Disability dynamics, care home admissions, and mortality: evidence form two national English studies to support insurance product development

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To the benefit of the society

Abstract

Social and demographic trends in the UK point out an ageing population and declining availability of family carers, leading to increase in the need for formal care. In England, formal care can be costly and may oblige an older person to sell her or his home. Designing a financial product to cover these costs requires an understanding of the complex underlying risks of longevity and disability. In this thesis, data from two English surveys are used to analyse these risks. Data on subjects in the English Longitudinal Study of Ageing (ELSA), who are interviewed biennially, are used to estimate Cox proportional hazards models using two alternative approaches. Initially the baseline values are used for all predictors. This corresponds to the most likely situation for insurance companies when they set premiums. Subsequently the value of predictors, such as disability levels, can change over time. ELSA is then used to analyse changes in disability that sample members experienced. Results show that disability is not a static process, improvement and recovery are both possible and mortality can be predicted better if changes in health and disability can be taken into account. Therefore, the insurer may offer incentive for after sale reporting of health events that impact on care needs and carry on regular assessments of claimants disability levels. Data from the Cognitive Functioning and Ageing Study (MRC CFAS I) is used to examine how mortality is affected by the onset of disability or entry to care homes. Both onset of disability and care home entry are found to reduce life expectancy. This offers the possibility of annuities whose payments increase following onset of disability or care home entry.

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Chapter 1

Funding Long-term care in the United Kingdom

1.1 Introduction

Long-term care is a combination of services (medical, nursing, social and community) that are provided to the elderly in the time of need, i.e. as they lose the ability to look after themselves. Long-term care services are designed to help people with disabilities or with chronic care needs. While most of the care is provided informally (Vlachantoni *et al.* (2011)), but the increase in life expectancy and the projected decline in the supply of informal care (Pickard (2008)) is leading to increase in the need for formal care. Approximately, half of the people aged 65 and older have disability and/or activity limiting health problem (Office of National Statistics (ONS) (2013)), hence the need for care is inevitable at old age. Moreover, of the 352 thousand persons living in care home with/without nursing in 2011 (Office of National Statistics (ONS) (2014)), there are more than 80% of the care home residents aged 65 and older, with the majority from the oldest old (58% of the care home residents were 85 years and older). On the other hand the oldest old are only 12% of the old people living at homes.

There is a growing number of people who are in need for care provided by long-term care institutions (Office of National Statistics (ONS) (2014)). Care homes in the UK are largely private, hence the costs form a burden on older persons in the times of deterioration. This is a major concern facing individuals and governments worldwide. In the recent years, the UK government has been planning reforms to the English long-term care financing system (HM Government (2009)), which were announced to be introduced in 2016, then were postponed until 2020. These reforms were established in shadows of the recommendations by the Dilnote commission (Dilnot (2011); HM Government (2012a)), and the responses lead by concerned institutions representing the public interest (e.g. care home providers, academics, insurance professionals). Since then there have been rich discussions on the proposed reforms (HM Government (2012b, 2013); Humphries (2013)).

A long-term care financial product that provides cover to the costs associated with needing care in the future, i.e. the payments start in later life when a carer is needed or the policyholder is admitted to care home. Such products can be funded by pension savings, as an add-on life annuity, or at point of need. Although such a product seems critical to face the ageing population problem, there is currently no such a cover for sale in the U.K. Insurers attempted introducing a deferred-need long-term care product during the 1990s, but this sold in very few numbers and companies withdrew from the market immediately. Further, it was shown in the Dilnot (2011) that at the end of 2009 there were about 36,000 long term care policies in force among Association of British Insurers (ABI) members.

One of the main reasons behind the lack of public interest in long-term care insurance is the misconception about the availability of care for free at the point of care. This misconception is a result of the confusion between medical and social care needs. Hence, the public expects the state to pay for care of the elderly. In England, Northern Ireland and Wales means-tested support is provided by local authorities to protect the poorest. For those with assets worth under £23,250. The lack of awareness means that an elderly quite possibly would have to sell their own home to pay for care.

Despite the failure of the 1990s attempt at establishing long-term care insurance market in the U.K., Dilnot (2011) outlines a role for insurers alongside the state. The report investigated the two extremes where the risk is left to private sector and a fully social scheme. Both will result in unwanted consequences, hence a collaboration was recommended. In order to stimulate the insurance market, it was proposed that excessively large and long term costs would be transferred to the government, through a cap on costs. The proposed cap would reduce the tail risk on insurance policy, and hence provide an opportunity for an affordable private product. Reports from the Institute and Faculty of Actuaries (Pensions and Long-Term Care Working Party Kenny and Barnfield (2013)) concluded that only 8% of men and 15% of women would ever benefit from the cap. And a parliamentary statement (Minister of State for Community and Social Care (2015)) stated that there are no indications the private insurance market will develop as anticipated, and a decision has been taken to postpone the introduction of cap on care costs until April 2020.

