Variation in end-of-life hospital spending in England: Evidence from linked survey and administrative data

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Abstract

Much of lifetime healthcare spending is concentrated at the end of life. This paper uses survey data linked to administrative hospital and mortality records to examine how the pattern of end-of-life hospital inpatient spending varies across different groups in England. We find that the pattern of end-of-life spending varies across household composition and socioeconomic status. Quarterly spending increases more sharply for those in couples at the end of life: a 10% reduction in time to death is associated with a 10% rise in individual spending among couples, but only 8% for singles. Spending is also lower in the last 18 months of life for those with no formal qualifications relative to their more educated peers due to lower use of elective care. Differences across groups are not explained by differences in observed morbidity or cause of death, but could be explained by differential access to, or preferences for, care. Given recent trends towards increased cohabitation at older ages and higher educational attainment, these results suggest that policymakers should consider a broader range of sociodemographic attributes when forecasting future health spending and in evaluating inequity in healthcare use.

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1 Introduction

End-of-life medical spending has attracted substantial interest from academics and policymakers in recent years. It is well established that much of medical spending is concentrated in the final years of life (French et al., 2016), and that when controlling for time to death, age is only weakly related to high medical costs (Zweifel et al., 1999; Felder et al., 2010; Howdon and Rice, 2018). This has led to renewed debate about the extent to which medical spending will rise as the population ages: if large medical costs are delayed until the end of life then the growth in spending associated with increases in life expectancy may be smaller than the projected changes in the size of the older population would suggest.

Previous studies have used the hospital records of decedents to examine the relationship between medical spending, age and time to death. This literature concludes that time to death, and not age, is strongly related to medical spending (Zweifel et al., 1999; Felder et al., 2010; Howdon and Rice, 2018), while time to death itself is likely to be a proxy for declining underlying health (Howdon and Rice, 2018). However, much less is known about how the relationship between spending and time to death is related to wider patient characteristics such as household composition and socioeconomic status. As the characteristics of the population evolve over time, understanding these relationships is important in planning for and meeting future healthcare costs, and in understanding whether use of medical care is equitably distributed across different parts of society.

This paper examines how the relationship between inpatient hospital spending and time to death varies across different groups within the older population in England. We use a novel dataset that links survey responses from the English Longitudinal Study of Ageing (ELSA) with administrative hospital records from the Hospital Episode Statistics (HES). This allows us to analyse the relationship between health spending, age, time to death, and a number of demographic, socioeconomic and health characteristics in more detail than previously possible. In particular, we extend the existing literature by examining how the relationship between spending and time to death varies across those living with and without a partner, and across socioeconomic status as proxied by educational attainment.

We have four main findings. First, there is a strong association between inpatient spending and time to death, with large increases in spending in the last two years of life. This pattern remains even after controlling for a range of sociodemographic variables, an extensive list of self-reported health measures and administrative records of comorbidities, and cause of death. Our baseline estimates suggest that after taking these factors into account, a reduction of 10% in time to death is associated with a 9% rise in quarterly spending. This is driven by large increases in spending in the last year of life. In contrast, when controlling for time to death there is little evidence of a positive relationship between spending and age. This is in line with previous findings that age is likely to be a proxy for reduced time to death and worse underlying health, rather than an independent driver of medical costs in of itself.

Second, the increases in spending at the end of life are driven primarily by increases in emergency rather than elective (pre-planned) treatment. A 10% reduction in time to death is associated with a 9% increase in emergency spending when controlling for other factors. This compares to a 0.7% increase for elective spending for the same reduction in time to death.

Third, there is meaningful variation in the magnitude and timing of spending across those who live with a partner and those who are single. After controlling for differences in health across groups, the elastisticity of health spending with respect to time to death is 25% greater for those in couples relative to singles: a 10% reduction in time to death is associated with a 10% rise in quarterly spending among individuals living with a partner but only 8% for those not in a couple.

Finally, spending also varies across educational attainment. For a 10% reduction in time to death, our estimates indicate that spending increases by 8% for those with no compulsory education, and 9% for all others with greater educational attainment. These differences are driven by lower elective spending among the low education group in the final years of life.

We also repeat our analysis using a non-parametric specification to further examine the timing of spending across groups. This shows that the differences in spending across singles and couples, and across education groups, is most pronounced in the last 18 months of life, with higher spending for couples and the more educated group. The differences across groups are not explained by observed differences in morbidity or cause of death, but could instead be explained by unobserved changes in health across groups at the end of life, differential access to care, or variation in the preferences for treatment.

These findings are informative for improving the accuracy of current approaches to forecasting future health spending. Existing approaches tend to use information on age, sex, time to death, and changing morbidity to forecast future spending pressures.[1] However, our findings show that household composition and socioeconomic status contain additional information about spending at the end of life. While these factors may simply be proxies for unobserved differences or changes in morbidity, they remain more easily observed than the potential underlying changes in the health of the population. Given recent trends in these characteristics across cohorts, with increasing rates of cohabitation at older ages due to increased male life expectancy (Emmerson et al., 2014) and increasing educational attainment, factoring these changes into forecasts of health spending may improve the accuracy of such models. For example, our estimates suggest that the increasing trend towards living with a partner at older ages was associated with an increase of 1% in overall spending on people in the last 18 months of life between 2002 and 2014. If this trend continues then end-of-life spending is likely to continue to rise. Factoring in these trends could therefore improve the accuracy of future forecasts.

This paper contributes to two literatures. First, we contribute to the 'red herring' literature that examines the roles of age and time to death in determining health spending (Zweifel et al., 1999; Werblow et al., 2007; Felder et al., 2010; Wong et al., 2011; Howdown and Rice, 2018) by extending previous work to examine how the relationships between spending and time to death vary across different groups in the population. Second, we contribute to a literature that examines variation in the use of healthcare across different socioeconomic groups (van Doorslaer et al., 2000; van Doorslaer et al., 2004; Morris et al., 2005) by analysing changes in spending across groups at the end of life after taking into account observed changes in health.[2]

[1] For a discussion and recent examples of health spending forecasts in the UK, see Licchetta and Stelmach (2016) and Charlesworth et al., (2018).

[2] This also relates to a literature that looks at variation in spending across different groups in England (Aragón et al., 2016; Kelly et al., 2016) but did not take into account observed differences in health due to data constraints.

The rest of the paper is organised as follows. Section 2 outlines the institutional background, and describes the data. Section 3 describes patterns in the timing and levels of spending over the last five years of life, and how this varies across groups. Section 4 sets out an empirical strategy to examine the relationship between spending and time to death while controlling for other observable differences across patients. Section 5 presents our results. Section 6 concludes.

2 Background and Data

2.1 Institutional background

The vast majority of healthcare in England is provided free to all residents by the National Health Service (NHS). Care is funded by the government through general taxation, and eligibility for treatment is not linked to income or tax payments. Primary care is provided by General Practitioners (GPs), who provide basic treatments in the community and act as gatekeepers for secondary (or hospital) care, which is provided by large, publicly owned NHS hospitals.

There are three main types of hospital care. Emergency departments, known as Accident and Emergency (A&E) departments, provide urgent care to patients who arrive at the hospital when care is required. Upon arrival, patients are triaged and after recieving basic treatment and investigations, are either discharged home or admitted to hospital for further treatment.

Outpatient care is provided to patients at hospitals without those patients being admitted. This includes visits to senior doctors (consultants), undergoing diagnostic tests, and some basic treatments that do not require a prolonged stay in hospital. Referral to an outpatient appointment is usually obtained from a GP or from another hospital consultant.

Inpatient care is provided to patients who are admitted to hospitals. Treatment is either elective (pre-planned) or emergency. Elective treatment involves a pre-planned hospital spell, often for a surgical procedure. Elective care is rationed by waiting times and typically requires a referral from a GP and an initial outpatient appointment with a hospital consultant. Emergency treatment is not pre-planned, and usually follows a visit to A&E by the patient.

This paper focuses on public spending on inpatient hospital care. In 2017/18, this accounted for 52% of total hospital spending, and is therefore an important component of overall medical spending (NHS Improvement, 2018). However, it is important to note that the analysis does not include spending on broader medical care - including primary care and drugs outside of the hospital - or on long-term (social) care due to data constraints. Both formal and informal social care costs may be considerable at the end of life - particularly for certain conditions - and better data collection and study of these costs are an important avenue for future research.

