for example, to pay bills and keep track of expenses. Some studies create a dichotomous variable for the presence of limitations (Cai and Lubitz, 2007) or use the absolute number of limitations as the degree of impairment (Zimmer et al., 1998). Yang and Lee (2009) divided the ADL score into four different levels of functional impairment. We took a similar approach and divided the ADL and IADL scores into three groups: no impairment (no limitations), moderate (1 limitation) and severe impairment (2 or more limitations). The presence of at least one limitation is generally a useful criterion for determining disability, but this classification allowed us to quantify not only the presence but also the severity of impairment. Our third indicator (WALK) represents the degree of difficulty respondents report having in accomplishing a specific physical task: walking for a quarter of a mile. We retained the original scoring system of the survey: 1 for no difficulty, 2 for some difficulty, 3 for much difficulty, and 4 for unable to do this.

These three indicators may highlight different degrees of impairment associated with a common underlying condition. Unlike mere walking ability, ADL and IADL difficulties are not only an assessment of physical capacity but also reflect environmental and social factors (Freedman and Martin, 1998). While ADL indicates difficulties in basic everyday activities, IADL constitutes a broader indicator of impairment that reflects environmental factors influencing the ability to live independently as well as the perception of disability (Spillman, 2004). Moreover, difficulties in instrumental activities of daily living are also related to the cognitive component.

Socioeconomic variables

We use three indicators for socioeconomic status: education, equivalised household income and wealth. Concerning the educational variable, information about the highest attained qualification came from Wave 0 for all cases. We assigned individuals without any qualification to the first educational category, those with secondary education or below to the second category, and those with higher education below degree or degree to the third category. The individuals with foreign education (44 in total) were classified according to the age at which they finished full time education (first educational category if they never been in full time education or they were 14 or under, second educational category if the age ranges between 15 and 17, and third educational category for age 18 or 19 and over).

Data on income and wealth were derived from period -4. Monetary income is reported as weekly equivalent income and refers to the household. Income is the sum of several possible sources of income: employment income, self-employment income, state benefit income, state pension income, private pension income, asset income, and other income. Wealth is measured as the net total wealth of the household, which is the sum of savings, investments, physical wealth, and housing wealth after financial and mortgage debt has been subtracted. Note that wealth can also assume negative values if debts are larger than assets. We used the OECD equivalence scale to take into account household size (OECD, 2013). Income and wealth were divided into quartiles based on the

distributions among all dead and alive respondents in the sample with the age range of interest. All socioeconomic factors are included in the form of dummy variables to allow for non-linear associations.

Methods

Our analysis proceeded in two steps. First, we applied repeated measures latent class analysis (RMLCA) to describe the most common pathways to death in our sample (Collins and Lanza, 2010) for walking ability (WALK), activities of daily living (ADL), and instrumental activities of daily living (IADL). Prior research has analysed how socioeconomic position influences the onset and progression of health problems, often by imposing a priori parametric forms to the patterns such as strictly linearity of changes (Ferraro, 2011; Zimmer et al., 2012). However, Ferraro (2011) points out that health changes tend to have an episodic and nonlinear nature. Therefore, RMLCA seems to be a preferable method for this analysis compared to latent class trajectory analysis (LCTA), because change over time is modelled without imposing any functional form (George, 2009). RMLCA is especially helpful in this case since the change over time could differ across classes: for example, if we expect one class with a smooth decline, one with an abrupt decline and one with more discontinuous changes, RMLCA will be able to identify them distinctly. By using RMLCA the patterns of disability are modelled in such a way that they could take any form in each latent class. On the contrary, an LCTA approach would require the choice of a unique functional form for the growth in all classes.

Moreover, RMLCA models within-time and between-time changes together, while latent transition analysis (LTA) models latent classes at different point and then estimates the transition probabilities from one class to the other. Latent classes defined by RMLCA are characterized by individuals' responses to each disability indicator over time with the goal of finding the patterns to explain variation in disability across periods. On the contrary, LTA does not model one vector over time for each individual, but it focuses more on the transitions between one class to the other across

periods. In this study, we are interested in the patterns over time rather than states changes across consecutive periods, and this motivates the choice of the RMLCA approach.

One of the main assumptions for the RMLCA is local independence, meaning that the four observed variables are related only through the latent variable. We, therefore, assume that, conditional on latent class membership, the variables are unrelated over time. We estimate three separate models one for each disability outcome. Each health impairment variable has four observed variables corresponding to the periods before death with three response categories based on severity (except for walking, where there are four categories). It is important to highlight that the latent class analysis approach is a probabilistic one, meaning that patterns are probabilistic and they do not represent real entities (i.e. cases are similar to each other because their responses are generated by the same probability distribution). In order to simplify the interpretation we apply labels to the class identified with the aim of characterizing the probabilistic patterns found. Latent classes are denoted as pathways or patterns in the following sections. However, the group identified cannot be considered completely homogenous. The algorithm used to optimize was the Expectation - Maximization (EM) one. The model was estimated 300 times and the maximum number of iterations for the estimation algorithm was set to 100,000 to avoid local maxima.

The number of classes was chosen by fitting latent class models for each health variable starting from one class and progressively adding more classes (Nylund et al., 2007). The optimal number was determined by looking at different criteria such as BIC and likelihood ratio Chi-squared (Schwarz, 1978; Magidson and Vermunt, 2004). In particular, the BIC is the preferred criterion, because it takes into account the goodness of fit as well as the parsimony of the model. A less-formal criterion widely used in the literature consists in looking the change in likelihood ratio compared to the one-class model. According to this test, the adequate number of classes is obtained when a significant change is not observable anymore (Magidson and Vermunt, 2004).

