Pathways to Death by Socioeconomic Status

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Abstract

Socioeconomic status plays an ambiguous role in later life health. We study health pathways using death as fixed end point and examine the trajectories preceding death. The central idea is that socioeconomic status has a critical role in shaping health in proximity to death partially irrespective of age. This approach allows us to make lose centrality to age. Data are from the English Longitudinal Study of Aging (Wave 0 - 5). Through latent class analysis the most common patterns leading to death are selected and analyzed. Using a multinomial logit model we see how different SES indicators predict belonging to a certain trajectory. This allows us to examine existing theories about SES and health. For example, accumulation of risk theory would predict a more abrupt decline in health for more advantaged groups. Three pathways emerged, and income, education and wealth seem to play different roles in explaining membership to these three patterns.
INTRODUCTION

While the general pattern of the 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 socioeconomic status across the life course. The ways in which socioeconomic status may be important for health and mortality in later life is one such area where still much is to be learned.

For instance, some scholars (Herd, 2006; House, Lantz, & Herd, 2005) have argued that differences in the association between socioeconomic status and health fade away as people age. Others (Dannefer, 2003; Ross & Wu, 1996) predict a divergent pattern in health disparity among socioeconomic groups as a result of the accumulation of risks during the life course. In most of the literature on socioeconomic difference in ageing, chronological age is the central dimension around which analyses are designed. As a consequence of this centrality of age, we have a relatively limited understanding of actual health trajectories in the last years before death (in contrast to trajectories in old age). Moreover, we know little about the socioeconomic differences in these pathways to death. What are the most common health pathways leading to death in old populations? How do these health processes in proximity to death vary among different socioeconomic groups?

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 health care policy perspective as the last years of life are the most expensive ones in terms of inpatient and social care costs (Bardsley, Georghiou, & Dixon, 2010). And thirdly, we can use these pathways, in which age is no longer central, to further our understanding of theories about socio-economic variation in health.

First, we contribute to the growing literature on SES and health in later life by taking time to death rather than age as the central dimension. The innovation here is to analyze health trajectories with respect to a fixed end point: death. Socioeconomic status might have a critical role in shaping these health trajectories to death irrespective of age. Although age represents one of the determinants for the health status in later life, health and chronological age are associated in an uncertain way in old age (Lloyd-Sherlock et al., 2012). Also in medical studies, age is gradually losing importance as determinants of biological ageing, and environmental and life style factors appear to be much more relevant in driving it (Belsky et al., 2015). As 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.” Already in 1987 Rowe and Khan (1987) advocated a less central role of age in geriatric studies which was too often used as the only sufficient
explanatory variable. Some extrinsic factors help to distinguish different pathways of health in later life and consequently to determine beyond the genetic factors the membership to successful or usual ageing trajectories. The second contribution of this study is the analysis of the explanatory power that traditional SES indicators have for health trajectories at the end of life. We take into account the multidimensionality of health outcomes and socioeconomic indicators. It has long been acknowledged that there are different mechanisms operating through different measures of socioeconomic positions (Cutler, Lleras-Muney, & Vogl, 2011; Torssander & Erikson, 2010). SES is linked in a more direct way to some dimensions of health, and in a more indirect way to others (Robert & House, 1996). It is therefore important to study whether and how the association between pathways and SES varies by chosen indicators of socioeconomic position and health.

The aim of this paper is to understand whether and to what extent health trajectories preceding death are shaped by socioeconomic differences. United Kingdom is the country on which we focus our work, therefore we use English Longitudinal Study of Aging (ELSA) data from Wave 0 to Wave 5. The analysis proceeds in three steps. First, we use latent class analysis to understand what the different pathways are. Next we study how different socioeconomic indicators help to predict the probability of experiencing a certain pathway (i.e. membership to the different latent classes). Finally, we address selectivity by matching individuals who die during the observation period to individuals with similar characteristics at the beginning of the period who survive. In this work we also examine whether socioeconomic status indicators are related differently to pathways to death compared to the usual health trajectories by age.

BACKGROUND

End of Life Trajectories

Studies of health trajectories in late life so far have focused on age- and cohort-related patterns of health measures (Lynch, 2003; Rohlfsen & Kronenfeld, 2014; Zimmer, Martin, Nagin, & Jones, 2012). Often the attention has been on disability trajectories in order to study compression of morbidity in later life, considering death just in term of attrition bias (Taylor, 2010). Only a small number of studies explicitly looked at trajectories preceding death. For instance, Gerstorf et al (2008) have analyzed decline in life satisfaction in the period prior to death. They challenge the idea that chronological age is the only useful indicator for describing the differences among individuals and find that distance to death is as useful as discriminator. Moreover, Gerstorf et al. (2013) compare the age and time-to-death perspectives for changes (decline) in six health domains (i.e.
cognitive, sensory, physical, health, social, and perceived control) in the Berlin Ageing Study. They study how between-person differences in socio-demographic characteristics and burden of pathologies are linked to health disparities in the different health domains. Growth curve models show that less advantaged socio-demographic characteristics and the presence of comorbidity and disability are correlated with lower health conditions at the baseline. Socioeconomic status was not associated with differential rates of declines. However, a composite index of education, occupational status, and income was used to examine socioeconomic status rather than examining separately the effect of different socioeconomic dimensions. Nevertheless, the most important result from this study suggests that the mortality-related perspective describes changes better compared than a age-related scale.