There are several factors that are contributing the slow development of private insurance market of long-term care insurance. Insurance firms weighing potential costs against potential profits, might prefer to avoid the repetition of the 1990s failed attempt. Furthermore, insurance companies are concerned with their reputation, and aware of the potential distrust in financial industry, and the resistance of financial advisors to the introduction of a complex product. Moreover, all insurance firms are required to hold sufficient capital that reflect the uncertainty of the products sold to ensure solvency. Drastic amount of capital might be required from an insurance company to enter the dungeon of uncertainty of long-term care. Additionally, the last decade has seen a rise in informal care, but the availability of insurance might disincentives informal carers, and this will change future demand for care.

Essentially, the insurance firms would need to establish a claim assessment system and premium rating that provide significant security against failing the long-term care insurance market. It is prevalent that there is significant uncertainty on the interaction between longevity and disability. It could be argued that they are pulling life expectancy in opposite directions, but future trends are still fuzzy. Understanding functional ability deterioration and recovery and their impact on care home admission and on mortality is a key to unravel the puzzle. Moreover, a simple guidance is needed to assist the older people to take the right financial decision before it is late. Understanding the process of physical and cognitive disability is the core to establishing guidance that informs an older person when, and why they should buy a given long-term care financial product. Furthermore, it would form the core to the claims assessment and premium rating sold by insurance companies.

In short, the need to ensure financial sustainability of older people is recognised by the government, academics and the insurance industry. There is a growing research interest in the place of death (Perrels *et al.* (2013); Fleming *et al.* (2010)), health status in care homes (Gordon *et al.* (2014)) and the provision of care (Kinley *et al.* (2013)). There is also an emerging body of literature on possible financial products that supports financial needs of the elderly, e.g. Mayhew *et al.* (2010); Kenny and Barnfield (2013). Hence, this research aims to add to current literature on ageing, and put the disablement process in a financial needs context, that could be used by an older person taking financial decision to fund their future needs, or by insurance company to design their claim trigger.

1.2 Long-Term Care Insurance

Long-term care insurance policy is a contract that provides the policyholder with benefits to cover the costs associated with needing care, i.e. the payments to a carer or a care home. A person requires care from a carer is due to the loss of functional or cognitive ability. Long-term care insurance is usually aimed at individuals who are not going to get better, and who have lost independence in performing their day-to-day living. The care provided aims to slow down deterioration, provide support and maintain well being.

The costs associated with the loss of care at old age can be categorised into two main groups; hotel costs and care costs. Hotel costs are mainly living expenses and housing costs. Both living expenses and housing costs are incurred by everyone, but usually higher for persons in need for care, e.g. the need for extra heating, and the need for particular adaptation like a bath hoist. On the other hand, care costs are only incurred by persons in need for care. Care costs vary depending on the level of deterioration of health. Some persons would require basic personal care is few of their day-to-day living. Others would require nursing care which require the specific knowledge or skills of a registered nurse.

Long-term care insurance is an indemnity contract, where the insured person is covered against the additional costs associated with the need for care. The contract can be purchased as a deferred-need (i.e. a pre-funded plan purchased by relatively healthy individual), or as an immediate needs purchased by a person receiving care and seeking protection against uncertain survival duration. Moreover, it can be purchased as a top-up option on another insurance contract. In all three types the insurer takes measures to prevent catastrophic losses by building a claims system and setting premiums that reflect the risk undertaken. Claims are usually triggered by an event or a set of multiple events. Events that trigger claim could be set by the loss of functional ability, cognitive impairment or admission to care home.

Functional ability is commonly measured using the Activities of Daily Living (ADLs). The ADLs are the fundamental daily activities that an individual would require to maintain independence. The ADLs are typically bathing, dressing, toileting, transferring, continence and feeding. A common trigger of insurance claims is the failure in number of ADLs (usually failure in 2 or 3 activities).

As recovery of ability after the first failure in ADLs is possible, some insurance firms might require deferred period before the initial claim is incurred. This deferral period is used to avoid the trigger of claims where the policyholder does not require long period of care. Pritchard (2006) have showed that LTC insurance contracts that excludes recovery could overstate the LTC costs substantially.

Impairment to cognitive functioning that affects the thought, memory, judgement and personality are other main reasons of loss of independence. These symptoms are progressive, but they usually reach severity in old ages. As a person suffers from the loss of cognitive functioning care may be necessary. Moreover, dementia (whether Alzheimer's or non-Alzheimer's) is one of the main reasons of admission to care homes.

Emerging vs established market

In emerging markets for an insurance product, where experience is insufficient, insurers will not be able to set appropriate premiums that reflects the uncertainty of the risks ahead. Hence, premiums tend to fluctuate in the early years of the introduction of such a new product. As the market matures, premiums reach plateau and they reach levels that absorb the costs of providing benefits. Although, long-term care insurance is an emerging in the UK, but it could benefit from the established pensions vehicle that is used to manage financial needs at old age.

As an established saving vehicle that is used and trusted by retired old persons to manager their old age finances, pensions provide an opportunity to accommodate for long-term care costs. The existing pensions might not be suitable to cater for the additional costs of long-term care, but the pensions freedom act, extends the possibilities that old people could use their savings. The pension savings could be used early after retirement to acquire a plan that covers retirement living expenses, and the additional costs when health deteriorates in the future.