Second, we used multinomial logistic model to investigate how socioeconomic characteristics—education, income and wealth—are related to membership of the different pathways (i.e. to the

latent classes obtained from our RMLCA). In order to estimate the coefficient without bias, we apply the "one-step" technique in which the covariates' coefficients are estimated as part of the latent class model (Bolck et al., 2004). We also included, as control variables, age, sex and marital status (i.e. if the individual is married four periods before death). We tested the robustness of the results differentiating those suffering widowhood during the four periods analysed. Moreover, all SES variables are included simultaneously in the model. Similar results are obtained by including the three SES variables separately (results available on request). For all analyses we use the poLCA package in R (Linzer and Lewis, 2011).

Results

Pathways to death

Which pathways to death do we observe in the data? Following the criteria described in the method section, three pathways emerge as adequate for walking ability and instrumental activities of daily living model. In ADL model instead the optimal number of pathways identified is only two. Model fit statistics according to which we decide the optimal number of classes are presented in Table 3.

<Table 3>

The composition and prevalence of the pathways vary somewhat among the disability measures, but three similar patterns can be identified. Figure 1 presents the probability composition for the classes. It visualizes these three pathways with time to death on the x-axis and the probability of reporting different scores on the y-axis. Each colour represents the probability of reporting a particular impairment score. Individuals belonging to the first pathway, which we denote “Low Disability”, have a high probability of reporting no difficulty over the whole period (i.e. high value for the probability of an impairment score equal to one). This group is characterized by low disability conditions in the four periods before death and a small slightly increasing probability of moderate difficulties. A pattern of constant high disability (“High Disability”) is evident in the second pathway; a high likelihood of severe impairment in all four periods before death is evident

from the large probability of having more than two ADL and IADL limitations and from the inability or severe difficulty in walking a quarter of a mile. The third pathway, "Medium Disability", shows medium but increasing probability of impairment over four periods.

The prevalence of the first pathway "Low Disability" varies across the health outcomes. In the walking ability model, only 35 per cent of the sample falls into the pathway, whereas the percentage increases to 66 per cent for IADL. The prevalence of the "High Disability" pathway ranges between 27 per cent for walking ability and 38 per cent for ADL. While "Medium Disability" pathway is the most common pathway in the model including walking ability, it is the least prevalent in the instrumental activity limitations model: 38 per cent of the sample have this pathway for walking ability and only 10 per cent for IADL limitations. A medium impairment pathway does not emerge from the ADL model.

Table 4 presents the joint distribution of class assignment for the three different models. The classification seems quite consistent across disability indicators, and especially so for the “Low Disability” pathways. For example, the majority of the individuals in the “Low Disability” category in the IADL model are similarly assigned to the low impairment class in the other two models. However, a good amount of dissimilarity among classifications exists, especially when looking at the “Medium Disability” pathways; this can be explained by the fact that the three disability indicators aim to measure different types of functional limitations. Therefore, the separate analysis of the three disability indicators offers a multi-faceted view on impairment status.

<Table 4>

<Figure 1>

Pathways to death by socioeconomic status

How are these pathways associated with socioeconomic status? Table 5 shows the relative risk ratios along with 95% confidence intervals for income, wealth and education, and for different impairment indicators. We compare the likelihood of experiencing the "High Disability" or "Medium Disability" pathways to the likelihood of experiencing the "Low Disability" one. Therefore, for all SES indicators we use the "Low Disability" pathway as the reference. Relative risk ratios greater than one imply a raised probability of belonging to "High Disability" or "Medium Disability" as opposed to "Low Disability".

Two main observations can be made. First, contrary to our expectations, education and to some extent income do not appear to be associated with any particular pathway. As to the association between pathways to death and education, we see that the coefficients are not significant in almost any of the models. Second, we find a wealth gradient in the pathways to death for almost all disability indicators. The relative risk ratios of the "High Disability" pathway for respondents in the third and fourth wealth quartiles are lower than one indicating decreased probability of belonging to this pathway compared to the reference category (lowest wealth quartile). In other words, being in the highest wealth quartiles implies decreased odds of belonging to "High Disability" pathway rather than the "Low Disability" one. The decrease in the odds of the "High Disability" pathway ranges from 50 (being in the fourth wealth quartile for walking ability) to 80 per cent (being in the third wealth quartile for IADL) depending on the disability indicator analysed. No wealth gradient is evident in the relative risk for "Medium Disability". Holding all other factors constant, the relative risk of "Medium Disability" does not exhibit any consistent gradient for any socioeconomic indicator.

Our results also point to the presence of non-linearity in the association between income on the one hand and pathways to death on the other in the walking ability model. Surprisingly, the relative risk of experiencing the "High Disability" pathway, rather than the "Low Disability" one, is higher in the second and third income quartiles than in the lowest quartile. For example, for a person in the

second income quartile, the relative risk of being in the poor walking ability pathway rather than the low disability one is 2.7 times (1.8 times for ADL) higher than the one of a person in the first income quartile. Therefore, being in the second income quartile represents a disadvantage for health compared to being in the lowest one. However, this result is evident only in the walking ability and ADL model. Some non-linearity is also evident in the wealth gradient. In general, the decrease in the odds of "High Disability" compared to "Low Disability" is larger in the third quartile compared to the fourth. Therefore, for all impairments individuals in the third quartile of wealth seem to have a greater decrease in the odds of the more disabled pathway to death compared to individuals in the fourth quartile.

Our models consider the three SES indicators simultaneously. When examining the three socioeconomic indicators we found that income, education and wealth are somewhat distinct in their association with disability at the end of life. Higher wealth is associated with a less disabled pathway to death, but higher income or educational attainment is not. Moreover, different disability indicators produce similar but not completely identical results. A very clear gradient for wealth is evident from the latent class analysis performed on instrumental activities of daily living and walking ability, and partially for activity of daily living. In particular, in the relative risk ratios for ADL, significant differences are only observed between the third and first quartiles of wealth. Being in the most advantageous wealth quartile does not seem to make a difference in terms of ADL, but it matters for IADL and walking ability.

The control variables show the expected patterns. Men are less likely than women to be in the "High Disability" or "Medium Disability" pathways for all three health outcomes. This is in line with previous studies documenting a higher rate of functional limitations and disability among women during old age, as compared to men (Arber and Ginn, 1993; Case and Paxson, 2005). This finding demonstrates that even in the terminal phase of life men exhibit an advantage in terms of disability that women do not, as also Lunney and colleagues (2003) have pointed out. Unfortunately, further investigation of gender differences is not feasible because of the sample size.