2.2 Data sources

Our analysis is based on a dataset that links survey information from the English Longitudinal Study of Ageing (ELSA) with official death registration data from the UK Office for National Statistics (ONS) and the administrative hospital records contained in the Hospital Episode Statistics (HES). This represents a large data advance on the data available for previous studies, using for the first time a dataset that allows us to study the relationship between mortality and health spending with individual information on socioeconomic and health status alongside detailed administrative information on hospital use and mortality outcomes.

2.2.1 English Longitudinal Study of Ageing

ELSA is a panel survey of a representative sample of the English household population aged 50 years and above. Beginning in 2002/03, respondents are re-interviewed every two years. In this paper, we use data from the first six survey waves (2002/03 - 2012/13).

Information is collected through computer-assisted interviews with a trained interviewer and a self-completed questionnaire. Each survey wave covers a broad range of topics, including the demographic and socioeconomic characteristics of respondents, and a variety of objective and subjective measures of their health. This includes the age and sex of the respondent, household composition and educational attainment. We use information on the household composition to classify respondents into those who are single and those who live with a partner. We use information on educational attainment to proxy for socioeconomic status. Educational attainment is largely time invariant, and therefore will not change in response to health shocks (Grundy and Holt, 2001).[3] We classify respondents into two education groups: those who have formal qualifications (high) and those who do not (low).

The survey also includes information on the underlying health of respondents. This includes in every wave: a self-reported measure of health status that we classify into a three point scale[4]; the number of self-reported mobility difficulties; the number of self-reported difficulties with activities of daily living (ADLs) and instrumental activities of daily living (IADLs); and indicators of whether the respondent has ever been diagnosed with 19 different medical conditions by a doctor.

ELSA data are also linked to the Office for National Statistics mortality records. These records contain the month and year of death, in addition to the primary cause of death, which is classified into four broad categories: cancer, cardiovascular disease, respiratory disease, and other causes. There is information on deaths up to April 2018. By linking this to ELSA-HES we are able to describe how inpatient spending changes as someone approaches death.

2.2.2 Hospital Episode Statistics

HES contains the census of visits to publicly funded hospitals in England. Using a pseudonymised unique identifier for each ELSA respondent, we are able to link responses to the ELSA survey to administrative hospital records at an individual level. These records include all inpatient admissions from April 1997 to April 2018.

Inpatient records are reported at the episode level, defined as a continuous period of care under the responsibility of a single consultant. They include admission and discharge dates, diagnosis codes and details on the procedures undergone by the patient. They also include

[3]For this reason, we prefer this measure to current income, which may fall as health spending increases if underlying health affects the ability to work.

[4]For all waves apart from wave 3 (2006) the Health & Retirement Study (HRS) measure was used. In wave 3 the HRS measure was not asked so we use the Health Survey for England (HSE) measure instead. We create a 3-point measure across waves: (i) excellent/very good, (ii) good, and (iii) fair/poor/bad/very bad.

an admission method for each episode, which we use to categorise inpatient treatment into emergency and elective (pre-planned) treatment.

Hospitals receive fixed payments for providing most types of care to patients according to their Healthcare Resource Group (HRG).[5] These payments are established by a national set of tariffs that are meant to reflect the average cost of providing these treatments, with some adjustments for longer-than-expected length of stays and geographical variation in costs. However, some treatments will not attract a national cost, and are instead subject to (unobserved to the researcher) local price negotiation between hospitals and local commissioners.

We therefore assign costs to all activity in the following way. First, we use the 2014-15 set of tariffs to calculate costs for each patient with a valid HRG in the full 2014-15 inpatient HES dataset. Second, we take the average cost for elective and emergency patients with each primary operation, and costs for elective and emergency patients with each primary diagnosis. This yields 13,000 primary operation-elective categories and 15,000 primary diagnosis-elective combinations. Episodes with a primary operation code are assigned costs based on the first measure. In cases where operation codes are missing, episodes are assigned a cost based on the second measure.[6] This makes the cost of a particular treatment fixed over time. Any changes in costs across time therefore accurately reflect changes in activity rather than the tariffs paid by the government to NHS hospitals. All costs are reported in 2018-19 prices, converted using the December 2018 GDP deflator.

2.3 Sample construction

We conduct our analysis using a sample of ELSA respondents aged 50 years and above who consented for their hospital records to be linked to their survey answers, and who died five years (or more) after their initial interview. The sample is constructed at the person-quarter level. We assign hospital spending to specific quarters prior to death based on the date of admission. Some hospital visits also take place over long periods, and potentially, across different quarters. We assign spending to each quarter based on the share (in days) of the admission that takes place in a given quarter.[7]

Mortality and HES data are available up to April 2018, and the earliest ELSA interviews took place in March 2002. As a result, we restrict our sample to those who died between March 2007 and April 2018. This gives us a final sample of 2,571 respondents who we follow for 20 quarters (5 years) before their death (51,420 observations).

80% of ELSA respondents (comprising 85% of observations across all waves) provided consent for their hospital records to be linked to their survey responses. The consenting sample is slightly younger and slightly healthier than the full ELSA sample. To maintain population representativeness, we therefore weight all analysis using adjusted cross-sectional survey weights attached to a respondent's initial interview. ELSA includes cross-sectional inverse probability

[5] HRGs group together procedures and conditions with similar costs. These are similar to Diagnostic-Related Groups (DRGs) in the US.

[6] 99.3% of inpatient episodes can be costed using these two methods. We exclude the remaining episodes from our analysis.

[7] All results are robust to assigning all spending to the quarter in which the initial day of admission takes place.

weights to scale observations to the nationally representative level. We re-weight observations to allow for selection into the consenting sample on the basis of observable characteristics.[8]

3 Patterns in end-of-life spending

In this section we describe how spending evolves over the last five years of life. We examine how this differs by admission type (emergency or elective), and how it varies across different groups on the basis of household composition and educational attainment.

Figure 1 shows mean inpatient spending over the last 5 years of life. Panel A shows spending in each quarter and Panel B shows cumulative spending over the period (summed backwards from the time of death). Mean spending over the five years was £18,565. Spending is relatively flat between one and five years prior to death, with sharp increases in spending in the last year of life. Mean spending was £3,381 in the last quarter of life, equivalent to 18.2% of spending over the five year period. Mean spending in the final year of life was £8,793, or just under half (47.4%) of spending over the entire period.

Figure 1 also breaks down spending by whether treatment is emergency or elective (pre-planned). 20 quarters prior to death, mean emergency spending was £250 and mean elective spending was £126. In the final quarter of life, emergency spending had increased to £3,189 (94% of total spending in that quarter). Elective spending was £192. So while elective spending does increase a little over the period, peaking at spending of £289 in the quarter prior to death, the vast majority of spending increases at the end of life are driven by growth in emergency spending.

The patterns of spending at the end of life may differ across people with different characteristics. We therefore examine how these profiles of spending over the last five years of life differ across two particular dimensions: whether the respondent lives with a partner or alone; and their educational attainment.

Figure 2 shows spending over the last five years of life by whether the respondent lived with a partner at the start of the period. Panel A shows quarterly spending and panel B shows cumulative spending. Spending on individuals living with a partner ('couples') was £19,046. Spending on those without a partner ('singles') was £18,016. However, the relative level of spending varies at different points of time. Spending 10-20 quarters prior to death is consistently higher among singles, and spending is similar for the four quarters after that. Spending is then noticeably higher for those living in couples in the last 18 months of life.

There are also differences in the pattern of emergency and elective spending across these groups. Figure 3 shows quarterly spending for emergency (panel A) and elective (panel B) spending separately. The pattern in emergency spending reflects the pattern observed in the total data. Interesting, elective spending is always higher among those in couples, but these differences increase substantially in the final 18 months of life. Mean elective spending for the whole period is £4,290 for someone living with a partner, compared to £2,424 for someone who does not. In the final year of life, elective spending for these two groups was £1,265 and £651

[8]We use a probit regression to estimate the relationship between consent and the full set of ELSA controls used in our analysis to predict presence in the sample. We then multiply predicted participation by the inverse of the existing weights to produce updated inverse probability weights.

respectively.