One argument is that both longevity and disability risks work in opposite direction. This means that older persons are living longer, but as their health deteriorates and they develop disability, they live shorter than their healthy peers. Slightly more than quarter of the older persons admitted to care homes live more than 3 years. The pooling cost of funding care for those admitted to care homes, should be weighed against the pooling cost if they stayed healthy.

1.2.1 Drivers of the costs of long-term care

The costs of long-term care are influenced by:

- the general improvements in old age mortality rates over time,
- the increase in mortality due to disability,
- the severity of the disability,

- the rates of disablement (i.e. the rate at which a healthy person develops disability)
- deterioration and recovery rates,
- care home admission rates, and mortality in care homes

1.3 Previous models of long-term care

Here we review the methodology and the aims of some of the models of long-term care in the U.K. The major difference between the methodologies is with regards to the use of either transition intensities or prevalence rates. The first studies we consider used a transition intensity based approach. Transition intensities are a more fundamental quantity than prevalence rates. Using transition intensities into and out of a state, it is possible to calculate prevalence at any given time. The benefit of using transition intensities is that they allow greater flexibility in the modelling. the prevalence of diseases can change overtime and using transition intensities enables this to happen. However they are more difficult to come by, whereas prevalence requires only a snapshot of a population at one point, to estimate transition intensities, we need to understand how the population changes over time. Ideally, such an exercise would involve revisiting the population at a later time to find the details of any changes in health, increasing the cost and duration of analysis.

Macdonald and Pritchard (2000) set out a Markov model for the onset of dementia dependent on the APOE variants carried by the life. They had a state for where the dementia had progressed to the stage of requiring care in an institution (residential care home), but data available to them was limited for their transition intensities post dementia diagnosis. They use this model in Macdonald and Pritchard (2001) in the context of an established market for long-term care to calculate potential adverse selection costs from high-risk genotypes buying at an increased rate. As a proxy for the onset of a claim, they consider the trigger for a claim to be the transition into an institution. They calculated single premiums for each genotype using Norberg (1995) equations and averaged these across genotype with weights equal to the proportion of lives assumed to buy insurance. Adverse selection cost was calculated as the percentage increase in premiums after increasing the proportion of lives of high-risk genotypes among those who buy the contract.

Pritchard (2006) fitted a Markov model for disability with 5 levels of functional disability to the results of the National Long Term Care Study in the U.S (Manton (1988)). His aim was to estimate the costs of disability claims in a long-term care contract. He calculated the expected present value of the benefits attributable to occupancy of each state and found that where studies exclude recovery, they could substantially overstate the cost of benefits.

Akodu (2006) used a Markov model of functional ability and cognitive function. The model was based on the Cognitive Function and Ageing Studies I (CFAS) data. Akodu (2006) did not consider dementia types separately, but instead classed any life with MMSE score below a certain point as cognitively impaired. To perform a sensitivity analysis on how dementia was defined, models were fitted for MMSE scores below 10, 18, 20 and 21 which were chosen to conform to classifications given by McNamee (2004); Neale *et al.* (2001); Spiers *et al.* (2005) respectively. It was not an insurance model therefore its aim was not to measure adverse selection; instead it was estimating the future demand for long-term care in the U.K. based on projected population sizes of different states.

On the other hand, there are studies which used a prevalence data based approach. A drawback of using such data is that it requires an assumption of static prevalence, whereas in reality the pattern may change over time.

Similarly, the Personal Social Service Research Unit (PSSRU) of the London School of Economics and the University of Kent, have performed various modelling exercises with regards to long-term care demand and expenditure using updated versions of Wittenberg *et al.* (1998) spreadsheet based model e.g. Hancock *et al.* (2007); Wittenberg *et al.* (2006). They split the population by risk-factors: age, gender, dependency, household type, housing tenure (as a proxy for economic circumstances) and whether in receipt of informal care. The number of males and females in each age band were projected forward using the U.K.'s Office for National Statistics' and Government Actuary's Department's projections. These were further split into cells for the remaining factors and a probability of receiving formal care attached by fitting functions to the General Household Survey results. A development to Wittenberg *et al.* (1998) of note was by Comas-Herrera *et al.* (2003). This was by amending the probability of receiving formal care to include services for cognitive impairment specifically.

Nuttall *et al.* (1994) used Office of Population Censuses and Surveys prevalence data to fit a discrete-time multiple state model of disability in the U.K.. The aim was to project future demand and costs of care and assess the implications on different sectors ability to finance long-term care. They used 3 states to represent the health of lives, with separate models for different levels of disability. To fit their transition intensities they assumed prevalence of disability was unchanging, although as they point out, their calculated intensities contradict this assumption.

Rickayzen and Walsh (2002) extended Nuttall *et al.* (1994) model to allow transition between ADL states, including recovery. Annual probabilities of transition between states and trends for how these might change over time, were derived from the General Household Survey, Government Actuary's Department projections and Office of Population Censuses and Surveys data. They used this to project the number of disabled people with no regard to care costs.