Moreover, the relative risks of high or medium impairment are smaller among married individuals than among those who are unmarried, although they are not statistically significant. This accords with the extensively documented positive association between marital status and low disability (Pienta et al., 2000; Liu and Zhang, 2013). There seems to be an exception in the IADL model, where being married four periods before death is positively associated with the "High Disability" pathway. Since the instrumental activities of daily living represent more practical abilities married individuals could be able to rely on the other partner for these activities more than those remaining unmarried. As a robustness check, we include an indicator of whether individuals experience widowhood during the three periods before death. The experience of widowhood can have adverse health consequences for the surviving partner and even affect their mortality (Williams and Umberson, 2004; Elwert and Christakis, 2008). We found that experiencing widowhood is not associated with any pathway to death, and the results remain unchanged once we include this information in the model (results available upon request). Similarly, we check the robustness of the results by including in the analysis an indicator of whether the person is living with a child and the number of people in the household. Results remain stable also with the inclusion of these variables. Finally, older age is consistently associated with worse disability pathways.

<Table 5>

Conclusions

The patterns of disability prevalence and intensity in the last years of life are successfully described in this work. To our knowledge, our analysis represents the first attempt to model the association between different socioeconomic indicators and pathways of disability in the terminal phase of life. The first aim of this study was to understand the most common pathways leading to death, without imposing a strict functional form when modelling the data. Using repeated measures latent class analysis three patterns emerged from the analysis of walking ability and IADL (only two pathways emerge in the case of ADL). The first pathway to death was characterized by general low disability over the eight years preceding death. The second pathway was characterized by increasing probability of impairment over this period. Finally, the pathway of medium impairment showed a decreasing likelihood of no disability and an increasing one for impairment. Second, we find that the different socioeconomic indicators have uneven explanatory powers with respect to disability patterns at the end of life. The socioeconomic gradient in the pathways to death appears to be evident only for wealth. Higher wealth accumulation is associated with less disabled pathways to death. Therefore, those who reach death in low impairment are also those who have a high level of net wealth. On the contrary, there are no clear significant differences between income quartiles as well as educational groups in terms of pathways to death.

This analysis represents the first attempt to study the association between different socioeconomic indicators with disability patterns in the last years of life. Previous studies have limited their analysis to selected indicators with little attention to the comparison of different ones (Liao et al., 1999; Schoeni et al., 2003). Therefore, our analysis studies the association between various socioeconomic indicators and later-life functioning in the last years of life. The heterogeneous results of different socioeconomic indicators highlight the need for more detailed analyses of how socioeconomic variables produce later-life functioning patterns. The disablement process might have early origins during the life-course as well as be dependent on the length of exposure to unfavourable circumstances. In the context of old populations, income may be

considered a reflection of economic circumstances over the life course to a less extent compared to wealth (Smith and Kington, 2004). Prolonged exposure to favourable economic conditions may lead to both accumulation of resources and a long-run health advantage, which—in turn—will affect disability patterns in the last years of life. This could represent an explanation as to why those with a high level of wealth are more likely to be in less disabled pathways to death, while high levels of income or education are not associated with a reduction of the time spent in disabled conditions in the last years of life.

The presence of a wealth gradient for the disability patterns in the last years of life points in the direction of wealth as a relevant and independent dimension of social stratification (Killewald et al., 2017). However, the emergence of a wealth gradient and the absence of a clear association with education and income could be related to the specificity of the English context. The important role of wealth in later life in England has been found also in other studies which focused on specific health conditions and mortality (Banks et al., 2010; Demakakos et al., 2012, 2015; Tanaka et al., 2012). Moreover, most of the analyses on trajectories in the latter years of life have been based on data from the United States. Unlike the United States, England has universal health insurance coverage, the National Health Service (NHS), which provides a comprehensive range of healthcare services for free over the entire life-course. In particular, Banks and colleagues (2010) have found a significant income and wealth gradient for mortality in the United States but only a wealth-related one in England. According to them one possible explanation for the absence of the income gradient in England is the welfare benefits received during retirement, which are largely flat below the median. However, this explanation would not be able to justify completely our result of a higher disadvantage for the second and third income quartile in terms of pathway to death.

Furthermore, by examining the association between disability and SES in the process of dying we learn about the socioeconomic gradient in old age overcoming the limitations of conventional designs. We found wealth-related differences in disability in the last years of life which in turn could be reflected in the socioeconomic gradient over age. Since those who have higher wealth

experience a less disabled pathway and more sudden death, the wealth gradient over age may mechanically widen as a consequence of the difference in the process of dying. Therefore, this study suggests the importance of considering the socioeconomic differences in pathways to death for a better understanding of health inequality in old age.

Finally, our results are relevant to healthcare system and policy, given the high costs typically incurred at the end of life. In the study of the health care expenditures across the life-course, the "red herring" hypothesis emphasizes the differential role of proximity to death and age for old people (Zweifel et al., 1999). While some studies have emphasized that age is a "red herring" for the large health care expenditures in later life and proximity to death is the real driver, other studies have suggested that proximity to death represents one of the important mediators together with morbidity and impairment (Seshamani and Gray, 2004; Howdon and Rice, 2015; Hazra et al., 2017). Our results suggest that the health care expenditures in the last years of life might differ greatly according to the individuals' accumulated resources. Understanding better the mechanisms through which wealth is related to disability in the pathways to death might contribute to a more efficient management of health care costs in last years of life.