Liao, McGee, Kaufman, Cao, and Cooper (1999) explored socioeconomic differentials in morbidity and disability in the last years of life in a 1986-1990 US sample. They found that more educated individuals have better conditions in terms of activity limitations, chronic conditions, bed days, and hospital days in the years prior to death. These findings strongly suggest that health trajectories to death vary by socioeconomic status but Liao et al do not report actual trajectories. Other studies have looked at actual health trajectories to death of individuals in late life for various indicators of morbidity and disability levels; however, they have not related the observed patterns to the socioeconomic differences or have examined only short periods before death (Gill, Gahbauer, Han, & Allore, 2010; Guralnik, LaCroix, Branch, Kasl, & Wallace, 1991; Klijs, Mackenbach, & Kunst, 2010; Lunney, Lynn, Foley, & Lipson, 2003).

Xu et al. (2014) focus specifically on the population of old Americans with the aim of studying the joint trajectories of different health dimensions and the interaction between socioeconomic differences in health and age. They show convergence of health by education group as age increases. However, age does not seem to play a significant role in the association between financial variables and multidimensional health trajectories. Although the multidimensional approach to health offers interesting insights on the simultaneous ageing process in different domains, the joint consideration of the trajectories might obscure the different effects of SES on distinct health outcomes. In this study we consider only the most physical dimensions of health, excluding the cognitive and emotional ones. The association between socioeconomic status and separate physical health domains might help to highlight heterogeneous mechanisms.

The current study applies Latent Class Analysis (Collins & Lanza, 2010) with the aim of exploring patterns of physical functioning (FUNC), activities of daily living (ADL) and instrumental activities of daily living (IADL). Prior research has analyzed how socioeconomic position influences onset
and progression of health problems, often by imposing a priori parametric forms to the patterns and by examining them in terms of linearity of changes (Ferraro, 2011; Zimmer et al., 2012). The aim of this work is to extract from the data the most common pathways across the four periods preceding death. Since the survey is carried out every two years, the four periods represent eight years before death. The growth curve model widely applied to study disability trajectories (Taylor & Lynch, 2004) does not appear entirely appropriate for describing the pathways to death. In fact, Ferraro (2011) points out the episodic and nonlinear nature of health changes. Therefore, latent class analysis seems to be an adequate method for this analysis.

Cumulative Advantage and Compression of Morbidity in Health Trajectories

Cumulative advantage theory predicts health conditions in different socioeconomic strata will diverge with age because people with higher socioeconomic status experience a less sharp deterioration of health during life (Crystal & Shea, 1990; Dannefer, 2003). Evidence in support of this theory is provided by Ross and Wu (1996) who focus on how the relationship between health and education varies with age. Likewise, Lauderdale (2001) supports the accumulation-divergence hypothesis by finding widening educational differences in survival rates with age. Although Lauderdale's study is not able to completely separate age effects from period effects, educational differences seem to lead to diverging health outcomes in late life, supporting the idea of a social gradient in health across the full length of the life course. However, up to now cumulative advantage theory has always been applied on age-related scales. The same holds true for other hypothesis about the association between socioeconomic status and health in later life. For example, Taylor (2010) looks explicitly at the role of socioeconomic status in disability trajectories in old age. The results obtained through latent curve modeling confirm previous findings about how education and income generate different effects on health in old age (Zimmer & House, 2003). Education has a significant role in delaying the onset of disability whereas income acts as a protective factor and a moderator once the disability has arisen (Zimmer & House, 2003). Moreover, financial status also influences the slope of the disability over time. However, the effect on the slope is observed for the youngest cohorts, but it gradually decreases in the older ones. This decreased effect with age/cohoid might indicate that at the end of life the relevant metrics to measure health decline could be time-to-death instead of chronological age.

Therefore, we apply the cumulative advantage perspective to pathways of health using distance-to-death as the time metrics rather than chronological age. We test the presence of cumulative advantage in the terminal phase of life. Cumulative advantage may shape over age the level of health (Taylor, 2010), but also health trajectories towards death for different individuals. However,
to our knowledge, none has tested the presence of cumulative advantage in the end of life trajectories. The differential terminal paths among socioeconomic groups might indicate that compression of morbidity does not happen homogenously within a population. House et al. (2005) found that compression of morbidity takes place to different extents for individuals with a higher level of education compared to those with a lower educational attainment. Therefore, education and income predict differential compression and postponement of morbidity within a population (Herd, Goesling, & House, 2007). In particular, education seems to influence the onset of health problems, while income affects the progression rate. It is important to notice that other socioeconomic status indicators such as wealth and occupation are not commonly studied as stratification markers for health inequality in old age. Nevertheless, Robert and House (1994) show how liquid assets and home-ownership predict better than income and education the differences in functional health in old age. The compression of morbidity hypothesis initially proposed by Fries (1980) has always been tested with reference to chronological age. Therefore, our design makes it possible also to test directly compression of disability and functional health in the last periods of life for different age groups. Time-to-death substitutes age as a time variable, but the moderating role of age in the health and socioeconomic status relationship is taken into account.

To study the association between socioeconomic status and health in end-of-life trajectories, this analysis examines the effect of different socioeconomic indicators on the membership in latent classes. Socioeconomic status affects health through heterogeneous mechanisms during the life-course (Torssander & Erikson, 2010). Additionally, health conditions observed about eight years before death reflect the cumulative effect of life-course circumstances that have shaped the history of each individual up to the observed point. The observed trajectories could reveal how individuals cope through their socioeconomic status with increasing health problems as they approach death. Different socioeconomic indicators might affect dissimilarly the pathways to death, since they can affect individuals' resources or reactions in various ways. Given the explorative nature of this work and stepwise procedure for identifying trajectories it does not appear appropriate to formulate specific hypotheses concerning the association between health pathways and socioeconomic factors. In the following section we introduce some of the possible mechanisms that we expect to be in place for health outcomes in the pathways to death.