1.4 Outline of the dissertation

This section provides an outline of analysis presented in this dissertation. The research questions that were approached in each chapter aimed to provide clues to what the British insurers can learn from available longitudinal data. The main motivation to investigate the complex relationship between longevity and disability in older age. Starting with investigation of mortality in older age, with the aim to compare between mortality of the disabled and the non-disabled, lead to learning about the dynamic nature of disability. The first chapter explores this using the English Longitudinal Study of Ageing. While performing the analysis, it was observed that there a high rate of recovery from disability. This motivated the second chapter. The hypothesis that there is a great deal of error in the self-reported data was investigated, but with a look at exciting literature, the question changed from doubting the accuracy of self-reporting to try and understand the dynamic nature of disability. In chapters 4 and 5, we returned back to the original research question and tried to find evidence in the Cognitive Functioning and Ageing study that can help explain the relationship between disability and longevity.

Chapter 2

Observing the changes in health and disability levels at older age improves prediction of mortality: results from English Longitudinal Study of Ageing

Abstract

Insurance firms that sells long-term care covers do not observe changes in health, behaviour and disability levels. Conventionally they collect such information at the point of sale to set premiums, and they wait for claims trigger. This indicates a loss of information probably leading to underestimation of mortality at older age. In chapter 2, data from the English Longitudinal Study of Ageing (ELSA) is used to compare between the use of baseline predictors, and allowing time-varying predictors. Data from 15,346 subjects aged 50 and older, who are interviewed biennial, is used to estimate two competing risks cox proportional hazard models using two approaches. Death was the primary outcome of interest and institutionalisation was a competing risk. The predictors used in the models were demographics (age, sex and marital status), socioeconomic status (educational qualification and social class), health related behaviour (smoking and alcohol consumption), and self-reported health (motor skills, activities of daily living, and instrumental activities of daily living). Sex, smoking and al-

cohol drinking are independent predictors of mortality. Mortality hazard from life threatening diseases, and disability is significant when allowed observation of changes over time. Inequality in health between socioeconomic groups was more prominent when changes in health and disability were allowed in the model. In conclusion, taking into account changes in health and disability improves mortality prediction. Therefore, insurers may consider designing a product that encourages policyholders to report health events.

2.1 Introduction

The future of long-term care funding in England is envisaged to be a partnership between the government and the private insurance market. There are proposals of insurance and pension products that may provide extra income to cover the costs of care, (Kenny and Barnfield (2013)). An Individual's socioeconomic characteristics, health behaviour and medical history will determine which products are most appropriate, and will be used by the insurers for premium setting. Commonly, Insurers will collect this information from their customers at the point of sale. They would not come back to review the changes in customer's circumstances, and the changes only observed when claims are triggered.

At older age, health and health behaviour are likely to change. For example, and older person may be requested by a doctor or a nurse to quit smoking, and reduce alcohol consumption, usually with the onset of a life threatening condition. Moreover, multi-morbidities contribute to the vulnerability of the elders and increase their chances of incurring disability (Boult *et al.* (1994)). Disability itself can take the form of a gradual decline or an abrupt loss of function short before death (Jagger *et al.* (2007); d'Orsi *et al.* (2014)). Not observing these changes may put the insurers at loss of information, hence premium reviews will depend only on claims experience. The aim of this paper is to examine the predictors of mortality among older people and contrast a statistical approach, which allows for changes over time in those characteristics with one that does not.

In this paper, data from the English Longitudinal Study of Ageing (ELSA) a nationally representative sample of older English people living in households, who were interviewed biennially, is used to compare between the use of baseline predictors, and allowing time-varying predictors. ELSA sample consisted of persons aged 50 and older on 1 March 2002, and two refreshment samples added on 1 March 2006 and 1 March 2008 followed up until death, institutionalisation, loss to follow-up, or completion of the follow-up period by 2010. Data from 15,346 subjects used to estimate two competing risks cox proportional hazard models using two approaches. Death was the primary outcome of interest and institutionalisation was a competing risk. The models used demographics (age, sex and marital status), socioeconomic status (educational qualification and social class), health related behaviour (smoking and alcohol consumption), and self-reported health (motor skills, activities of daily living, and instrumental activities of daily living) as predictors of mortality.

This paper is organised as follows: section 2.2 provides a discussion of current literature on mortality in older age. Section 2.3 describes the data from the English Longitudinal Study of Ageing (ELSA), the sample, variables and the models used in the underlying analysis. Section 2.4 outlines the descriptive statistics of the sample and the results from the estimated models. Finally, section 2.5 discusses the results, shortcomings of the modelling, and put on considerations of insurance product design. Appendix 2.A provides summary of the datasets from previous literature. Appendix 2.B compares mortality experience and ageing structure of ELSA with the English population, and appendix 2.C outlines the methodology used to calculate the mean and median ages at death.

2.2 Predictors of mortality at old age

Pricing of financial products that provide funding for long-term care needs, e.g. long-term care annuity, should fairly reflect the disability and mortality experience of the insured. Traditionally, life related financial products would use demographic and geographic information as risk factors in pricing. Conventionally the same practice would be inherited into price rating of products that cover long-term care costs at old age. It is true that both demographic and geographic information affect disability and mortality experience of older persons, but there are other factors (e.g. health behaviour) and life event (e.g. onset of a chronic condition) that contribute to older age disability and death. Perhaps insurers may take into account chronic and acute illness, behaviours such as smoking and drinking, socioeconomic factor characteristics, recent surgical operations such as joint replacement, and the potential care needs in order to set their premiums. In this section, we discuss the literature on predictors of mortality in older age.