Our analysis is not free from limitations. Firstly, the time separating observed health outcomes is relatively large, since we observe individuals every two years. In addition, we are unable to differentiate those who are interviewed close to their death from those who are interviewed longer before their death. More frequent observations might allow us to distinguish more patterns, although this would obviously also require a lager sample size. Nevertheless, we are still able to examine major changes happening across individuals' last years of life. Second, we do not analyse causes of death despite the information different causes provide regarding the rate of decline. However, we did not use information on cause of death as the reliability of stated cause of death is rather low in old populations because of the high comorbidity rate in later life (Sington and Cottrell, 2002; Harteloh et al., 2010). Since diseases and health problems occurring in old age tend to be highly interrelated, it is often hard even for medical professionals to establish an individual's 'true'

cause of death. Third, sample size limits the extent of our analysis by forcing us to analyse the female and male sample together. A smaller sample size could reduce the chances of detecting weaker but significant effects that might be nonetheless present. Consequently, we might be able to observe only significant results for relative strong effects. Finally, the attrition of more socioeconomically disadvantaged individuals over years may have skewed the sample towards individuals with higher wealth and education, as presented in Table 2. We may consequently have underestimated the magnitude of wealth and education disparities in the disability pathways to death.

Recommended next steps to further our understanding of social variations in pathways to death include investigating the role of different socioeconomic indicators in the disability pathways, by using data with more frequent observations and lager sample sizes. Moreover, the study of disability pathways at the end of life might be enhanced by models that consider the interaction between multiple socioeconomic indicators. The intersection of different socioeconomic conditions could be associated with distinct impairment patterns in the last years of life. We believe that further studies on how SES is related to the pathways to death can contribute to a better understanding of health inequality in old age.

References

Arber, S., and J. Ginn. 1993. Gender and inequalities in health in later life, *Social Science & Medicine* 36(1): 33–46.

Banks, J., A. Muriel, and J. P. Smith. 2010. Disease Prevalence, Disease Incidence, and Mortality in the United States and in England, *Demography* 47(Supplement): S211–S231.

Bardsley, M., T. Georghiou, and J. Dixon. 2010. *Social care and hospital use at the end of life. London: The Nuffield Trust*. . Retrieved from http://www.nuffieldtrust.org.uk/sites/files/nuffield/Social_care_and_hospital_use-full_report_Dec 2010.pdf

Beckett, M. 2000. Converging Health Inequalities in Later Life - an Artifact of Mortality Selection?, *Journal of Health and Social Behavior* 41(1): 106–119.

Biering, K., N. H. Hjollund, and M. Frydenberg. 2015. Using multiple imputation to deal with missing data and attrition in longitudinal studies with repeated measures of patient-reported outcomes, *Clinical Epidemiology* 7: 91–106.

Bolck, A., M. Croon, and J. Hagenaars. 2004. Estimating latent structure models with categorical variables: One-step versus three-step estimators, *Political Analysis* 12(1): 3–27.

Bradley, E. H., T. R. Fried, S. V. Kasl, and Idler Ellen L. 2000. Quality-of-Life Trajectories of Elders in the End of Life, In *Annual review of gerontology and geriatrics*. (Vol. 20).

Cai, L., and J. Lubitz. 2007. Was there compression of disability for older Americans from 1992 to 2003?, *Demography* 44(3): 479–495.

Case, A., and C. H. Paxson. 2005. Sex Differences in Morbidity and Mortality, *Demography* 42(2): 189–214.

Collins, L. M., and S. T. Lanza. 2010. *Latent class and latent transition analysis : with applications in the social, behavioral, and health sciences*. Hoboken, New Jersey: John Wiley & Sons, Inc.

Cutler, D. M., A. Lleras-Muney, and T. Vogl. 2011. Socioeconomic Status and Health: Dimensions and Mechanisms, In S. Glied and P. C. Smith (Eds.), *The Oxford Handbook of Health Economics*. Oxford University Press.

Cutler, D. M., and E. Meara. 2001. The Concentration of Medical Spending: An Update, In D. A. Wise (Ed.), *Themes in the Economics of Aging*. University of Chicago Press.

Demakakos, P., J. P. Biddulph, M. Bobak, and M. G. Marmot. 2015. Wealth and mortality at older ages: a prospective cohort study., *Journal of Epidemiology and Community Health* 70(4): 346–53.

Demakakos, P., M. Marmot, and A. Steptoe. 2012. Socioeconomic position and the incidence of type 2 diabetes: the ELSA study., *European Journal of Epidemiology* 27(5): 367–78.

Diehr, P., and D. L. Patrick. 2003. Trajectories of health for older adults over time:accounting fully for death, *Ann Intern Med* 139(September): 416–420.

Diggle, P. J., I. Sousa, and A. G. Chetwynd. 2008. Joint modelling of repeated measurements and time-to-event outcomes: The fourth Armitage lecture, *Statistics in Medicine* 27(16): 2981–2998.

Dodge, H. H., Y. Du, J. a. Saxton, and M. Ganguli. 2006. Cognitive Domains and Trajectories of Functional Independence in Nondemented Elderly Persons, *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 61(12): 1330–1337.

Dupre, M. E. 2007. Educational differences in age-related patterns of disease: reconsidering the cumulative disadvantage and age-as-leveler hypotheses., *Journal of Health and Social Behavior* 48(1): 1–15.

Elwert, F., and N. A. Christakis. 2008. Wives and ex-wives: a new test for homogamy bias in the widowhood effect., *Demography* 45(4): 851–873.

Ferraro, K. F. 2011. Health and Aging: Early Origins, Persistent Inequalities, In R. A. J. Settersten and J. L. Angel (Eds.), *Handbook of Sociology of Aging*. Springer.