Figure 4 shows spending over the last five years of life separately by education group. Individuals in the 'low education' group are those without formal qualifications. Panel A shows quarterly spending and panel B shows cumulative spending. Total spending is similar across the two groups, with slightly higher spending for the high education group (£18,879) than those in the low education group (£18,316). However, this again masks differences in the timing and types of spending across the two groups. Spending is slightly lower for the high education group up until two years prior to death, after which it is consistently higher. Figure 5 shows quarterly spending separately on emergency and elective treatment. This shows little difference in emergency spending over the period, while elective spending is consistently higher among the high education group in the final two years of life.

These different patterns in spending across different groups - and particularly for elective care - could reflect a number of mechanisms. First, partners may provide informal care, and reduce the necessity for emergency hospital care at an earlier stage in life. Second, there may be differences in access to care across couples and singles, and across education groups. The presence of a partner may help someone to navigate the system, or aid them to attend hospital appointments. Higher levels of education may also allow a patient to engage better with their care (e.g. through greater adherence to treatment) or to better navigate the health system. Finally, variation in spending may also reflect a difference in preferences for care. Patients with partners or higher levels of education may be more willing to continue with treatment for longer, and this could be reflected in higher expenditures in the final quarters of life.

4 Empirical strategy

The differences in the profile of end-of-life spending across groups may be explained by a variety of related factors, including differences in the underlying health of people across groups and time to death. In this section, we set out an empirical strategy that examines the relationship between spending and time to death across different groups of interest, while controlling for other observed differences in characteristics.

To do this we follow the existing literature (Zweifel et al., 1999; Howdon and Rice, 2018) and estimate the following baseline specification for hospital spending on person i, t quarters before death:

$$log(cost_{it}) = \psi Age_{it} + \beta X_{it} + \theta log(TTD_{it}) + \gamma Health_{it} + T_t + \epsilon_{it} \quad (1)$$

$Log(cost_{it})$ is the natural logarithm of inpatient costs for person i that fall in quarter t.[9] Age_{it} is the age of the respondent at the start of the quarter, entered in five year age bands.[10] X_{it} is a vector of sociodemographic controls including sex, whether the respondent lives with a partner at the start of the period, and their educational attainment. $Log(TTD_{it})$ is the natural logarithm of the number of quarters until death (ranging from 1 to 20) for person i in quarter

[9]We use $log(cost_{it} + 1)$ to account for any periods of zero spending.

[10]We group all those aged 85 years and above together.

t.[11] This specification facilitates an easy interpretation of θ: a 1% increase in time to death is associated with a θ % increase in quarterly hospital spending. However, one downside of this specification is that we are imposing a curvature restriction on the profile of spending. We therefore also estimate an alternative specification where we replace $log(cost)$ with the level of spending and $log(TTD)$ with dummy variables representing the number of quarters to death (relative to 20 quarters prior to death) in order to fully trace out spending changes over time.

As argued by Howdon and Rice (2018), in addition to age, time to death is also likely to be a proxy for the underlying (declining) health of individuals. We therefore control for observable differences in health to examine whether time to death is still associated with higher medical spending. $Health_{it}$ contains a number of different health measures, including an extensive set of comorbidities from the administrative hospital records, where each component equals one if an individual has a hospital appointment with that diagnosis and zero otherwise.[12] We also include a set of time-invariant health measures, collected at the time of the ELSA interview immediately prior to the five year period that we examine, including: self-reported health on a three-point scale; the number of self-reported difficulties with mobility, ADLs and IADLs; whether the respondent receives any informal or formal social care; and 19 indicators of self-reported diagnoses. T_t includes a full set of dummy variables that interact calendar year and quarter of admission to capture national time trends in hospital spending.

We are interested in how the profile of spending varies with household composition and educational attainment. We therefore augment this baseline specification by interacting time to death with our individual characteristics of interest. This means that we run a specification of the following form:

$$log(cost_{it}) = \psi Age_{it} + \beta X_{it} + \theta log(TTD_{it}) + \nu[log(TTD_{it}) * Couple_i] + \gamma Health_{it} + T_t + \epsilon_{it} \quad (2)$$

where ν captures the additional change in spending as person i approaches death if they have a partner at the beginning of the period. We replace the couple dummy in the interaction term with a low education dummy to study differences across education groups.

We are interested in θ and ν. These coefficients show the relationship between spending and time to death, and the additional change in spending associated with changes in time to death for those in couples (or with low educational attainment), after taking into account observable differences in health and sociodemographic variables. However, we do not make causal claims: both personal characteristics (such as couple status) and time to death may be correlated with unobserved health factors that would influence health spending. While we control for a range of health measures using ELSA and HES data, these variables may not capture all changes in health. This is particularly the case at the end of life, where health status may decline rapidly in ways that we do not directly observe (e.g. frailty). Such changes would therefore likely overstate the importance of time to death for spending - as opposed to the impact of declining

[11] In this case, the quarter in which the patient dies is equal to one (rather than zero).

[12] Comorbidities are classified based on the Healthcare Cost and Utilization Project's mapping of ICD-10 codes to Clinical Classifications. We assign comorbidities to patients based on the (primary and secondary) diagnoses recorded in any hospital admissions that quarter. In the absence of any admissions in that quarter, we assign any diagnoses from the last quarter in which an admission takes place. Results are robust to an alternative assumption when previous diagnoses are not carried over across quarters.

underlying health - in our estimates.

In addition, time to death may in fact be determined by past and current levels of health spending: higher spending may delay death if treatment is effective. As a result, time to death is likely to be endogenous with respect to health spending. Previous work has attempted to address this problem using instrumental variable regressions, instrumenting time to death with other variables that may be otherwise unrelated to health spending. This includes predicting life expectancy using lagged personal characteristics (Felder et al., 2010) or using local geographical variation in health and life expectancy (Howdon and Rice, 2018). These papers conclude that the finding that time to death, rather than age, is the main driver of spending is largely unaltered by endogeneity, but the exact magnitude of the relationship (particularly when not including morbidity controls) may be biased downwards. For example, Howdon and Rice (2018) find that their estimates of the effect of time to death on health spending increase in magnitude when instrumenting time to death with local area measures of 'years of potential lives lost', albeit with much larger standard errors (effects are no longer statistically significantly different from zero). We considered a variety of instruments to predict time to death, including local area variation in deprivation or lives lost, and personal information on life expectancy (such as parental age of death). However, none of these options proved to be sufficiently strong instruments (potentially due to limited sample sizes). We therefore control for a rich set of health covariates, but do not otherwise address this potential endogeneity problem directly.

Even with these concerns noted, better understanding of the pattern of spending at the end-of-life remains important for policymaking. Current approaches to forecasting future health spending typically take into account changes in the age, sex and (observed) health of the population. It does not take into account the wider characteristics of the population, such as household composition. If these characteristics are associated with different levels of spending - over and above the observed variables used in current forecasting techniques - these relationships still contain useful information even if they do not uncover the exact causal mechanisms that underlie them. The results also show how spending is distributed across different groups, which is important in realising policy objectives aimed at eliminating inequities in access to healthcare and health outcomes that were legislated as part of the 2012 Health and Social Care Act.[13]

5 Results

In this section we estimate the specifications set out above. We first examine the aggregate relationship between spending, age, time to death and morbidity. We then examine how these relationships vary across those living with and without partners, and across groups with different educational attainment.

5.1 Aggregate results

Table 1 shows the results of estimating equation 1. In the first column, we regress $log(cost)$ on 5-year age categories, a full set of quarter-year dummy variables, and dummy variables for

[13]For more details, see: https://www.gov.uk/government/publications/health-and-social-care-act-2012-fact-sheets

whether the person is male, in a couple, and has no formal qualifications. Spending is in general positively associated with age, with higher spending for those aged between 65 and 84 years (relative to those aged 55-59) but not for those at the oldest ages (85+). For example, spending is 61% higher for a person aged 70-74 compared to someone who is aged 55-59.[14] There are no statistically significant associations between spending and the other sociodemographic controls.

In column two we also include $log(TTD)$ on the right hand side. The results indicate that time to death has a strong negative association with health spending: moving 10% closer to death is associated with an increase of 13% in quarterly spending. By contrast, the coefficients on all age bands fall in magnitude, and there are only statistically significant differences for those in their seventies.