*Socioeconomic Mechanisms in the Pathways to Death*

First, education through human capital might influence disease management and lifestyle factors. For example, more schooling is associated also with better health behaviors such as smoking, obesity, and alcohol abuse. In the literature the reasons why education matters for health are
several: some have suggested the central role of information and higher willingness towards the adoption of innovative medical technologies, others the importance of cognitive ability in shaping health behaviors, and finally some have proposed the differences in preferences and in ability to change behaviors (for review see Cutler et al. (2011)). All these factors help in the accumulation of health advantages during the life course which would lead to better health outcomes in later life. Therefore, we expect that those with higher level of education are more likely to have better health for two reasons. First, education increases the ability to manage illness (for example, Lakwadalla and Goldman (2001) have found that the returns to education are much higher for chronically ill patients compared to healthy individuals). Second, highly educated people are proved to have greater take-up of new medical technologies, which could help to mitigate unfavorable health conditions in the end-of-life trajectories (Lleras-Muney & Lichenberg, 2002). Education in the terminal pathways represents both an important factor for the accumulation of health advantage over the life course and a positive mediating element in presence of increasing health troubles.

The financial resources taken into account in our analyses are income and wealth. Although they could seem very similar resources, they have heterogeneous functions and assume different meanings in the context of an old population (J. M. Poterba, Venti, & Wise, 2013; J. Poterba, Venti, & Wise, 2011; Wise, 1998). Income has primarily a purchasing function in daily life, since it fuels daily expenditures and a certain standard of living. Moreover, income might be used to save money for future expenses. We can see income as reflecting more the short-term aspect of the financial resources. Wealth can assume many other functions in addition to the purchasing one. It can have a insurance function for unexpected unfavorable events such as health shocks or unforeseen economic hardships. Moreover, for old individuals wealth can have also a bequest or inter-vivo transfers purpose: individuals might want to accumulate financial resources with perspective of transferring them to their closer connections later on. All these functions are inter-related and they can help to explain the mechanisms through which they could influence health outcomes in the end-of-life trajectories. Therefore, income and wealth might differ in their relevant time dimension. On one side, income represents short-term fuel for expenditures, which on a less extent reflects the accumulation of resources over the life course (even if it is still partially related to past earnings). Income for individuals older than 64 is mostly derived from pension (more than 70 % of the income in this group comes from state or private pensions). On the other side, wealth is a more accurate measure of the accumulation of advantageous conditions over the life course. These accumulated favorable circumstances might be also correlated with unobservable preferences such as a higher degree of risk aversion, which for example also leads to the accumulation of less risky behaviors during the life course and consequently better health outcomes in proximity to death.
Therefore, the goal is to see how different socioeconomic indicators predict the membership to certain trajectories of health outcomes. Our expectations are differential associations of the three SES indicators with the health trajectories observed in the data.

Finally, we apply a matching method in order to match individuals with similar characteristics five periods before death, and then we compare the trajectories for those who died at the end of the trajectories and those who were still alive. This comparison tests whether socioeconomic status predicts a differential path for those approaching to death compared to those subject to the normal ageing process. If the cumulative advantage effect has an impact specifically in the last period of life, we expect to see a differential effect of socioeconomic characteristics among these two groups.

DATA AND METHODS

Data

We use English Longitudinal Study of Aging (ELSA) from Wave 0 to Wave 5 as data source (1998). The sample consists of individuals who have died after Wave 4 or Wave 5 and for whom information about the previous four waves is available (i.e. the sample contains data from Waves 2-5 for individuals died after Wave 5 and Waves 1-4 for those who died between Wave 4 and Wave 5). Time is coded as distance to death (-1 stands for 1 period before death, -2 for 2 periods before death and so on). The distance between waves is approximately two years. This sample allows us to visualize trajectories across four periods before the death of the individual. For the third stage of the analysis, the data contains also individuals with similar characteristics five periods before death (i.e. Wave 1 or Wave 0), but who are still alive after period -1.

Our main analytic sample consists of 438 individuals of whom about 50 percent is female (225). The analysis includes only individuals older than 64 years. The mean age at period -1 is 80 and 83 for men and women respectively.

Socioeconomic and Health Variables

Information about the highest attained qualification is from Wave 0 for both subsamples. The individuals with foreign education are coded using as a proxy the age at which they finished full time education (education is equal to 1 if they never been in full time education or they were 14 or under, then equal to 2 if the age ranges between 15 and 17, finally when the age is 18 or 19 and over the educational level is imputed as 3).
Income and wealth information are derived from period -4. Monetary income is reported as weekly equivalent, and refers to the whole benefit unit. Wealth consists of the net total wealth at benefit unit level, which is the sum of savings, investments, physical wealth and housing wealth after financial debt and mortgage debt has been subtracted. 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. The different household size is considered using the OECD equivalence scale. Income and wealth are divided in quartiles (based on the total distribution of individuals older than 65). We provide more details on these variables in the appendix. Note that wealth can also assume negative values since is the net of different wealth indicators and debts. All the socioeconomic factors are included as dummy variables since the effects appear to be non-linear.