The Longitudinal Study (LS) is a census-based dataset for a 1% sample of the population of England and Wales since 1971 census. Information about the sample is updated with every census in 1981, 1991, 2001 and 2011. New sample members are from new births and immigrants. Breeze *et al.* (1999) used the LS to examine the socioeconomic and demographic characteristics as predictors of mortality and institutionalisation among the middle aged and older people living in England and Wales between 1971 and 1981. Mortality data up to 1992 was used in the analysis. Stratified samples by gender and age groups 55 to 64 and 65 to 74 in 1971 were used in the analysis to differentiate between middle aged and older people. Two sets of separate models for mortality and institutionalisation were estimated. Models had follow-up of 20 years (between 1971 and 1992), and 10 years (between 1982 and 1992). The 20 years models controlled for baseline socioeconomic characteristics and demographics collected in 1971. The 10 years modelling, controlled for baseline characteristics and intercensal changes between 1971 and 1982. The models were estimated once for mortality risk, then for institutionalisation risk. The models used were multivariate logistic regression. The sample consisted of 43 092 men and 51 278 women aged 55-74 in the LS sample in 1971. By the end 20 years follow-up 93% of men and 84% of women aged 65-74 had died. People living in rented houses who do not own a car had higher mortality than those who own a house and a car. Respondents living in institutions had higher risk of death. Unmarried men living alone were associated with higher risk of death, while marital status did not show any significant difference for women. Analysis on socioeconomic changes between census dates showed that moving from owned to rented property is associated with higher risk of mortality. Loss of car had significant increase of men mortality, but the effect was not significantly difference from zero for women. Additionally, analysis of admission to institutions showed that not having access to a car, and being single both are strong predictors of institutionalisation. Loss of spouse between censuses showed increase in admission to care home for men, but not for women. In summary, the analysis found that deterioration in circumstances of people (loss of car, moving from owned to rented housing, getting divorced widowed or separated, starting living alone) significantly increase the risks of mortality and admission to care home, compared to those who had less favourable circumstances for the baseline. The proposition that changes in socioeconomic status and demographics affect mortality at older age is supported by this analysis. The analysis fails to capture changes adequately as the interval between censuses is very long (10 years).

The English Longitudinal Study of Ageing (ELSA) is a longitudinal sample of English household residents ages 50 and older on 21 March 2002. Subjects were interviewed between 1 March 2002 and 1 March 2003, and were followed-up in six biennial interview. Two refreshment samples were added on the third (2006/7) and fourth (2008/9) biennial interviews. The focus of literature presented in this section is on risk factors and observed life events that predicts mortality. However, literature on subjective measures (e.g. anticipated life expectancy, health literacy and self-rated health) as predictors of mortality are discussed whenever ELSA was the study of interest. The rationale behind this is that differentials in mortality resulting from subjective measures, might be an echo of other factors (e.g. socioeconomic status, or illnesses prevalent before baseline interview).

Adams *et al.* (2014) used data on subject responded to baseline interview of ELSA to investigate the socioeconomic differentials and anticipated life expectancy as predictors of survival. Mortality data up to end of 2011 were used to fit Cox proportional hazard regression models with anticipated survival as the independent variable adjusting for demographics, health behaviour and baseline health variables, and with socioeconomic characteristics. Separate models were estimated for each socioeconomic measure: years in full-time education, occupational class, household income, and the Index of Multiple Deprivation (IMD). Results showed that mortality risk was lower for women than for men. Mortality increased with age, and was high among those who were not married compared to those who were. Subjects who smoke, who do not partake physical activities, with low self-rated health, or with higher Instrumental Activities of Daily Living (IADLs) score had high mortality hazard. Activities of Daily Living (ADLs) score had a particularly interesting effect on mortality. Scores of “1-2 ADLs” increased mortality compared with “zero ADLs”. On the other hand, “3 or more ADLs” did not increased mortality compared with “zero ADLs”. This might be the case of using baseline ADLs and 10 years mortality. It is possible that subjects with “3 or more ADLs” have recovered or dropped out of the follow-up. None of the socioeconomic measures were significant predictor of mortality.

Health and Retirement Survey (HRS) is a US based longitudinal sample of American household residents aged 50 and older. HRS has a similar design to ELSA which enables comparative studies. Both ELSA and HRS samples cover demographics, socioeconomic status, health and disability of their subjects.

ELSA initial sample was taken from the Health Survey of England (HSE), an annual cross-sectional survey of the English household population. ELSA subjects were chosen from a sub-sample of HSE respondents who were aged 50 and older on 21 March 2002. Baseline sample of ELSA was taken from the HSE years 1998, 1999 and 2001. ELSA data set contain information carried forward from the HSE, and it has been used in literature on ELSA.