Freedman, V. A., and L. G. Martin. 1998. Understanding trends in functional limitations among

older Americans., *American Journal of Public Health* 88(10): 1457–62.
Freedman, V. A., L. G. Martin, R. F. Schoeni, and J. C. Cornman. 2008. Declines in late-life disability: The role of early- and mid-life factors, *Social Science and Medicine* 66(7): 1588–1602.
Fried, L. P., Y. Young, G. Rubin, and K. Bandeen-Roche. 2001. Self-reported preclinical disability identifies older women with early declines in performance and early disease, *Journal of Clinical Epidemiology* 54(9): 889–901.
George, L. K. 2009. Conceptualizing and Measuring Trajectories, In G. H. Elder and J. Z. Giele (Eds.), *The craft of life course research*. New York: Guilford Press.
Gerstorf, D., and N. Ram. 2013. Inquiry into terminal decline: Five objectives for future study, *Gerontologist* 53(5): 727–737.
Gerstorf, D., N. Ram, U. Lindenberger, and J. Smith. 2013. Age and time-to-death trajectories of change in indicators of cognitive, sensory, physical, health, social, and self-related functions., *Developmental Psychology* 49(10): 1805–21.
Gill, T. M., E. A. Gahbauer, L. Han, and H. G. Allore. 2010. Trajectories of disability in the last year of life, *New England Journal of Medicine* 362(13): 1173–1180.
Glaser, B. G., and A. L. Strauss. 1968. *Time for dying*. Chicago: Aldine.
Goldman, D., and D. Lakdawalla. 2001. Understanding Health Disparities Across Education Groups, *National Bureau of Economic Research - NBR* 3: 47.
Guralnik, J. M., L. P. Fried, and M. E. Salive. 1996. Disability as a Public Health Outcome in the Aging Population, *Annual Review of Public Health* 17(1): 25–46.
Guralnik, J. M., a. Z. LaCroix, L. G. Branch, S. V. Kasl, and R. B. Wallace. 1991. Morbidity and disability in older persons in the years prior to death, *American Journal of Public Health* 81: 443–447.
Harteloh, P., K. De Bruin, and J. Kardaun. 2010. The reliability of cause-of-death coding in The Netherlands, *European Journal of Epidemiology* 25: 531–538.
Hazra, N. C., C. Rudisill, and M. C. Gulliford. 2017. Determinants of health care costs in the senior elderly: age, comorbidity, impairment, or proximity to death?, *European Journal of Health Economics* 1–12.
Herd, P., B. Goesling, and J. S. House. 2007. Socioeconomic position and health: the differential effects of education versus income on the onset versus progression of health problems., *Journal of Health and Social Behavior* 48: 223–238.
Hoffmann, R. 2008. *Socioeconomic Differences in Old Age Mortality (The Springer Series on Demographic Methods and Population Analysis)*. Springer.
House, J. S., P. M. Lantz, and P. Herd. 2005. Continuity and Change in the Social Stratification of Aging and Health Over the Life Course: Evidence From a Nationally Representative Longitudinal Study From 1986 to 2001/2002 (Americans' Changing Lives Study), *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 60(Special Issue 2): S15–S26.
Howdon, D., and N. Rice. 2015. Health care expenditures, age, proximity to death and morbidity: implications for an ageing population, *IDEAS Working Paper Series from RePEc* .
Kelley-Moore, J. A., and J. Lin. 2012. Widening the View: Capturing "Unobserved" Heterogeneity in Study of Age and the Life Course, In R. A. Settersten and J. L. Angel (Eds.), *Handbook of sociology of aging*. New York: Springer.
Killewald, A., F. T. Pfeffer, and J. N. Schachner. 2017. Wealth Inequality and Accumulation, *Annual Review of Sociology* 43(1): 1–26.
Klijs, B., J. P. Mackenbach, and A. E. Kunst. 2010. Disability occurrence and proximity to death., *Disability and Rehabilitation* 32(21): 1733–1741.
Liang, J., C. N. Wang, X. Xu, H. C. Hsu, H. S. Lin, and Y. H. Lin. 2010. Trajectory of functional status among older Taiwanese: Gender and age variations, *Social Science and Medicine* 71(6): 1208–1217.

Liao, Y., D. L. McGee, J. S. Kaufman, G. Cao, and R. S. Cooper. 1999. Socioeconomic status and morbidity in the last years of life, *American Journal of Public Health* 89(4): 569–572.

Linzer, D. A., and J. B. Lewis. 2011. poLCA: An R Package for Polytomous Variable Latent Class Analysis, *Journal of Statistical Software* 42(10): 1–29.

Liu, H., and Z. Zhang. 2013. Disability Trends by Marital Status Among Older Americans, 1997-2010: An Examination by Gender and Race, *Population Research and Policy Review* 32(1): 103–127.

Lleras-Muney, A., and F. R. Lichenberg. 2002. The Effect of Education on Medical Technology Adoption: Are the More Educated More Likely to Use new Drugs?, *NBER Working Paper* (9185): .

Lowsky, D. J., S. J. Olshansky, J. Bhattacharya, and D. P. Goldman. 2014. Heterogeneity in healthy aging, *Journals of Gerontology - Series A Biological Sciences and Medical Sciences* 69(6): 640–649.

Lunney, J. R., J. Lynn, D. J. Foley, and S. Lipson. 2003. Patterns of functional decline at the end of life, *JAMA* 289(18): 2387–2392.

Lynch, S. M. 2003. Cohort and life-course patterns in the relationship between education and health: a hierarchical approach., *Demography* 40(2): 309–331.

Lynch, S. M. 2015. Commentary on "Disability Trajectories at the End of Life: A Countdown Model" The Problems With Time-to-Death as a Predictor of Disability, *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 70(5): 753–756.

MacDonald, S. W. S., D. F. Hultsch, and R. A. Dixon. 2011. Aging and the shape of cognitive change before death: Terminal decline or terminal drop?, *Journals of Gerontology - Series B Psychological Sciences and Social Sciences* 66 B(3): 292–301.

Magidson, J., and J. K. Vermunt. 2004. Laten Class Models, In D. Kaplan (Ed.), *The SAGE Handbook of Quantitative Methodology for the Social Sciences*. Thousand Oaks, Calif.: SAGE Publications, Inc.

Marmot, M. et al. 1998. English Longitudinal Study of Ageing: Waves 0-5, 1998-2011, Colchester, Essex: UK Data Archive [distributor].

Martin, L. G., R. F. Schoeni, and P. M. Andreski. 2010. Trends in health of older adults in the United States: past, present, future., *Demography* 47 Suppl: S17–S40.