**Dependent Variables**

We use three different variables to depict the health status of individuals. The first two are indicators of activities of daily living (Martin, Schoeni, & Andreski, 2010; Montez & Hayward, 2014). Activities of Daily Living (ADL) refers more to the physical dimension of the everyday activities. The questionnaire asks to report the presence of difficulties in carrying out activities such as walking 100 yards or climbing one flight of stairs without resting. Instrumental Activities of Daily Living (IADL) involves everyday tasks which are not necessarily physically intense but require a good level of cognition as well, like using a map to figure out how to get around in a strange place, preparing a hot meal, and shopping for groceries. In the original data these variables take value zero if the individual does not show any difficulty, alternatively the number of difficulties reported. Some studies use this score by dichotomizing it (Cai & Lubitz, 2007) or by applying the number of limitations as a degree of impairment (Zimmer, Liu, Hermalin, & Chuang, 1998). We divide the values on these two variables in three groups. A similar approach was applied by Yang and Lee (2009), which divided the ADL score in 4 different levels of functional impairment. We divided the ADL and IADL scores in three levels of difficulty with activities of daily living low (less than 1), medium (between 1 and 3) and high (more than 4).

Our third indicator (FUNC) represents the degree of difficulty respondents have in accomplishing a specific physical task: walking for a quarter of a mile. We keep the original score of the survey: 1 no difficulty, 2 some difficulty, 3 much difficulty, and 4 unable to do this. Table A reports the descriptive statistics of the health variables in the four periods.
Although these indicators seem to measure a similar underlying disability condition, we include the three indicators separately in order to highlight different degrees of impairment. ADL and IADL difficulties are not only an assessment of physical capacity, but they also reflect more environmental and social factors compared to mere physical functioning (Freedman & Martin, 1998). Therefore, it seems appropriate to include the physical functioning to filter influences by social roles and environmental constraints. Similarly, ADL and IADL are used in this work as separate indicators because they can provide a more complete picture of health status in proximity to death. While ADL indicate difficulties in basic everyday activities, IADL represent a more broad indicator of impairment since they reveal more closely the environmental factors influencing the ability of living independently and the perception of disability (Spillman, 2004). Moreover, the difficulties in the instrumental activities of daily living are also related to cognitive components of health status. The different use of ADL and IADL scores and the separate analysis of different disability indicators represent important strengths of this work.

Methods

First, we apply latent class analysis (LCA) with the aim of exploring the most common pathways to death observed in the data and understanding how these trajectories are distributed and shaped. Second, we use multinomial logit model introducing socioeconomic characteristics as covariates, since they can point out the effect of socioeconomic characteristics on the membership to different classes. Recently, LCA has been used to examine intergenerational SES exposure (Scharoun-Lee et al., 2011) and health impairment trajectories during young adulthood (Pais, 2014). The focus on health trajectories in old age has been applied sometimes in medical research (Chang, Lu, Lan, & Wu, 2013), but none in this area has included so far the socioeconomic factors as key explanatory variables for the class membership. Additionally, we apply the Coarsened Matching Method (CEM) (Iacus, King, & Porro, 2009) in order to compare the individuals in the pathway to death and in the normal ageing process. This method represents an advantage compared to traditional methods since it allows choosing the maximum imbalance desired before estimating the model. Therefore, it is not necessary to run the model and check ex-post the imbalance obtained. The matching performed is one to one without replacement. The analyses are executed using R for LCA (Linzer & Lewis, 2011) and Stata for CEM (Blackwell, Iacus, King, & Porro, 2009).

Although the idea of a categorical latent variable was already present in the literature, LCA was comprehensively introduced by Lazarsfeld and Henry (1968). Following Lanza and Collins (2010), we briefly describe our latent class models. Our objective is to model three latent variables one for
each health dimension. Figure 1 presents a diagram to explain this relationship. One of the necessary assumptions is the local independence, meaning that the four observed variables are related only through the latent variable. Therefore, conditional on the latent class membership we assume that the variables are unrelated over time.

We estimate three separate models one for each health outcome $h = ADL, IADL, FUNC$. Each health outcome has four observed variables $h_t = (h_{t1}, h_{t2}, h_{t3}, h_{t4})$ with $r_{hti} = 1, ..., m$ response categories, where $m$ is equal to 3 (except for $FUNC$, where it is equal to 4) and $i = 1, ..., 4$. It is possible to identify from the data a vector of response pattern to the $m$ categories $y = (n_{ht1}, n_{ht2}, n_{ht3}, n_{ht4})$. $P(Y = y)$ represents the probability associated with each pattern of responses. The output from the latent class analysis leads to a set of latent class prevalence $\gamma$ and a vector of item response probabilities $\rho$. Therefore, $\rho_{hti}n_{hti}$ is the probability of response $n_{hti}$ to the observed variable $h_{ti}$. This set of parameters represents the accuracy of classification for individuals into latent classes given the observed variables (Collins & Lanza, 2010). The model is estimate 300 times and the maximum number of iterations for the estimation algorithm is set to 100 thousand in order to avoid local maxima and achieve convergence.

The Coarsened Exact Matching is an emerging technique for matching which has the advantage of being free from assumptions concerning the data generating process (except for the ignorability assumption meaning that the treatment is independent from the outcome). The method guarantees that "the imbalance between matched and treated groups will not be larger than the ex ante user choice" (Iacus, King, & Porro, 2012, p. 2). It represents an improvement compared to the widely used methods, since they need a number of unverifiable assumptions and the reduction of imbalance is not guaranteed. We apply this technique to generate a more heterogeneous sample which helps us to control for the confounding effect of selection into the mortality pattern.