Lang *et al.* (2007a) used HRS and linked data of HSE and initial ELSA interviews to study the effect of levels of alcohol consumption on disability and mortality in older age, and compared between the mortality experiences of the English and the American elders. The analysis modelled levels of alcohol reported in 1998/99 in both the English and American sample. The study followed disability and mortality of subjects aged 65 and older up to the year 2002. Separate logistic regression models were used to find the odds ratio of alcohol consumption on 1 or more ADL limitations, one or more IADL limitations, cognitive impairment and mortality. The model controlled for age at baseline, sex, body mass index (BMI), education, smoking, multi-morbidities (heart conditions, stroke, high blood pressure, diabetes, arthritis, or dementia), income quintile, wealth quintile, physical exercise, and depression (the 8-point Centre for Epidemiological Studies Depression Scale (CES-D)). Results showed that disability and mortality did not increase when frequency of drinking rose from one drink per day to more than one to two drinks per day. However, disability risk increased significantly among those who drink more than two drinks per day. Teetotallers had higher disability and mortality risks than drinkers did. Sensitivity of the models to change in alcohol behaviour was tested, and it did not show any difference in the disability and mortality experienced by ELSA or HRS subjects. Although the results showed positive influence on life of the older people, they should not be taken literally, and alcohol consumption should not be treated as healthy behaviour. Moreover, HRS and ELSA subjects were mostly moderate drinkers.

Lang *et al.* (2008) used data for subjects aged 65 and older who responded to first ELSA interview in 2002/03, who has complete Body Mass Index (BMI) data collected in HSE. The study examined obesity differential in five years mortality follow-up. The models controlled for age, sex, health status, health behaviours, and socioeconomic status, and multi-morbidities. Multinomial logistic models were used to estimate the relative risk ratios of disability and mortality. Results showed that mortality levels were higher in men, and there was no difference in the proportion of subjects dead at follow-up in relation to baseline BMI categories. Mortality risk was the same for the overweight, the obese and those of recommended weight. This was true for both men and women. Severely obese men had greater mortality risk. In conclusion, excess body weight has stronger associations with disability than with mortality.

Bostock and Steptoe (2012) looked at reduction in mortality for respondent with medium or higher health literacy aged 52 and older on 1 March 2004, who responded to second wave of ELSA and followed-up till 2009, excluding those who died within 1 year of the second wave interview. The analysis focused mainly on health literacy as predictor of mortality among ELSA respondents. The models controlled for socio-demographic factors; age, sex, education, social class, wealth quintiles and ethnicity. Other covariates controlled for include health status; long standing illness, self-reported difficulties in activities of daily living, depressive symptoms and major life threatening chronic and heart conditions. Additionally, health behaviours (smoking, drinking and exercise), and cognitive functioning. There were 8,316 ELSA subjects, who completed the assessment of health literacy. Health literacy was categorised in three categories high (maximum score), medium (one error), and low (more than one error). Low 'health literacy' scores were more common in older age and among subjects with low socioeconomic position. Half of the subjects aged 80 and older, and one in four of the subjects aged 60 and older had low score. Subjects with no educational qualifications scored low in health literacy. Depressive symptoms, ADLs and chronic disease were all indicators of low score in health literacy. Adverse health behaviours (i.e. smoking and physical inactivity) were positively related to low health literacy. Moreover, alcohol consumption less than daily was linked to low scores. Results showed that low health literacy, old age, and being males are strongly associated with higher mortality. Education, social class, wealth and ethnicity did not show any significant association with mortality and their hazard ratios were not much different from one. Out of the health status covariates, long standing illness, limitation in ADLs significantly increased the risk of mortality. Other life threatening condition (heart disease, hypertension, diabetes, stroke, asthma and chronic lung disease) did not show any strong association with mortality. Smoking increased mortality as opposed to exercise. Mortality was indifferent between drinkers and abstainers. Although the study focuses on health literacy, but the results showed connection to the low health literacy to other socioeconomic, and health risk factors. Those factors contribute to the mortality differentials observed between subjects with different levels of health literacy.

Steptoe and Wardle (2012) analysed the positive association of enjoying life measured by the pleasure subscale from the CASP-19 (Control, Autonomy, Self-realisation and Pleasure) and survival amongst respondents of ELSA with mortality follow up of 7 years and 3 months. Cox-proportional hazard was estimated to predict mortality controlling for age at baseline, sex, demographic factors (wealth, education, ethnicity, marital status and employment status), health indicators (limiting long-standing illness, cancer, coronary heart disease, stroke, diabetes, heart failure and chronic lung disease), depression measured using the Centre for Epidemiologic Studies Depression (CES-D) Scale, and health behaviour (smoking, physical activities and alcohol intake). The analysis showed the positive influence of enjoyment of life on survival. Enjoying life is a subjective measure, and the reduction in mortality from higher satisfaction of life may be a reflection of unobserved health conditions before ELSA baseline. This was seen as more control covariates were added into the models, the effect of enjoying life was reduced and weakened.