Montez, J. K., and M. D. Hayward. 2014. Cumulative Childhood Adversity, Educational Attainment, and Active Life Expectancy Among U.S. Adults, *Demography* 51(2): 413–435.

Morgan, L. A., and S. Kunkel. 2016. *Aging, society, and the life course*. (Fifth)New York, New York: Springer Publishing Company.

Murphy, T. E., L. Han, H. G. Allore, P. N. Peduzzi, T. M. Gill, and H. Lin. 2011. Treatment of death in the analysis of longitudinal studies of gerontological outcomes, *Journals of Gerontology - Series A Biological Sciences and Medical Sciences* 66 A(1): 109–114.

Nylund, K. L., T. Asparouhov, and B. O. Muthén. 2007. Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study, *Structural Equation Modeling: A Multidisciplinary Journal* 14(4): 535–569.

OECD. 2013. Framework for integrated analysis, In *OECD Framework for Statistics on the Distribution of Household Income, Consumption and Wealth*. Paris.

Pienta, A. M., M. D. Hayward, and K. R. Jenkins. 2000. Health Consequences of Marriage for the Retirement Years, *Journal of Family Issues* .

Poterba, J. M., S. F. Venti, and D. A. Wise. 2013. Health, Education, and the Post-Retirement Evolution of Household Assets, *NBER Working Paper* .

Poterba, J. M., S. Venti, and D. A. Wise. 2011. Wealth in Retirement, *National Bureau of Economic Research Working Paper Series* 25(4): 95–118.

Power, C., S. Matthews, and O. Manor. 1998. Inequalities in self-rated health: Explanations from different stages of life, *Lancet* 351(9108): 1009–1014.

Rajan, K. B., and S. E. Leurgans. 2010. Joint modeling of missing data due to non-participation and

death in longitudinal aging studies, *Statistics in Medicine* 29(21): 2260–2268.
Robert, S. A., and J. S. House. 1994. Social Structures, Quality of Life, and Aging, In R. Abeles, H. Gift, and M. G. Ory (Eds.), *Aging and Quality of Life*. New York, NY, USA: Springer Publishing Company.
Robert, S. A., and J. S. House. 1996. SES Differentials in Health by Age and Alternative Indicators of SES, *Journal of Aging and Health* 8(3): 359–388.
Rohlfsen, L. S., and J. J. Kronenfeld. 2014. Gender Differences in Trajectories of Self-Rated Health in Middle and Old Age: An Examination of Differential Exposure and Differential Vulnerability, *Journal of Aging and Health* 26: 637–662.
Ross, C. E., and C.-L. Wu. 1996. Education, age, and the cumulative advantage in health., *Journal of Health and Social Behavior* 37(1): 104–120.
Schoeni, R. F., V. A. Freedman, and R. B. Wallace. 2003. Late-life disability trajectories and socioeconomic status, In *Annual review of gerontology and geriatrics*. (Vol. 22).
Schwarz, G. 1978. Estimating the Dimension of a Model, *The Annals of Statistics* 6(2): 461–464.
Seshamani, M., and A. Gray. 2004. Ageing and health-care expenditure: The red herring argument revisited, *Health Economics* 13(4): 303–314.
Simm, A., N. Nass, B. Bartling, B. Hofmann, R. E. Silber, and A. Navarrete Santos. 2008. Potential biomarkers of ageing, *Biological Chemistry* 389(3): 257–265.
Sington, J. D., and B. J. Cottrell. 2002. Analysis of the sensitivity of death certificates in 440 hospital deaths: a comparison with necropsy findings, *Journal of Clinical Pathology* 55: 499–502.
Smith, J. P., and R. Kington. 2004. *Race, Socioeconomic Status, and Health in Late Life*. . Retrieved from http://econpapers.repec.org/RePEc:wpa:wuwphe:0403001
Spillman, B. C. 2004. Changes in elderly disability rates and the implications for health care utilization and cost, *The Milbank Quarterly* 82(1): 157–194.
Steptoe, A., E. Breeze, J. Banks, and J. Nazroo. 2013. Cohort profile: The English Longitudinal Study of Ageing, *International Journal of Epidemiology* 42(6): 1640–1648.
Stuck, A. E., J. M. Walthert, T. Nikolaus, C. J. Büla, C. Hohmann, and J. C. Beck. 1999. Risk factors for functional status decline in community-living elderly people: a systematic literature review, *Social Science & Medicine* 48(4): 445–469.
Tanaka, T., E. Gjona, and M. C. Gulliford. 2012. Income, wealth and risk of diabetes among older adults: Cohort study using the English longitudinal study of ageing, *European Journal of Public Health* 22(3): 310–317.
Taylor, M. G. 2010. Capturing transitions and trajectories: The role of socioeconomic status in later life disability, *Journals of Gerontology - Series B Psychological Sciences and Social Sciences* 65 B: 733–743.
Torssander, J., and R. Erikson. 2010. Stratification and Mortality: A Comparison of Education, Class, Status, and Income, *European Sociological Review* 26(4): 465–474.
Tsiatis, A. A., and M. Davidian. 2004. Joint modeling of Longitudinal and Time-to-Event Data: An Overview, *Statistica Sinica* 14: 809–834.
Williams, K., and D. J. Umberson. 2004. Marital status, marital transitions, and health: a gendered life course perspective., *Journal of Health and Social Behavior* 45(1): 81–98.
Willson, A. E., K. M. Shuey, and G. H. Elder. 2007. Cumulative Advantage Processes as Mechanisms of Inequality in Life Course Health, *American Journal of Sociology* 112(6): 1886–1924.
Wilson, R. S., L. A. Beckett, J. L. Bienias, D. A. Evans, and D. A. Bennett. 2003. Terminal decline in cognitive function, *Neurology* 60(11): 1782–1787.
Wise, D. A. 1998. *Frontiers in Economics of Aging*. (D. Wise, Ed.)The University of Chicago Press.
Wolf, D. A., V. A. Freedman, J. I. Ondrich, C. L. Seplaki, and B. C. Spillman. 2015. Disability Trajectories at the End of Life: A “Countdown” Model, *The Journals of Gerontology. Series B,*