In column three we control for differences in observed health, including our measures of hospital comorbidities and ELSA-recorded (but time-invariant) health measures, and cause of death. Controlling for differences in health reduces the magnitude of the coefficient on time to death by approximately a third: a 10% increase in time to death is now associated with a 9% increase in spending. This change in magnitude is consistent with previous findings (Howdon and Rice, 2018), and indicates that at least part of increased spending at end-of-life is explained by (observably) deteriorating health. However, the relationship between time to death and spending is still statistically significant and large in magnitude.

Column three also shows some differences in health spending across different causes of death. Relative to all other causes, spending is 10% lower in each quarter for someone who dies of cardiovascular disease. There are no statistically significant differences in spending across people who die of cancer and respiratory disease (compared to other causes) after controlling for other factors.

Columns 4 and 5 repeat this analysis separately for emergency and elective spending respectively. This shows that the relationship between spending and time to death is driven primarily by the timing of emergency spending. A 10% increase in time to death is associated with a 9% increase in emergency spending, holding all other factors constant. For elective spending, the same change in time to death is associated only with a 0.7% increase in costs.

These results also point to other differences in the factors related to emergency and elective spending. Emergency spending is lower for those dying of cancer and cardiovascular diseases compared to all other causes. People in their seventies have higher spending than younger people, while there are no significant differences in spending across couples or education group after controlling for other factors. In contrast, elective spending is 8% higher for those in couples, and 6% lower for those in the low education group, even after adjusting for health and other characteristics. Elective spending is 26% lower among the oldest age group compared to those aged 55-59, and patients who die of cancer have considerably higher elective spending than those who die of all other causes.

While these results show that time to death is strongly related to spending, they impose a functional form restriction on the profile of spending. We therefore repeat this analysis with a more flexible specification, allowing spending to freely vary across each quarter by replacing log(TTD) with a full set of dummy variables for time to death. We also consider cost (rather

[14] This is calculated as $\%\triangle y_{it} = 100.(exp(\beta) - 1)$. Substituting the coefficient into this formula equals 60.96%.

than log(cost)) as an outcome. In this way, we can examine how the levels of spending change (relative to spending 20 quarters prior to death) as people move each quarter closer to death when we do and do not control for other factors.

Figure 6 shows the results of this exercise, plotting the coefficients for each quarter backwards from death. The black series shows results when controlling only for sociodemographic controls and time trends. Spending is relatively constant between 20 and 6 quarters from death, before rising sharply in the final 18 months of life. In particular, spending increases in the final two quarters. The estimates indicate that spending in the last quarter of life was £3,049 higher than spending five year prior to death after controlling for age, sex, couple status and educational attainment.

The grey series plots the results when adding additional controls for health status and cause of death. This reduces the magnitude of the coefficients in all cases, and especially in the last 18 months of life. In particular, the coefficient in the final quarter of life falls by almost half compared to the initial specification. This suggests that a large share of additional spending at the end of life can be explained by observed changes in health. However, the estimates still indicate that spending in the final quarter of life is £1,603 higher than it was five years prior, even after controlling for observed changes in health. Time to death therefore remains strongly associated with hospital spending.

5.2 Variation in end-of-life spending across couples and singles

To examine whether end-of-life spending varies across household composition and education levels, we interact our measure of time to death with the characteristic of interest, as set out in equation 2. Table 2 shows the results when interacting log(TTD) with whether the individual lived with a partner at the beginning of the five year period. In column one we control only for age, sex, eduction group and year-quarter effects. The estimates indicate that a 10% reduction in time to death is associated with a 12% rise in quarterly spending. As with the initial analysis, time to death is negatively related to spending, while living with a partner is associated with 74% higher quarterly spending. The interaction term between log(TTD) and living with a partner is also negative. This indicates that spending increases more sharply with time to death for those in couples: a 10% reduction in time to death is associated with an additional 3% rise when living with a partner. These patterns remain after controlling for differences in underlying health and cause of death, although the magnitude of the coefficients falls. The estimates in column two indicate that spending on single people increased by 8% with a 10% reduction in time to death, while spending increased by 10% among someone with a partner for the same reduction in time to death.

Columns three and four repeat this analysis separately for emergency and elective spending respectively. The results are very similar for emergency spending as would be expected given the relative contribution of emergency spending to total spending. However, the results are a little different for elective spending. In this case, there is now no statistically significant relationship between spending and log(TTD), while the interaction terms remains negative and statistically significant. This indicates that the entire relationship between elective spending and time to death is driven by those living with a partner at the start of the period.

We examine these patterns in spending further by running our augmented specification where we regress cost on a set of time to death quarter dummies that we now interact with couple status. Figure 7 plots the point estimates and their 95% confidence intervals for the additional spending associated with living with a partner in each quarter backwards from death, after controlling for differences in sociodemographic characteristics, health status and cause of death.[15] Panel A shows coefficients for total spending, while panels B and C show results for emergency and elective spending respectively.

Although the estimates are relatively noisy, spending on those in couples appears to be lower in the first three years of the period, before rising much more quickly in the final two years of life. In particular, spending is higher for couples in the last 18 months. These differences peak in the quarter directly preceding the last quarter of life: the estimates indicate that spending was £555 higher for those in a couple in this quarter after controlling for all other factors. Summing the coefficients for the final six periods of life together indicates that mean cumulative spending was £1,569 higher over the last 18 months of life for someone in a couple compared to someone without a partner, after controlling for other factors.[16] This additional spending is equivalent to 16% of mean spending over the last 18 months of life for singles (£9,852). A similar pattern is seen for both emergency and elective spending, although differences tend not to be statistically significant for the elective estimates. Interestingly, while spending broadly increases for couples more quickly over the last 18 months, this difference is much less pronounced in the very last quarter of life, the period in which the highest expenditures occur.

These findings suggest that the overall cost of end-of-life hospital care will increase as a higher share of the population live with partners in old age. Recent trends in household composition among the older population point to an increased likelihood of living with a partner at older ages, mostly as a result of extended male life expectancy (Emmerson et al., 2014). For example, between 2002 and 2014, the proportion of ELSA respondents over the age of 60 who reported living with a partner increased by 5% after taking into the age structure of the sample.[17] Combining this trend with the estimates above suggest that spending on people in the last 18 months of life was around 1% higher at the end of the period as a result of changes in household composition among this population. Continuation of this trend in future would therefore lead to higher costs. This suggests that observable trends in couple status, and the differences in costs across couples and singles, should be accounted for in forecasts of future health spending in order to improve accuracy.

5.3 Variation in end-of-life spending across education groups

Table 3 shows the results when examining the patterns of spending across education groups. In this case, we estimate a version of equation 2 where we interact log(TTD) with an indicator

[15] We sum the coefficients on the couple dummy variable with the coefficients on the interaction term in each quarter and plot the resulting coefficients. Standard errors are constructed using the delta method. The plotted estimates therefore show the additional spending associated with an individual in a couple compared to a single person in each quarter.

[16] A joint test for significance (using the delta method) shows that this coefficient is different from zero at the 1% significance level (standard error = 417.59).

[17] We regress whether an individual lived with a partner on dummies for each survey wave and five year age bands.

that takes the value of one if the individual has no compulsory qualifications, and zero otherwise. Column one controls only for sociodemographic variables and time effects. The results indicate that quarterly spending is 28% lower among the low education group in each quarter, while spending is again negatively related to time to death. The interaction term between log(TTD) and low educational attainment is positive. This indicates that the negative relationship between spending and time to death is smaller in magnitude for the low education group relative to those with higher educational attainment.

In column two, we add additional controls for health status and cause of death. The inclusion of these controls reduces the magnitude of all the coefficients. The interaction term remains positive, but is now only significant at the 10% level. In columns three and four, we repeat the analysis separately for emergency and elective treatment. For emergency treatment, the interaction term is now very small in magnitude and no longer statistically significant from zero. This indicates that the relationship between emergency spending and time to death does not vary across education groups. However, for elective spending there are differences across groups with a positive and statistically significant coefficient on the interaction term. The results indicate that elective spending increased by 12% among high education groups groups for every 10% reduction in time to death, but only 11% for low education groups. This suggests that the profile of elective spending at the end of life is less steep for the low education group compared to the high education group, even after controlling for differences in health status.