Bambui Cohort Study of Ageing (BCSA), a cohort study initiated in 1997 in Bambui, Minas Gerais State, Brazil. The aim of the study is to investigate the health of an elderly population with low socio-economic level. 1,742 residents, aged 60 years and older, were eligible and 1,606 participated. Subjects were followed up for 10 years. Subjects of Bambui study had a high prevalence of non-transmissible diseases and widespread Trypanosoma cruzi infection, a protozoan that causes Chagas disease at baseline.

Lima-Costa *et al.* (2012) studied the interaction of income levels and predictive power of self-rated health reported by respondents to ELSA second interview (2004/5) and BCSA baseline (1997). The analysis compared 5 years of mortality experience between the two studies. Socio-demographic characteristics (age, sex, marital status, and monthly household income); lifestyle (smoking and exercises); medical diagnosed diseases; mental symptoms (depression); and functional status (ability to perform activities of daily living [ADL]) were all used as controls in the model. Kaplan-Meier and Cox proportional hazard model were used to compare between mortality experiences. The results showed that Brazilians were younger, poorer, and were more likely married, current smokers, with prior medical diagnosis for hypertension and diabetes, and reported mental symptoms at baseline. English subjects had higher prevalence of medical diagnosis for arthritis and coronary heart disease, and a larger waist circumference level. Brazilians had higher levels of non-HDL cholesterol and C-reactive protein. Poor self-rated health is found significantly associated with increase in mortality with and without the control variables included in the proportional hazard model. When stratified by income tertiles, poor self-rated health had increased mortality higher among the richest compared to the poorest.

The MRC Cognitive Function and Ageing study I (CFAS I) is a longitudinal sample of 13,004 older people aged 65 and older in 1991 from five areas of England and Wales (rural Cambridgeshire, Gwynedd, Newcastle, Nottingham and Oxford) including those in institutional care. The sample had equal numbers of people aged '65-74' and '75 and older' and follow-ups were biased towards the cognitively frail.

Bond *et al.* (2006) examined self-rated health as a predictor of deterioration of health and mortality at old age. The study used CFAS I to study the predictive power of self-rated health on mortality, functional and cognitive impairment. Multivariable Cox regression was used to estimate the hazard ratio for death, disability and cognitive impairment in relation to baseline self-reported health. The model was adjusted for age, gender, marital status, years of full time education, social class, Townsend deprivation score, ADLs, Mini Mental State Examination (MMSE), heart attack, stroke, diabetes, transient ischaemic attack, angina, intermittent claudication, depression and anxiety, medication use, and smoking history. The analysis used 10 years of death data. Subjects with higher health rating were less likely to die within the follow-up period. Subjects with better functional and cognitive abilities were likely to have better health and were more likely to self-report better health, and were less likely to die within the follow-up period. Smoking, not being married, lower education, lower social class, living in deprived areas, taking medication, suffering from anxiety or depression, and history of cardiovascular disease or diabetes were all associated to increased mortality. Although, self-rated health is a subjective measure, the analyses showed that it is a good predictor of mortality.

Chronic illnesses as well have been seen to increase older persons vulnerability, and increase mortality. Banks *et al.* (2010) used the first three waves of ELSA (2002/03, 2004/05 and 2006/07), and the corresponding waves from HRS. The study examined disease prevalence and incidence as predictors of mortality. The models compared the disease prevalence, disease incidence differentials in mortality between ELSA and HRS controlling for income and wealth quintiles, sex, age, marital status, education, health behaviours measures, obesity (BMI), self-reported health status, chronic health conditions: hypertension, diabetes, cancer, lung disease, heart disease, stroke, and arthritis. Models were estimated separately for two age groups: ages 55-64 and 70-80 and represent the estimated probability of death over four-year period. The results showed that standard behavioural risk factors (work, marriage, drinking, obesity, exercise, and smoking) almost fully explain income gradients in mortality among those 55-64 years old in both countries. Obesity and smoking both are more common among people in lower income and lower wealth quintiles, and both increase mortality. Exercise, work effort, and marriage are more common among people in higher income and wealth quintiles. These factors are associated with decrease in mortality. On the other hand, post retirement (aged 70 to 80) smoking was less common at these ages, and health behaviours were not much different across income and wealth quintiles.

Older people are vulnerable to chronic illnesses. Moreover, the onset of chronic illness is associated with disability and deterioration that might contribute to mortality. McMunn *et al.* (2009) studied wealth differentials on the onset of chronic illnesses and mortality among ELSA subjects. ELSA was split into three sub-samples based on self-rated health, ADLs, and heart disease. The analysis samples were 6,371 who had excellent, good or fair self-reported health at baseline, 6,911 with no ADLs at baseline and 7,171 who did not report heart disease at baseline. Three separate logistic regression models for the onset of illness and mortality were estimated controlling for wealth, income, housing tenure and age groups. The models showed that including death in the model increased the wealth differentials in the onset of poorer self-rated health, the onset of ADLs or the onset of heart disease.

2.2.1 International studies on mortality

In this section we discuss several studies that examined the mortality predictors of older people responded to longitudinal surveys from different parts of the world. While the results from these studies form guidance to the analysis presented in this paper, it is important to note that cultural and economic contexts are likely to impact on the mortality experience of older adults. There might be similarities in the effect of factors like gender, age and chronic conditions on mortality. But, there will be differences in factors that highly influenced by culture like health behaviours, e.g. smoking and alcohol; availability and accessibility medical treatments; and other factors.