Psychological Sciences and Social Sciences 70(5): 745–752.
Yang, Y., and L. C. Lee. 2009. Sex and Race Disparities in Health: Cohort Variations in Life Course Patterns, *Social Forces* 87(4): 2093–2124.
Zimmer, Z., X. Liu, a Hermalin, and Y. L. Chuang. 1998. Educational attainment and transitions in functional status among older Taiwanese., *Demography* 35(3): 361–375.
Zimmer, Z., L. G. Martin, D. S. Nagin, and B. L. Jones. 2012. Modeling Disability Trajectories and Mortality of the Oldest-Old in China, *Demography* 49(1): 291–314.
Zweifel, P., S. Felder, and M. Meiers. 1999. Ageing of population and health care expenditure: a red herring?, *Health Economics* 8(6): 485–496.

Figure 1 Probability composition of the pathways to death for walking ability, ADL and IADL

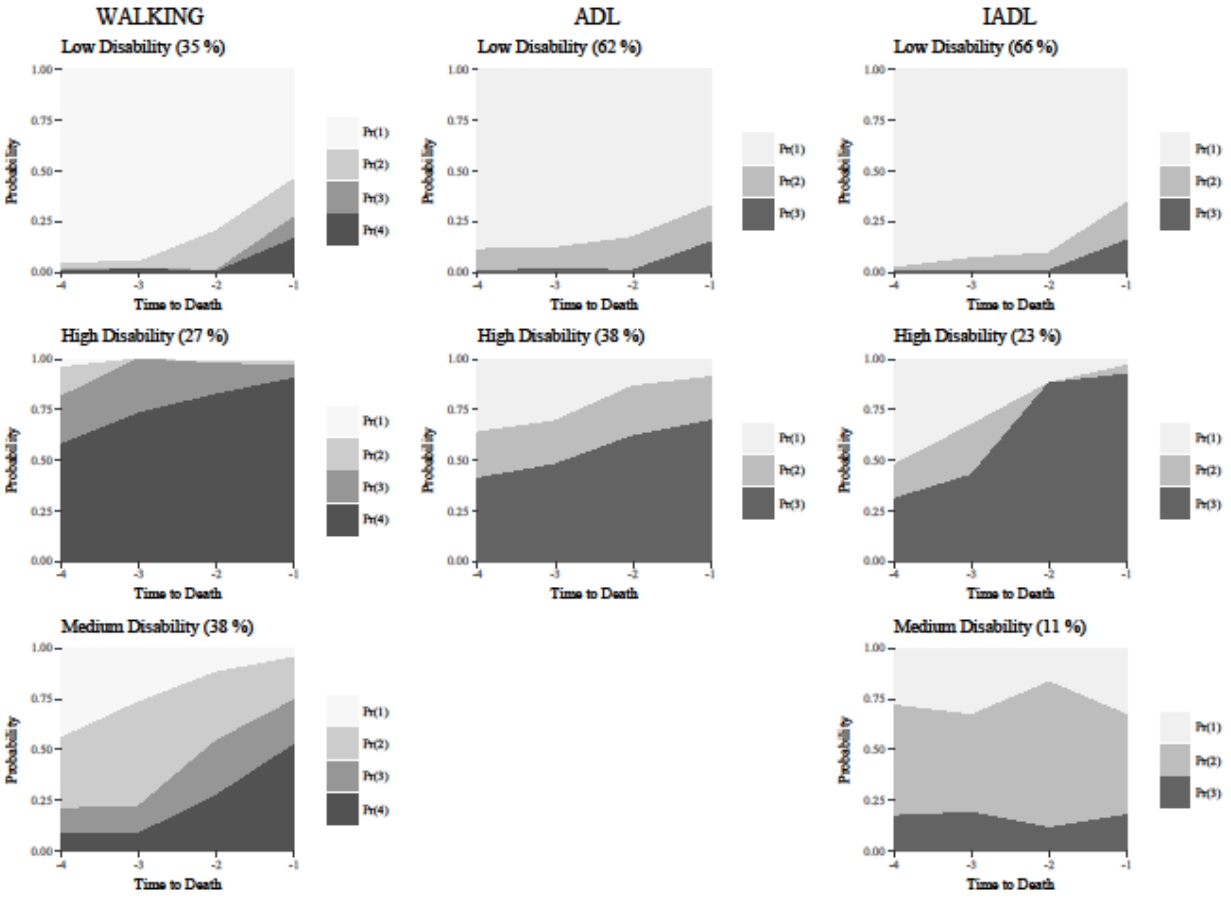

Table 1 Sample size in different waves and retention rates

	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Panel A					
N. of individuals (all sample)	12099	9432	9771	11050	10274
N. of individuals (for which we have data on previous waves, all sample)	12099	9324	7613	6367	5633
Panel retention (all sample)		*77%*	*81.6%*	*83.6%*	*88.5%*
Panel B					
N. of individuals dead after Wave 4 (for which we have data on previous waves - age 65 and above in period -1)	507	418	354	276	
Panel retention (dead after Wave 4)		*82.4%*	*84.7%*	*78%*	
Panel C					
N. of individuals dead after Wave 5 (for which we have data on previous waves - age 65 and above in period -1)		329	273	213	168
Panel retention (dead after Wave 5)			*83%*	*78%*	*78.8%*

Table 2 Descriptive statistics at the baseline (four periods before death) comparing the decedents in the sample and those who suffer attrition (excluding observations with missing data on SES)

	Present In All Waves			**Attrited**		
Variable	Mean / %	SD	N.	Mean / %	SD	N.
Male	49		437	46		384
Being Married (=1)	44*		437	51*		384
Age	76	7.8	437	76	7.2	384
Wealth	165916*	184264	437	141673*	165833	384
Income	195.9	135.8	437	190.5	114	384
Education	1.59*	0.76	437	1.49*	0.73	384
IADL	0.35	0.80	437	0.44	0.91	383
ADL	0.65	1.17	437	0.70	1.25	383
WALK	1.97	1.17	437	2.09	1.25	380