We can again examine this pattern further by regressing the level of spending on the interaction between time to death dummy variables and educational attainment. Figure 8 shows the estimates of the additional spending on the low education group for each quarter plotted backwards from death. Panel A shows total spending, and panels B and C show emergency and elective spending separately. The estimates are again noisy, but show a broad pattern of lower spending in the last 2 years of life among the low education group. This is most pronounced for elective spending in the last 6 quarters of life, where the differences between the groups are significant at the 10% level in four of the last 6 quarters. Combining the point estimates across these quarters indicates lower elective spending for the low education group of £310 over this period of time after adjusting for differences in health across groups.[18] This is equivalent to 25.8% of mean elective spending (£1,202) among the low education group in the last 18 months of life.

6 Conclusion

Demographic changes mean that governments across the world are facing the challenge of meeting rising healthcare costs. Spending at the end of life is an important component of overall spending on medical care, and as a result has attracted considerable attention from policymakers and researchers in recent years. In this paper, we have used new data on the sociodemographic and health characteristics of the older population in England linked to administrative hospital records to examine how spending evolves in the final years of life, and how this differs by household composition and educational attainment.

[18] A joint test for significance (using the delta method) shows that this coefficient is different from zero at the 5% significance level (standard error = 156.97).

Taken together, our findings suggest that there are meaningful differences in the pattern of spending at the end of life across people with different characteristics. While spending increases for most individuals at the end of life, these increases are larger for those living with partners and those with higher educational attainment. These differences are not explained by observed differences in age, health or cause of death. Given changes in the composition of households and educational attainment over time, factoring in these relationships is therefore likely to be important for improving the accuracy of estimates of future medical costs.

While our estimates show clearly that spending patterns differ across groups, they do not explain why these differences occur. Future research should therefore concentrate on establishing why such variation exists. In particular, spending differences between groups is likely to be explained by (potentially a mixture of) three factors: unobserved differences in health; differential access to care; and variation in the preferences for care. Those with partners or those in higher socioeconomic groups may have better health, may have better access to health care and informal or formal social care, and may prefer to use more healthcare for a longer period of time. Understanding whether such variation arises from differences in preferences is particularly important in thinking about how much care should be provided to different people at life, whether the current distribution is equitable, and whether there is scope to reduce costs - and improve wellbeing - during this period of life if patients do not want to undergo extensive treatment.

Finally, this paper focuses only on inpatient hospital spending. Other costs, and especially the costs of long-term or social care, are likely to be substantial at the end of life. Variation in this spending across groups is also likely to be even larger due to the greater substitutability of formal and informal social care, and because more of the provision of social care in England is currently privately funded. Understanding the pattern and drivers of these additional costs is important for meeting future demand for such care, but research in this area is limited by the lack of availability of detailed and timely data on the cost of care at the end of life. Improving data collection in this area and understanding these drivers of expenditure at older ages should therefore be a policy and research priority.

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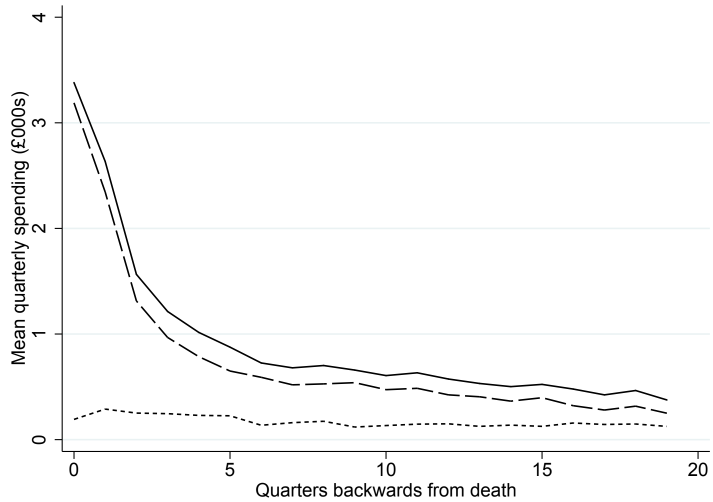
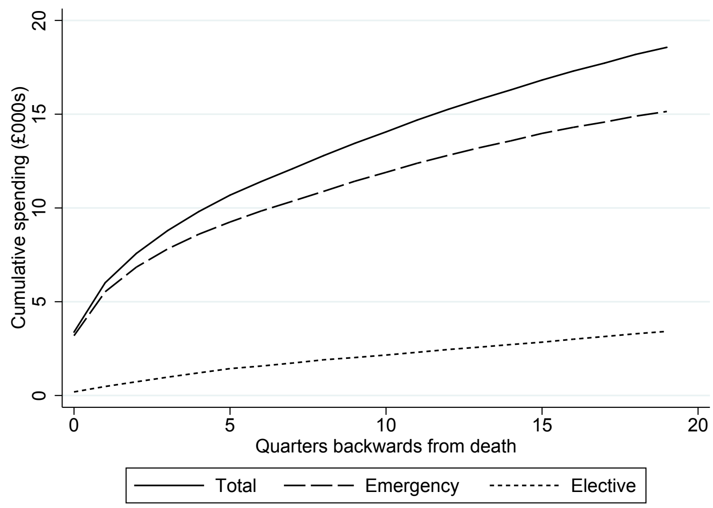
Figures and tables

Figure 1: Inpatient spending in the last 5 years of life, by time to death

(a) Quarterly spending



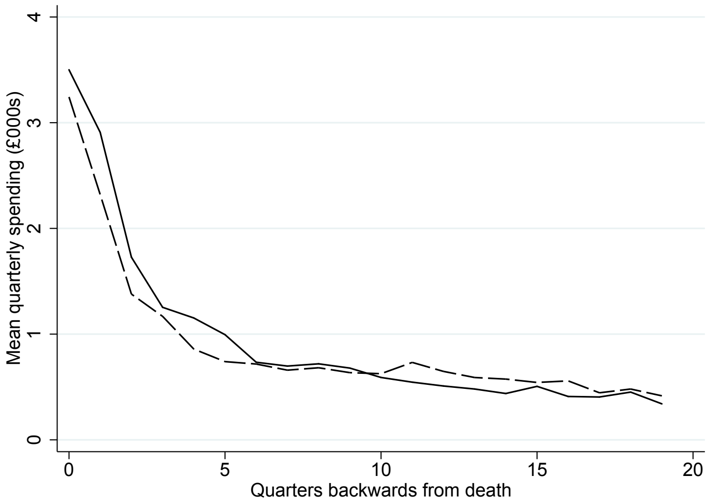
(b) Cumulative spending



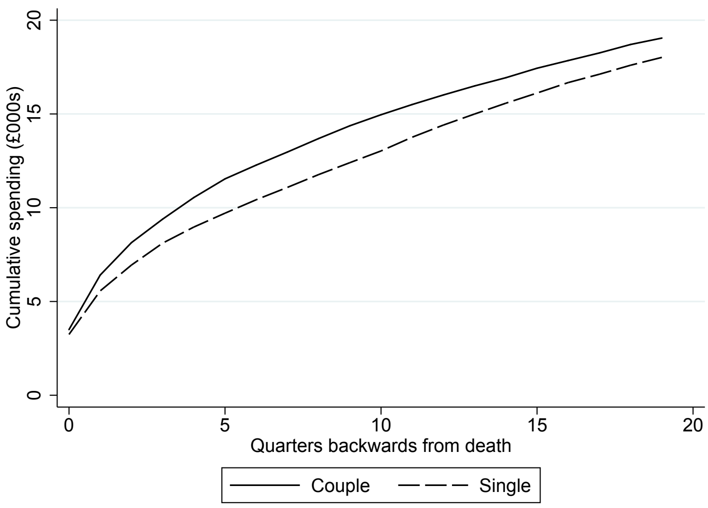
Notes: (1) Sample includes only ELSA respondents who died at least 5 years after their initial ELSA interview; (2) All figures are weighted, using the weights assigned from the interview immediately prior to the five year spending window.