RESULTS

Pathways to Death

Following the recommended practice for fitting latent class models (Nylund, Asparouhov, & Muthén, 2007), we estimate the model with different number of classes for each health variable. Then, the appropriate number of classes is defined by minimizing the Bayesian Information Criterion (BIC). Table 1 presents some statistics to evaluate the fit of different models.
From this analysis, three classes emerge for all health variables. Although the composition and prevalence of each class changes among different health measures, it is possible to identify three similar patterns. To begin with, the first classes present a general good health trend for the individuals belonging to them with a slight decline in the last period. Figure 1 presents the composition for different classes. On the x-axis we have time to death, whereas on the y-axis the probability of reporting different scores is shown. Each color represents the probability for a different score. The first class presents a high prevalence of no difficulties over the four periods. Individuals belonging to the first class (good health) have high probability of reporting no difficulty over the whole period. This group characterized by good health conditions in the four periods before death would have an abrupt decline just before death. A pattern of constant poor health (bad health) is evident in the second classes; the high level of health deterioration in all four periods before death is evident from the large prevalence of individuals with more than three ADL and IADL and with inability or severe difficulty in walking a quarter of mile. However, in the case of ADL difficulties the decline in prevalence of no difficulties starts from two periods before death. Another pattern is evident in the third classes which show medium level of impairment for different socioeconomic indicators. The probabilities of having medium impairment (gradual decline) represent the larger proportion of the total in all health outcome variables. Figure 1 presents the detailed stacked area plots where the groups are represented by different probability scores assumed by each variable.

The prevalence of the first pattern varies among the health outcomes. In the ADL model only 18 percent of the sample belongs to this class, whereas in the physical functioning one the percentage rises to around 34 percent. Concerning the poor health classes their prevalence in the sample ranges between 27 (FUNC, IADL) and 40 percent (ADL). The classes characterized by medium impairment have a much lower variation in the prevalence rate among models: 45 percent of the sample in the IADL model, 42 percent in the ADL one, and 39 percent in the physical functioning. Therefore, it results that the most common class among the different health outcomes is the medium impairment one.

**Predicted Pathways by Socioeconomic status**

After the estimation of the model with classes, we examine how socioeconomic status helps to predict the membership to different categories. This analysis draws attention to non homogenous results for different SES indicators. In particular, the odds of being in bad health class (Class 2)
rather than in good health (Class 1) for someone in the second, third or fourth income quartile are higher than the odds for someone in the lowest income quartile. The opposite result emerges for the wealth quartile: the odds of being in the poor health class rather than in the good one for someone in the second wealth quartile or above are lower than the odds for someone in the lowest wealth category. This result points out the fact that high income quartile implies higher probability of membership in the poor health class rather than in the good health in all health outcomes, while the opposite is true for wealth. Moreover, holding all the other factors constant, the odds of being in the third pattern of gradual decline (Class 3) rather than good health (Class 1) do not present any clear gradient for any socioeconomic indicator. Education and wealth play a quite similar role, although the coefficients are not significant for education in any of the model. Consequently, we obtain heterogeneous effects for different socioeconomic indicators. These results suggest that higher levels of wealth and education are associated with lower probability of being in the class characterized by bad health rather than good leading to an abrupt decline just before death. The results within different quartiles suggest the presence of non-linearity in the association between income and wealth. Surprisingly, a larger income quartile implies lower odds for being in bad health rather in the good health class compared to the lowest quartile. For example, the odds of a person in the second income quartile of being in the poor physical functioning health class rather in the good one are 3.53 times (3.93 for ADL and 3.53 for IADL) higher than the odds of a person in the first income quartile. The odds are slightly diminishing comparing those in the third and fourth income quartile with those in the first one.

From the analysis a specific role of income compared to wealth and education seems to emerge. High income quartiles which are not combined with high values of wealth do not seem to be associated with healthier pathways to death. This result could be a hint for the existence of specific mechanisms which both do not allow to save and produce poor health conditions.

By examining the odds ratios in Table 2 we also observe that men are less likely to be in bad health compared to good and they seem to have lower odds of experiencing a more gradual decline in all health outcomes. The results are in line with previous studies observing higher rate of functional limitations and disability for women during old age (Arber & Ginn, 1993; Case & Paxson, 2005), and they suggest that the pathways to death differ among the two groups. Unfortunately, further investigations of gender differences are limited by the sample size. For example, a male is 13 percent less likely than a female to be in the class of poor health relative to the good one in the case of ADL. Men appear to be more likely to experience a trajectory of good health compared to the constant poor, but they also experience less gradual decline compared to constant good health
status. Likewise, although the effect does not result significant in any of the models, married individuals have lower odds of being in bad health status or in medium impairment in almost all cases. The association between marital status and health, already well documented in the literature (Hughes & Waite, 2009; Liu, 2009), is only partially proved in this analysis. The role of age in the pathways to death seems to be as extensive as the socioeconomic indicators. In most of the cases age does not emerge as the only key determinant for driving the differences in class membership. However, an increase of one year in age leads to a rise of 6.6 per cent in the odds of being in bad health rather than good.

< TABLE 2>

Comparison with Matched Group

The aim of this part is to understand whether socioeconomic status has a different role at the end of life compared to the natural aging process. In order to achieve this goal, we replicate the analysis carried out in the previous points in an extended sample containing individuals still alive at the end of the period but with characteristics similar to dead individuals measured five periods before death. This sample will boost the original one providing stronger evidence for the specific socioeconomic influence in the terminal phase of life. We produce a matched sample that include the same number of control and treated individuals. The characteristics through which the individuals are exactly matched are three socioeconomic indicators (income quartile, education, and wealth), self-reported health (dichotomized in score equal to 1 if good or very good and equal to 2 if fair, bad or very bad), sex, marital status and age evaluated five periods before death (with the exception of wealth considered at period -4 since we do not have complete information for this indicator in the fifth period). The sample which results from this analysis has 528 observations almost exactly balanced with some slight difference concerning the age.