† p<.10; *p<.05; **p<.01; ***p<.001

Table 3 Model fit for different classes

Health outcome	N. latent classes	N. Parameters Estimated	G^2	Df	AIC	BIC	Log Likelihood
WALK	1	12	980.9	243	4437.1	4486	-2206.6
	2	25	396.3	230	3878.5	3989.3	-1914.2
	3	38	245.7	217	3753.9	3908.7	-1839
	4	51	190.1	204	3724.3	3932.1	-1811.2
	5	64	158.8	191	3719	3980	-1795.5
	6	77	136.8	178	3723	4037	-1784.5
	7	90	118.1	165	3730.4	4097	-1775.2
ADL	1	8	511.6	72	3337.1	3369.8	-1660.6
	2	17	125.2	63	2968.8	3038.1	-1467.4
	3	26	85.7	54	2947.2	3053.3	-1447.6
	4	35	62.4	45	2942	3084.8	-1436
	5	44	49.2	36	2946.7	3126.3	-1429.4
	6	53	35.7	27	2954.2	3167.5	-1422.6
	7	62	28.8	18	2962.4	3215.4	-1419.2
IADL	1	8	575.3	72	2974.4	3007	-1479.2
	2	17	180.2	63	2597.2	2666.6	-1281.6
	3	26	102.1	54	2537.2	2643.2	-1242.6
	4	35	59.8	45	2512.9	2655.7	-1221.5
	5	44	42.1	36	2513.1	2692.7	-1212.6
	6	53	32.1	27	2521.1	2737.4	-1207.6
	7	62	24.8	18	2531.8	2784.8	-1203.9

AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, G^2 = likelihood ratio/deviance statistics, Df = Degrees of Freedom

Table 4 Number of individuals classified in different classes for each disability indicator

		"Low Disability"	"High Disability"	"Medium Disability"
		IADL		
ADL	"Low Disability"	234	19	13
	"High Disability"	55	80	32
		WALK		
ADL	"Low Disability"	141	21	104
	"High Disability"	13	95	59
		IADL		
WALK	"Low Disability"	144	7	4
	"High Disability"	27	60	29
	"Medium Disability"	119	32	12

Table 5 Relative risk ratios for walking ability, ADL and IADL. Class 1 represents "Low Disability", 2 "High Disability" and 3 "Medium Disability".

	WALK		ADL	IADL	
	High vs. Low	Medium vs. Low	High vs. Low	High vs. Low	Medium vs. Low
Income Quartiles (ref. = lowest)					
Income Quartile 2	**2,723***	0,992	**1,781***	1,547	**3,887***
	(1,271 - 5,833)	(0,498 - 1,977)	**(1,039 - 3,051)**	(0,76 - 3,15)	**(1,358 - 11,13)**
Income Quartile 3	**2,838***	1,162	1,459	1,045	1,863
	(1,147 - 7,023)	(0,524 - 2,577)	(0,771 - 2,758)	(0,489 - 2,232)	(0,583 - 5,95)
Income Quartile 4	1,876	0,746	0,998	1,375	1,926
	(0,695 - 5,065)	(0,278 - 2,003)	(0,452 - 2,203)	(0,502 - 3,768)	(0,443 - 8,37)
Education (ref. = no qualifications)					
Education 2	0,750	0,573	1,219	1,038	1,291
	(0,318 - 1,317)	(0,34 - 1,233)	(0,7 - 2,124)	(0,501 - 2,148)	(0,477 - 3,496)
Education 3	0,729	1,061	1,254	1,284	0,511
	(0,372 - 3,014)	(0,727 - 3,937)	(0,63 - 2,496)	(0,548 - 3,004)	(0,105 - 2,489)
Wealth Quartiles (ref. lowest)					
Wealth Quartile 2	0,603	1,019	0,825	0,602	0,598
	(0,258 - 1,411)	(0,463 - 2,244)	(0,455 - 1,495)	(0,294 - 1,233)	(0,216 - 1,656)
Wealth Quartile 3	**0,221****	0,587	**0,478***	**0,200****	0,288
	(0,085 - 0,574)	(0,264 - 1,304)	**(0,246 - 0,931)**	**(0,082 - 0,49)**	(0,065 - 1,275)
Wealth Quartile 4	**0,324***	**0,323***	0,713	**0,370***	0,870
	(0,126 - 0,833)	**(0,121 - 0,866)**	(0,346 - 1,469)	**(0,146 - 0,938)**	(0,25 - 3,023)
Male	**0,336****	**0,486***	**0,600***	**0,506***	0,489
	(0,173 - 0,654)	**(0,272 - 0,868)**	**(0,378 - 0,951)**	**(0,278 - 0,922)**	(0,202 - 1,185)
Age	**1,069****	**1,058***	**1,030***	**1,086*****	1,011
	(1,028 - 1,113)	**(1,018 - 1,1)**	**(1,002 - 1,06)**	**(1,046 - 1,128)**	(0,96 - 1,064)
Married	0,678	1,030	0,902	**2,097***	**0,325***
	(0,328 - 1,401)	(0,572 - 1,857)	(0,55 - 1,479)	**(1,088 - 4,044)**	**(0,112 - 0,946)**
Intercept	**0,008****	**0,029***	0,083†	**0,001*****	0,142
	(0 - 0,225)	**(0,001 - 0,763)**	(0,007 - 0,946)	**(0 - 0,015)**	(0,002 - 10,403)
Observations	434		437	437	
AIC(3):	3710,648		2966,9	2508,2	
BIC(3):	3955,031		3081,2	2704,1	
$\chi^2(3)$:	395,5572		131,1	95,1	

Notes: 95 % confidence interval in parentheses and significant relative risk ratios in bold.

† p<.10; *p<.05; **p<.01; ***p<.001