Figure 2: Inpatient spending, by couple status and time to death

(a) Quarterly spending



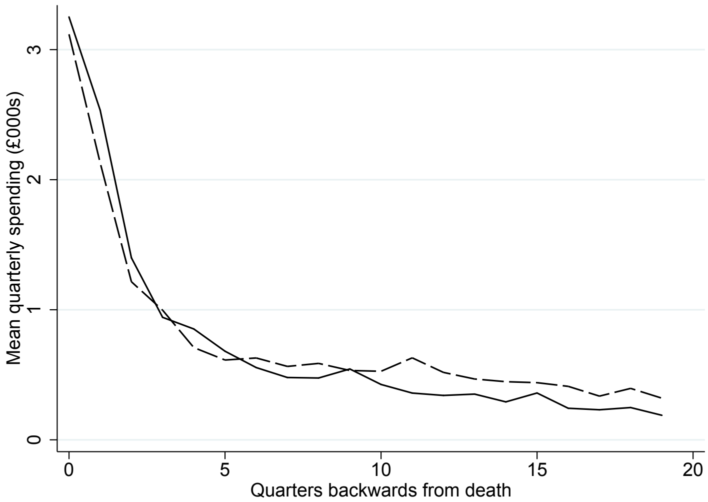
(b) Cumulative spending



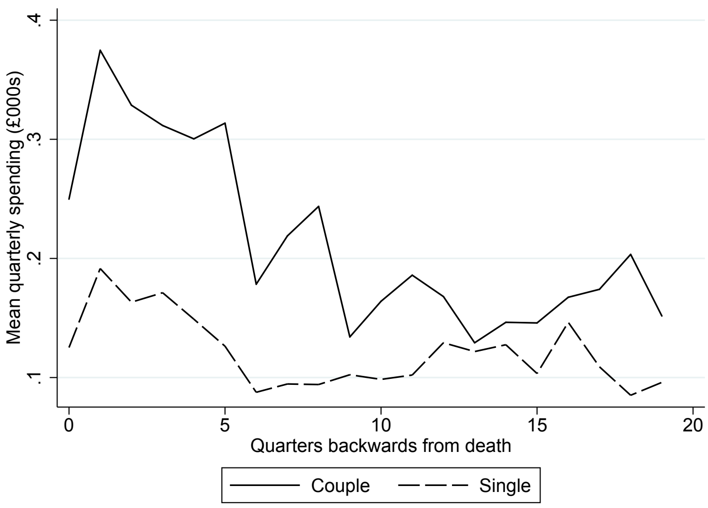
Notes: (1) Sample includes only ELSA respondents who died at least 5 years after their initial ELSA interview; (2) 'Couples' include respondents who report living with a partner in the last interview prior to the beginning of the five year period, 'singles' include all other respondents; (3) All figures are weighted, using the weights assigned from the interview immediately prior to the five year spending window.

Figure 3: Quarterly spending, by couple status, type of treatment and time to death

(a) Emergency



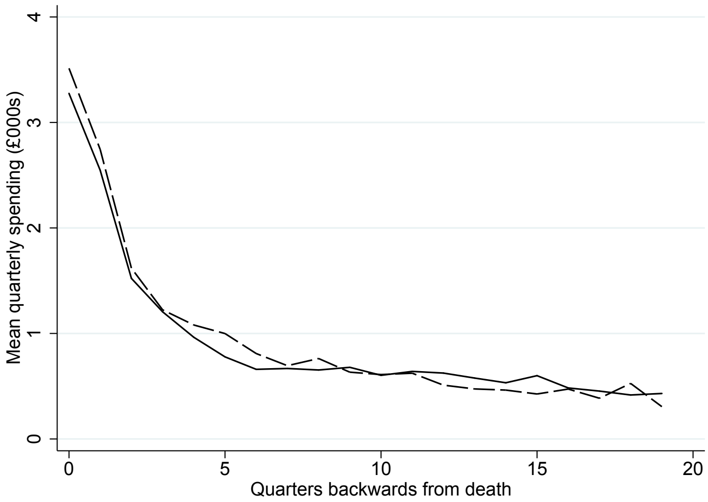
(b) Elective



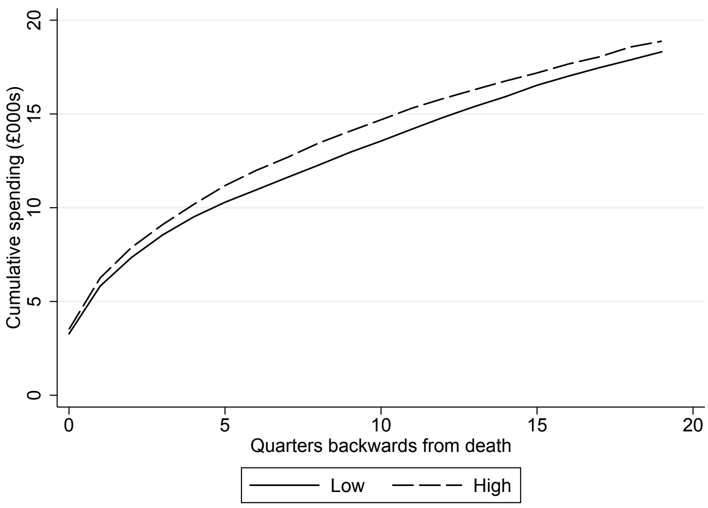
Notes: (1) Sample includes only ELSA respondents who died at least 5 years after their initial ELSA interview; (2) 'Couples' include respondents who report living with a partner in the last interview prior to the beginning of the five year period, 'singles' include all other respondents; (3) All figures are weighted, using the weights assigned from the interview immediately prior to the five year spending window.

Figure 4: Inpatient spending, by educational attainment and time to death

(a) Quarterly spending



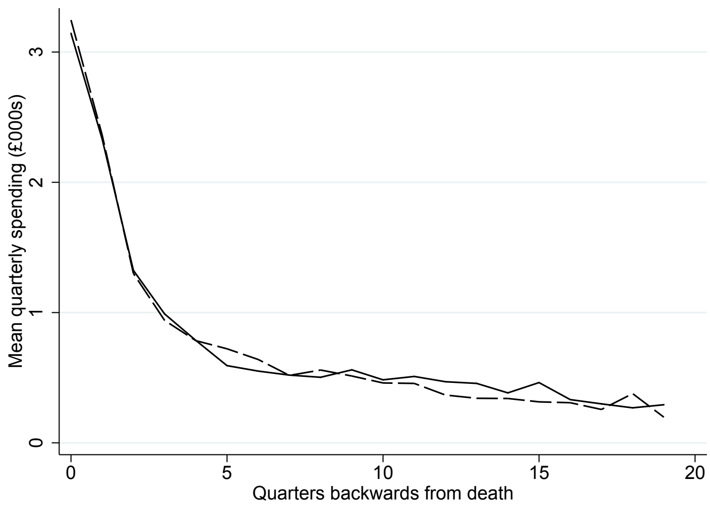
(b) Cumulative spending



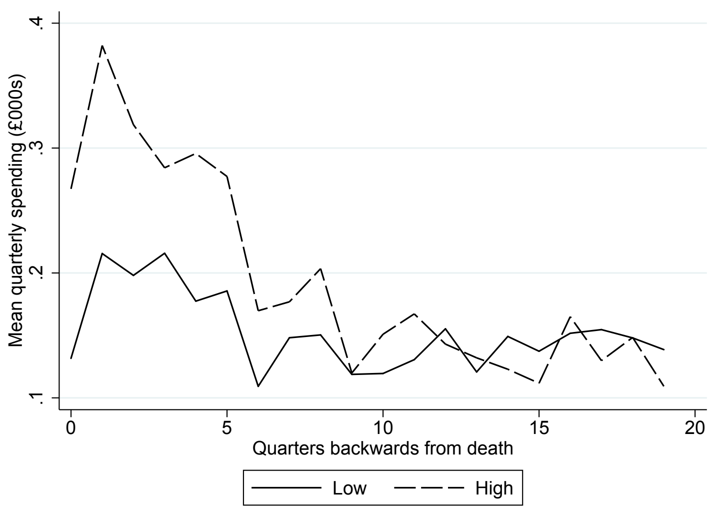
Notes: (1) Sample includes only ELSA respondents who died at least 5 years after their initial ELSA interview; (2) The low education group includes all individuals reporting no formal qualifications, the high education group include all other respondents; (3) All figures are weighted, using the weights assigned from the interview immediately prior to the five year spending window.