<TABLE 3>

First, we replicate the latent class analysis to understand what are the trajectories identified in the new dataset. The optimal number of classes in this sample according to the BIC is three for all the health outcomes. Although the pathways found are similar to the ones in the previous sample, their prevalence and composition changes slightly. For example, for the IADL indicator the prevalence of the class characterized by good health is much more common (38 %) compared to the sample with only deceased individuals (24 %). In the appendix the stacked area plots for all health outcomes are reported.
Secondly, the covariates and interaction terms between socioeconomic indicators and mortality status at the end of the period are included in the latent class analysis. This step is informative on the differential effect of socioeconomic indicators on the pathways to death respect to the normal ageing process. The interaction terms show how much the effect of socioeconomic status differs between dead and alive individuals in the sample. Individuals which experience death at the end of the period have a significant higher probability of being in the mixed and bad category compared to those still alive. The non-significant effects in the interaction coefficients in almost all models show that the socioeconomic indicators does not affect differently the class membership of dead and alive individuals. Although the interaction effect between higher educational category and mortality status results significant in most of the models, the difference in the predicted probabilities for those in the highest educational category does not result particularly evident from the analysis of the two samples. Similarly, the interaction with the fourth wealth quartile results significant in the IADL model, but leading to similar conclusions (results in appendix). From this analysis, we conclude that a difference in the association of SES with pathways to death is not clearly visible between dead and alive individuals.

CONCLUSIONS

Cumulative Advantage in Later Life and Compression of Morbidity by SES

The aim of this study was to understand the most common pathways leading to death without imposing a strong functional form in modeling the data. Latent class analysis emerges as a very useful tool in modeling trajectories at the end of life. Three patterns emerged from the analysis of physical functioning, ADL, and IADL. The first one is characterized by general good health over the four periods with a mild decline at the end of the period, which seems to suggest an abrupt decline just before death. The second pattern presents a high prevalence of poor health over the whole period. Finally, medium impairment characterizes the third pattern, which shows a decreasing prevalence of good health and increasing health decline. The prevalence rates of health outcomes vary by health outcome; however, the third class seems to be the most observed one.
The cumulative advantage theory predicts an accumulated differential between low and high SES individuals over the life course (Willson, Shuey, & Elder, 2007). The presented analyses tested the existence of this mechanism in the terminal health trajectories using distance-to-death as time metrics. The contribution of education for the accumulation of the advantage would manifest in an higher likelihood of belonging to the pathway of general good health and then an abrupt decline before death. However, this analysis suggests that education does not play a large role in creating a gradual decline by mitigating increasing health problems towards death as we expected since the results do not appear significant.

We expected that higher income was associated with greater likelihood of having gradual decline thanks to its purchasing function, which would mitigate unfavorable health circumstances in proximity to death. However, this does not seem to be the case, income does not appear as an effective predictor of gradual decline pathway. Wealth is strongly associated with a pathway of general good health and an abrupt decline just before death for all the health indicators. This may support the idea of wealth as a measure for the cumulative effect of advantage in the life-course and suggest its revealing role for individuals' unobserved preferences. Moreover, a weak role in predicting the gradual decline pathway emerges in the analysis of IADL. One of the possible explanations is the fact that wealth may serve as insurance function in case of unforeseen circumstances, and in particular it results helpful in mitigating difficulties in instrumental activities of daily living. Therefore, evidence for the effect of accumulated favorable circumstances in the end of life trajectories appears clear using wealth as indicator of cumulate advantage. Those who reach death in good health conditions seems to be also those who have higher level of net wealth. Education which helps individuals to accumulate wealth has a similar but non-significant effect. Wealth appears an appropriate socioeconomic measure for reflecting the accumulation of advantage/disadvantage over the life-course.

Therefore, the cumulative advantage seems to be verified when the socioeconomic indicator considered is wealth and to a lesser extent education. The effect of income on the membership in the good health class goes in the opposite direction compared to wealth and education. The specific role of income appears already clear in other studies (Herd et al., 2007). In this analysis being in a high income quartile does not represent an advantage in terms of pathway to death. In fact, higher income quartiles are associated with lower probabilities of good health over the period.

Our results strengthen the importance of the choice of the right socioeconomic indicator in later life in order to evaluate correctly the relationship with health. Although income can be considered one of fuels for the accumulation over the life-course, wealth reflects more accurately life circumstances
over time. The prolonged exposure to favorable economic conditions produces accumulation of resources and advantage. In turn, this will affect health trajectories at the end of life. Similarly, the compression of disability and physical functioning is evident for those with higher level of wealth and education. On the contrary, higher level of income does not guarantee a reduction of the time spent in poor health conditions. Education does not seem to have a predominant role in shaping the pathways to death. One of the possible explanations for this unexpected effect of education might be due to small number of observations in more educated groups. The probability of being in the mixed class produces heterogeneous results according to the health indicator considered. This suggests the high degree of heterogeneity in health outcomes for different individuals: some pathways are evident from the data whereas others are less distinct.

In order to reduce the selection into death of more disadvantaged individuals we adopt a matching strategy. The coarsened exact matching produces a sample containing people with similar characteristics to those deceased five periods before death. The analysis of this exactly matched sample reveals that most of socioeconomic gradients in the membership to classes are similar among alive and dead individuals. The only significant interaction effects are in highest educational category for all health indicators and in the largest wealth quartile for IADL.