Figure 5: Quarterly spending, by educational attainment, type of treatment and time to death

(a) Emergency

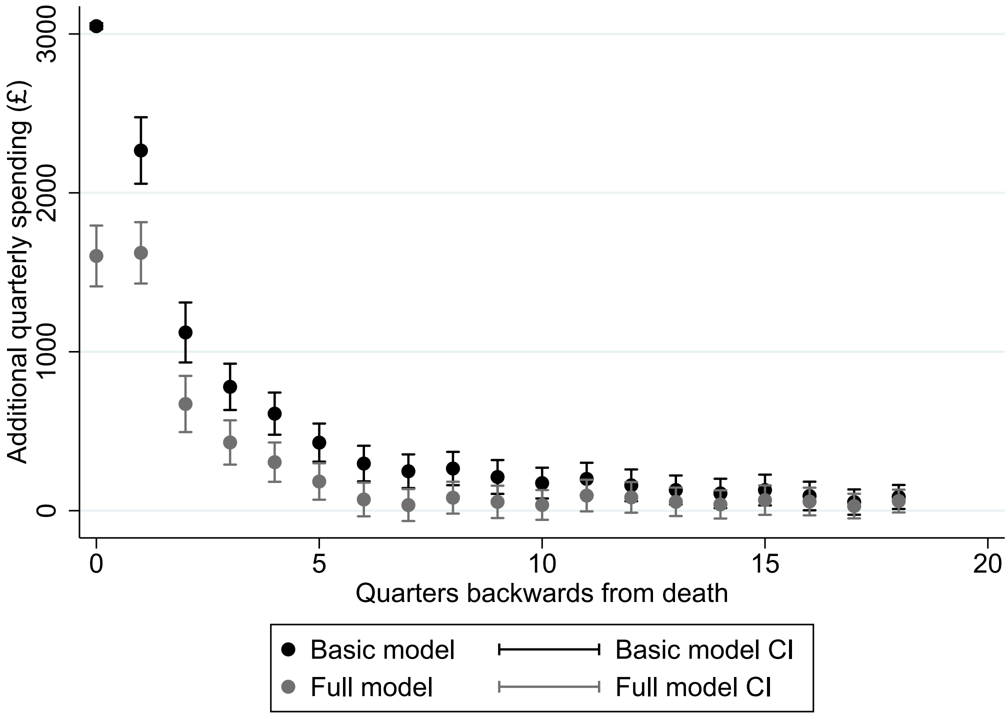


(b) Elective



Notes: (1) Sample includes only ELSA respondents who died at least 5 years after their initial ELSA interview; (2) The low education group includes all individuals reporting no formal qualifications, the high education group include all other respondents; (3) All figures are weighted, using the weights assigned from the interview immediately prior to the five year spending window.

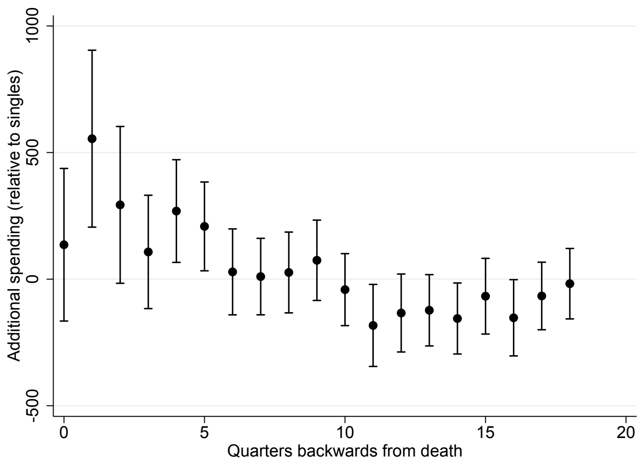
Figure 6: Estimates of additional spending by time to death, with and without controls



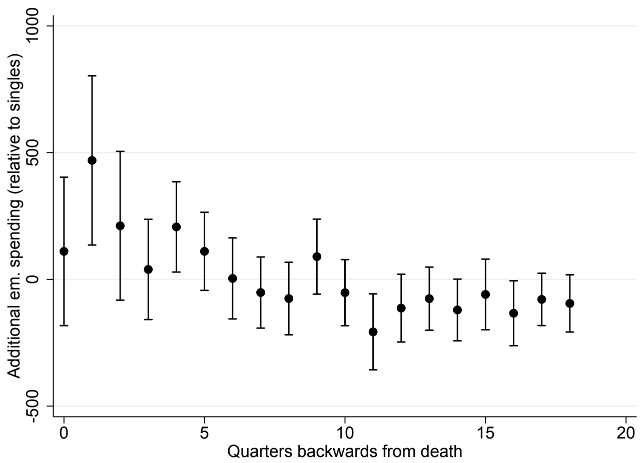
Notes: (1) Reported coefficients show spending in each quarter from death relative to spending 19 quarters prior to death ; (2) The quarter of death is classified as quarter = 1; (3) Basic model includes controls for age (in 5-year age bands), sex, education group, couple status, and a full set of year-quarter dummies; (4) Full model includes additional controls for health and cause of death, as set out in the text; (5) All standard errors are clustered at the individual level, and weighted using the adjusted weights from the interview immediately prior to the five year spending window; (6) Full results available upon request.

Figure 7: Estimates of additional spending on couples, by time to death and spending type

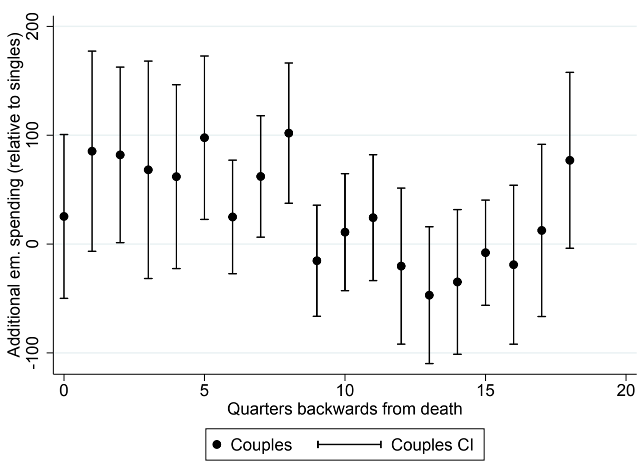
(a) Total



(b) Emergency



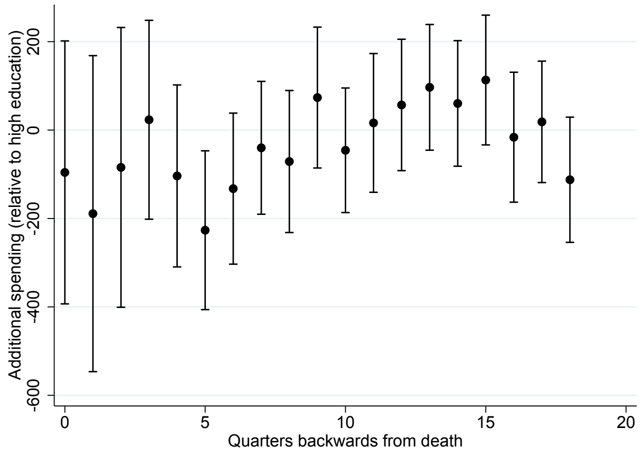
(c) Elective



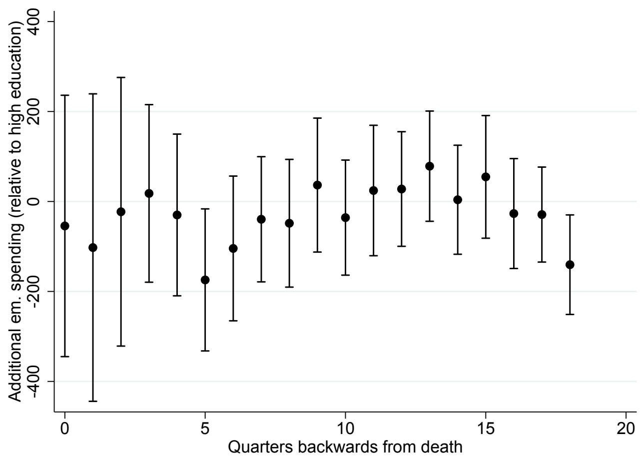
Notes: (1) Reported estimates show the sum of the coefficients on the couple dummy variable, and the interaction term between a couple dummy and dummy variables for each quarter from death (omitted group are those without partners); (2) The quarter of death is classified as quarter = 0; (3) The model includes controls for age (in 5-year age bands), sex, education group, couple status, a full set of year-quarter dummies, health controls and cause of death dummies; (4) All standard errors are clustered at the individual level, and weighted using the adjusted weights from the interview immediately prior to the five year spending window; (5) Full results available upon request.