**Strength and Limitations**

End of life trajectories are successfully described in this work. This analysis represents the first attempt to model pathways of health in the terminal phase of life without imposing any parametric form to the data. The relevance of the results for healthcare system are manifest because of the potential reduction of the high costs at the end of life. Moreover, this work represents an innovative application of cumulative advantage theory to pathways leading to death. We successfully test for the first time the relevance of this mechanism at the end of life using distance-to-death as time metrics. Age does not appear the only determinant for the terminal health trajectories even if the model control for its effect on class membership. In addition, the emphasis on multidimensionality both of health outcomes and socioeconomic indicators appears satisfactory. Different indicators show heterogeneous results that highlight the presence of several mechanisms operating through diverse channels. In particular, the opposite gradient between income and wealth/education for different health outcomes highlights the need for a separate consideration of the socioeconomic components to better understand the role of the accumulation of advantage over the life-course on health trajectories. The strength of this work is the ability to consider the role of diverse socioeconomic indicators on terminal trajectories for multiple outcomes. However, this analysis is not free from limitations. First of all, the space separating observed health outcomes is fairly large,
since we observe individuals every two years. Although the frequency of observations is suboptimal, it is still possible to extract major changes happening at the individual level. Second, we do not use the causes of death for this analysis despite they could be informative on the rate of decline. Gerstorf et al. (2013) studying mortality-related trajectories incur in the same drawback. However, the reliability of the stated cause of death is pretty low in older populations because of the high comorbidity rate in later life. Since the multiple diseases and health problems occurring in old age are highly interrelated, it is hard to recognize the true cause of death also for medical professionals. Nonetheless, the reasons behind death might be informative about the rate of decline for each individual. A recent analysis of trajectories of self-reported health preceding death points out the high prevalence of poor health already between 13 and 15 years before when the registered causes of death are ischemic and other cardiovascular disease, non-smoking related cancers, and external causes of death (Stenholm et al., 2015). On the contrary, for the individuals for which the cause of death is identified as non-ischemic heart diseases the increase in poor self-reported health occurs steeply just in proximity to death. Although this analysis does not take into account the causes of death, it is important to remark that also the distribution of these diseases might be socially patterned, and consequently the decline would reflect this allocation. For example, more advantaged individuals would be more likely to die because of some diseases, whereas disadvantaged individuals would have more frequently other causes of death. Future research needs to investigate more in-depth the role of different socioeconomic indicators in the health trajectories by cause of death. Moreover, the study of the role of socioeconomic status at the end of life might require the interaction among multiple socioeconomic indicators. The intersection of different socioeconomic conditions rather than a singular factor could lead to certain health trajectories at the end of life. For example, Hoffman (2004) has already proposed this idea for studying mortality risk in old age. He has found that wealth reduces mortality risk in combination with middle and high education and similarly high education produces benefits for individuals having at least average wealth. The application to terminal trajectories would bring additional knowledge concerning the mechanisms producing health inequalities at the end of life.
### Table 1 - Model fit for different classes

<table>
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<tr>
<th>Health outcome</th>
<th>N. latent classes</th>
<th>N. Parameters Estimated</th>
<th>$G^2$</th>
<th>Df</th>
<th>AIC</th>
<th>BIC</th>
<th>LL</th>
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<td>3908.7</td>
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<td>190.1</td>
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<tr>
<td></td>
<td>5</td>
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<td>191</td>
<td>3719</td>
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<td></td>
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<td>77</td>
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<td>178</td>
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<td>4037</td>
<td>-1784.5</td>
</tr>
<tr>
<td></td>
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<td>90</td>
<td>118.1</td>
<td>165</td>
<td>3730.4</td>
<td>4097</td>
<td>-1775.2</td>
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<td>54</td>
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<tr>
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<td>45</td>
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<td>2902.1</td>
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<td>IADL</td>
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<td>3322.5</td>
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<td>104.7</td>
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<td>69.9</td>
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<td></td>
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<td>24.6</td>
<td>18</td>
<td>3195.6</td>
<td>3448.7</td>
<td>-1535.8</td>
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</table>
Figure 1 - Three Latent Classes for FUNC, ADL and IADL. FUNC is the degree of difficulty respondents have in accomplishing a specific physical task: walking for a quarter of a mile (1 no difficulty, 2 some difficulty, 3 much difficulty, and 4 unable to do this). In the case of ADL and IADL, a score of 1 represents no difficulties, a score of 2 between 1 and 3 difficulties and finally a score of 3 more than three difficulties.
<table>
<thead>
<tr>
<th></th>
<th><strong>FUNC</strong></th>
<th></th>
<th><strong>ADL</strong></th>
<th></th>
<th><strong>IADL</strong></th>
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<tbody>
<tr>
<td></td>
<td>Class 2 / Class 1</td>
<td>Class 3 / Class 1</td>
<td>Class 2 / Class 1</td>
<td>Class 3 / Class 1</td>
<td>Class 2 / Class 1</td>
</tr>
<tr>
<td>intercept</td>
<td>0,009 (0,001 - 0,145)</td>
<td>0,040 (0,003 - 0,616)</td>
<td>0,341 (0,018 - 6,615)</td>
<td>0,094 (0,003 - 2,793)</td>
<td>0,006 (0 - 0,103)</td>
</tr>
<tr>
<td>male</td>
<td>0,306 (0,176 - 0,533)</td>
<td>0,476 (0,29 - 0,779)</td>
<td>0,138 (0,073 - 0,26)</td>
<td>0,363 (0,187 - 0,703)</td>
<td>0,339 (0,192 - 0,598)</td>
</tr>
<tr>
<td>age_t1</td>
<td>1,066 (1,032 - 1,102)</td>
<td>1,053 (1,019 - 1,088)</td>
<td>1,043 (1,004 - 1,082)</td>
<td>1,055 (1,012 - 1,1)</td>
<td>1,073 (1,037 - 1,11)</td>
</tr>
<tr>
<td>inc_q2</td>
<td>3,526 (1,893 - 6,57)</td>
<td>1,156 (0,653 - 2,047)</td>
<td>3,393 (1,621 - 7,1)</td>
<td>1,146 (0,539 - 2,435)</td>
<td>3,586 (1,873 - 6,869)</td>
</tr>
<tr>
<td>inc_q3</td>
<td>3,060 (1,348 - 6,948)</td>
<td>1,282 (0,598 - 2,748)</td>
<td>2,493 (1,027 - 6,052)</td>
<td>1,677 (0,694 - 4,056)</td>
<td>2,704 (1,196 - 6,11)</td>
</tr>
<tr>
<td>inc_q4</td>
<td>2,356 (0,983 - 5,649)</td>
<td>0,958 (0,387 - 2,372)</td>
<td>1,937 (0,717 - 5,237)</td>
<td>1,428 (0,54 - 3,778)</td>
<td>2,775 (0,988 - 7,79)</td>
</tr>
<tr>
<td>edu2</td>
<td>0,670 (0,364 - 1,234)</td>
<td>0,526 (0,301 - 0,919)</td>
<td>0,630 (0,329 - 1,21)</td>
<td>0,615 (0,319 - 1,182)</td>
<td>0,903 (0,459 - 1,778)</td>
</tr>
<tr>
<td>edu3</td>
<td>0,593 (0,258 - 1,361)</td>
<td>0,907 (0,459 - 1,792)</td>
<td>0,543 (0,231 - 1,276)</td>
<td>1,007 (0,468 - 2,165)</td>
<td>0,959 (0,434 - 2,122)</td>
</tr>
<tr>
<td>wealth_q2</td>
<td>0,456 (0,229 - 0,904)</td>
<td>0,818 (0,435 - 1,536)</td>
<td>0,398 (0,178 - 0,891)</td>
<td>0,703 (0,319 - 1,548)</td>
<td>0,356 (0,174 - 0,728)</td>
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<td>wealth_q3</td>
<td>0,303 (0,141 - 0,654)</td>
<td>0,719 (0,371 - 1,393)</td>
<td>0,400 (0,161 - 0,998)</td>
<td>0,851 (0,352 - 2,056)</td>
<td>0,252 (0,109 - 0,581)</td>
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<tr>
<td>wealth_q4</td>
<td>0,432 (0,184 - 1,017)</td>
<td>0,440 (0,181 - 1,069)</td>
<td>0,200 (0,076 - 0,527)</td>
<td>0,253 (0,095 - 0,671)</td>
<td>0,273 (0,11 - 0,675)</td>
</tr>
<tr>
<td>married_t4</td>
<td>0,631 (0,351 - 1,132)</td>
<td>0,955 (0,583 - 1,562)</td>
<td>0,632 (0,347 - 1,151)</td>
<td>0,675 (0,379 - 1,201)</td>
<td>0,939 (0,519 - 1,699)</td>
</tr>
</tbody>
</table>

Table 2 - Odds ratio for physical functioning, ADL and IADL. Class 1 represents good health, Class 2 poor and Class 3 mixed health. 90% confidence interval in parentheses and significant odds ratio in bold.
alive mean (0)  dead mean (1)  mean (0) - mean (1)  obs
inc_quart_t5  2.465909  2.465909  0  528
married_t5  0.564748  0.5647482  0  556
sah_t5  1.415162  1.415162  0  554
age_t1  80.21223  80.22302  -0.01079  556
educ_3a  1.485612  1.485612  0  556
wealth_quart_t4  2.003597  2.003597  0  554
sex  1.557554  1.557554  0  554

Table 3 - Imbalance between sample of individuals still alive after 5 periods and original sample

<table>
<thead>
<tr>
<th></th>
<th>FUNC</th>
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<th>IADL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample 1</td>
<td>Sample 2</td>
<td>Sample 1</td>
</tr>
<tr>
<td>Class 1</td>
<td>34 %</td>
<td>36 %</td>
<td>18 %</td>
</tr>
<tr>
<td>Class 2</td>
<td>27 %</td>
<td>24 %</td>
<td>40 %</td>
</tr>
<tr>
<td>Class 3</td>
<td>39 %</td>
<td>39 %</td>
<td>42 %</td>
</tr>
</tbody>
</table>

Table 4 - Estimated Class Population Shares in the Original and Matched Samples with Covariates

Figure 2 - Three Latent Classes for Physical Functioning in Matched Sample
Figure 3 - Predicted probabilities of class membership for dead and alive individuals in the highest educational category for physical functioning, ADL, and IADL indicators

REFERENCES


APPENDIX

Income quartiles and net total wealth

<table>
<thead>
<tr>
<th>Variable</th>
<th>-4</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
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<tr>
<td></td>
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<td>Mean</td>
<td>Obs</td>
<td>Mean</td>
</tr>
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<td>1.98</td>
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<td>2.15</td>
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<td>2.22</td>
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<tr>
<td>IADL</td>
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<td>1.62</td>
<td>438</td>
<td>1.69</td>
</tr>
</tbody>
</table>

Descriptive statistics health outcomes
Three Latent Classes for ADL and IADL in Matched Sample

Predicted Probabilities of class membership in the matched sample for the dummy variable wealth quartile 4 for the IADL indicator