Figure 8: Estimates of additional spending on low education group, by time to death and spending type

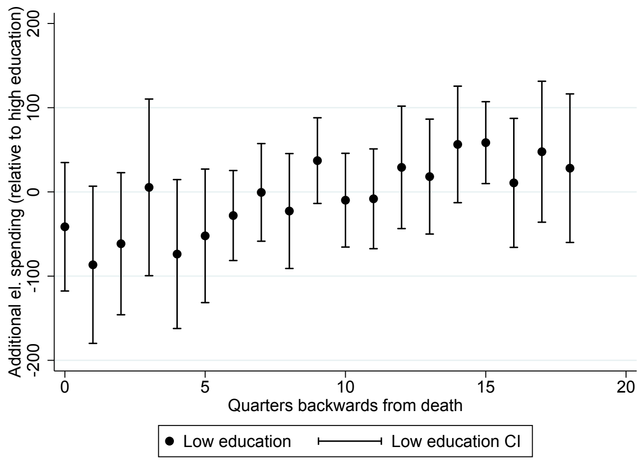
(a) Total



(b) Emergency



(c) Elective



Notes: (1) Reported estimates show the sum of the coefficients on the low education dummy variable, and the interaction term between a low education group dummy and dummy variables for each quarter from death (omitted group are those with formal qualifications); (2) The quarter of death is classified as quarter = 0; (3) The model includes controls for age (in 5-year age bands), sex, education group, couple status, a full set of year-quarter dummies, health controls and cause of death dummies; (4) All standard errors are clustered at the individual level, and weighted using the adjusted weights from the interview immediately prior to the five year spending window; (5) Full results available upon request.

Table 1: Estimates of the relationship between cost, time to death and personal characteristics

	Log(cost)				
	All			Emergency	Elective
	(1)	(2)	(3)	(4)	(5)
Age					
60 - 64	0.254	0.149	0.107	0.0921	0.0639
	(0.191)	(0.182)	(0.146)	(0.0910)	(0.122)
65 - 69	0.433**	0.245	0.136	0.0768	0.102
	(0.192)	(0.186)	(0.146)	(0.0894)	(0.124)
70 - 74	0.476**	0.332*	0.229	0.172**	0.0793
	(0.185)	(0.181)	(0.143)	(0.0860)	(0.122)
75 - 79	0.482***	0.308*	0.230*	0.164**	0.0928
	(0.179)	(0.175)	(0.137)	(0.0800)	(0.119)
80 - 84	0.412**	0.197	0.140	0.116	-0.00200
	(0.179)	(0.175)	(0.138)	(0.0816)	(0.119)
85+	0.229	-0.135	-0.0691	0.108	-0.232**
	(0.177)	(0.173)	(0.136)	(0.0808)	(0.117)
Sociodemographics					
Male	0.0816	0.0457	0.0371	0.0471	0.0282
	(0.0521)	(0.0503)	(0.0450)	(0.0366)	(0.0323)
Couple	0.0260	-0.0216	0.0427	-0.0144	0.0741**
	(0.0536)	(0.0517)	(0.0445)	(0.0363)	(0.0308)
Low education	0.0461	0.00624	-0.0545	-0.0162	-0.0562*
	(0.0509)	(0.0492)	(0.0436)	(0.0349)	(0.0307)
Time to death					
log(TTD)		-1.297***	-0.871***	-0.877***	-0.0715***
		(0.0280)	(0.0283)	(0.0254)	(0.0193)
Cause of death					
Cancer			-0.0466	-0.141***	0.224***
			(0.0594)	(0.0470)	(0.0420)
CVD			-0.0975*	-0.149***	0.0306
			(0.0564)	(0.0490)	(0.0336)
Respiratory			0.0039	-0.0156	-0.0017
			(0.0642)	(0.0566)	(0.0391)
Year-quarter effects	Yes	Yes	Yes	Yes	Yes
Health	No	No	Yes	Yes	Yes
Observations	51,420	51,420	51,420	51,420	51,420
R-squared	0.025	0.099	0.188	0.217	0.113

Notes: (1) All results are clustered at the individual level, and weighted using the adjusted survey weights from the interview immediately prior to the five-year period of study; (2) Age captures age at the beginning of the quarter, omitted category is 55-59; (3) Couple is equal to one if the respondent lived with a partner at the beginning of the period, and zero otherwise; (4) Cause of death captures the official primary cause of death, omitted category is 'other causes'; (5) Health controls include a set of dummy variables that take the value of one if a comorbidity (classified using the Clinical Classifications System) is recorded in an HES episode, and zero otherwise, self-reported health on a three-point scale, the number of self-reported difficulties with mobility, ADLs and IADLs, whether the respondent receives any informal or formal social care, and 19 indicators of self-reported diagnoses.

Table 2: Estimates of the relationship between cost, time to death and couple status

	Log(cost)			
	All		Emergency	Elective
	(1)	(2)	(3)	(4)
log(TTD)	-1.150***	-0.757***	-0.774***	-0.0200
	(0.0381)	(0.0367)	(0.0335)	(0.0228)
Couple	0.554***	0.499***	0.400***	0.280***
	(0.115)	(0.106)	(0.0991)	(0.0716)
log(TTD)*Couple	-0.272***	-0.215***	-0.195***	-0.0970***
	(0.0471)	(0.0436)	(0.0400)	(0.0287)
Year-quarter effects	Yes	Yes	Yes	Yes
Sociodemographics	Yes	Yes	Yes	Yes
Health	No	Yes	Yes	Yes
Cause of death	No	Yes	Yes	Yes
Observations	51,420	51,420	51,420	51,420
R-squared	0.100	0.189	0.218	0.113

Notes: (1) All results are clustered at the individual level, and weighted using the adjusted survey weights from the interview immediately prior to the five-year period of study; (2) Age captures age at the beginning of the quarter, omitted category is 55-59; (3) Couple is equal to one if the respondent lived with a partner at the beginning of the period, and zero otherwise; (4) Sociodemographic controls include age, sex and education status; (5) Health controls include a set of dummy variables that take the value of one if a comorbidity (classified using the Clinical Classifications System) is recorded in an HES episode in that quarter (or in a previous quarter if there are no admissions that quarter), and zero otherwise, self-reported health on a three-point scale, the number of self-reported difficulties with mobility, ADLs and IADLs, whether the respondent receives any informal or formal social care, and 19 indicators of self-reported diagnoses; (6) Cause of death categories include cancer, cardiovascular disease, respiratory disease and other causes.

Table 3: Estimates of the relationship between cost, time to death and educational attainment

	Log(cost)			
	All		Emergency	Elective
	(1)	(2)	(3)	(4)
log(TTD)	-1.358***	-0.909***	-0.890***	-0.117***
	(0.0373)	(0.0367)	(0.0327)	(0.0261)
Low education	-0.243**	-0.207*	-0.0693	-0.241***
	(0.115)	(0.107)	(0.0987)	(0.0731)
log(TTD)*Low education	0.118**	0.0717*	0.0250	0.0874***
	(0.0471)	(0.0434)	(0.0396)	(0.0295)
Year-quarter effects	Yes	Yes	Yes	Yes
Sociodemographics	Yes	Yes	Yes	Yes
Health	No	Yes	Yes	Yes
Cause of death	No	Yes	Yes	Yes
Observations	51,420	51,420	51,420	51,420
R-squared	0.099	0.188	0.217	0.113

Notes: (1) All results are clustered at the individual level, and weighted using the adjusted survey weights from the interview immediately prior to the five-year period of study; (2) Age captures age at the beginning of the quarter, omitted category is 55-59; (3) Low education is equal to one if the respondent has no formal qualifications, and zero otherwise; (4) Sociodemographic controls include age, sex and couple status; (5) Health controls include a set of dummy variables that take the value of one if a comorbidity (classified using the Clinical Classifications System) is recorded in an HES episode, and zero otherwise, self-reported health on a three-point scale, the number of self-reported difficulties with mobility, ADLs and IADLs, whether the respondent receives any informal or formal social care, and 19 indicators of self-reported diagnoses; (6) Cause of death categories include cancer, cardiovascular disease, respiratory disease and other causes.