Singapore Longitudinal Ageing Studies (SLAS) is a population-based study of f 2,808 older adults aged 55 years or more living in household the South-East Region of Singapore on September 2003. Baseline interview was conducted via face-to-face interviews in participants home and nurse assessments. The baseline covered demographic, biological, clinical, psychosocial and behavioural characteristics. The subjects were followed-up by a second interview one to two years (median 1.5 years) after the baseline. Ng *et al.* (2015) used baseline information on demographic variables, medical history, physical functional status and mental health status to study the mortality of older persons and its relationship to living alone. The analysis of living arrangement, living alone or with others, as a predictor for mortality was adjusted for housing type, multiple comorbidity, depression, 10 ADLs and 8 IADLs. Housing type was categorised in low end, or higher end public housing, or private housing. Multiple comorbidities covered hypertension, diabetes, stroke, lipid abnormalities, cataracts, asthma, chronic obstructive lung disease (COPD), arthritis, hip fracture and other problems; multiple comorbidity was defined as two or more medical conditions. Depression was measured using the Geriatric Depression Scale (GDS-15). The 10 ADL items were needing assistance in feeding, bathing, toileting, and grooming, and the 8 IADL items were needing assistance in using telephone, taking medicine, travelling, and managing money. Data on mortality used in the analysis was for 8 years up to December 2011. Kaplain-Meier's survival models were used to compare survival between subject living alone or living with others. Cox proportional hazard models were used to estimate hazard ratio of mortality rate associated with all the covariates. The analysis sample consisted of 2,553 Chinese participants with complete information on living arrangement. Subjects living alone were likely older, female, living in low-end public housing, and single, widowed or divorced. There was no differences in the prevalence of chronic conditions, ADLs and IADLs between subjects living alone or living with others. Mortality for those living alone was stronger among men than among women, and among single, divorced or widowed than married subjects. Higher mortality was also seen among the those living alone in younger old (aged below 75 years), and those with no IADL-ADL disability. Martial status and living alone were shown to be important factors contributing to the mortality observed among older people in Singapore. The study ignored behavioural factors (e.g. smoking, alcohol drinking).

RUIGÓMEZ *et al.* (1995) used data from the Health Interview Survey of Barcelona (HISB), a sample of 1,632 non-institutionalised people aged 65 and older in 1986 in the city of Barcelona. The interview in 1986 covered sociodemographic characteristics, self-perceived health, ADLs, health behaviours, chronic conditions, and health services use. The analysis used data for 1,219 elderly subjects who responded to the health behaviour section in the questionnaire. Health behaviours assessed by smoking status, alcohol consumption (currently and during the year preceding the interview), regular physical activity, and average number of hours of daily sleep were examined as predictors of mortality in older age. The analysis used proportional hazards regression models including the four health-related behaviours, and adjusted for age at baseline, sex, education level and self-perceived health status. The analysis used mortality data up to 5 years after the interview. After 5 years, the order of causes was cardiovascular, cancer, respiratory disease and digestive disorders. Men had higher mortality experience, and the distance in mortality increased with age. The mortality was higher among current smokers compared to quitters and non-smokers. Abstainers had higher mortality than those who reported consuming moderate to heavy amounts of alcohol. Subjects who slept more than 9 hours per day had worse mortality than those who slept less. The study shows that health behaviours could play a major role in stretching the lives of older people. The study does not follow-up on changes in health behaviours as the subjects aged, and might have overestimated the effect of healthy behaviour (e.g. subject who quit smoking later in life as a result of chronic conditions might have higher mortality).

Knoops *et al.* (2004) used data from the Healthy Ageing Longitudinal study in Europe (HALE) project. HALE project combines data on subjects who responded to Survey in Europe on Nutrition and the Elderly: a Concerned Action (SENECA) and Finland, Italy, the Netherlands, Elderly (FINE) studies. The baseline interviews for SENECA took place in 1988, and subjects were followed-up in 1993 and 1999. Subjects aged 70 to 75 at based line in 1988 and were from Belgium, Denmark, France, Greece, Hungary, Italy, the Netherlands, Portugal, Spain, and , Switzerland. The baseline interviews for FINE took place in 1984, and subjects were followed-up in 1989/91, 1994/95 and 1999-2000. Subjects aged 70 to 90 at 1989/91 interviews and were from Finland, Italy, and the Netherlands. The study focused on the diet and lifestyle as predictors of mortality. Hence, subjects with baseline diagnosis of Coronary Heart Disease (CHD), Cardiovascular Disease (CVD), cancer, or diabetes were excluded from the analysis. The two datasets contained data of diet, smoking status, physical activity level, educational achievement, the prevalence of CHD, stroke, diabetes, and cancer, the use of antihypertensive medication (only in FINE); occupation (only in FINE); weight, height, and waist circumference (SENECA only). Data on new diagnosis of CHD, CVD, cancer, and diabetes were collected at follow-ups. Cox proportional hazards models were used to examine the combined effect of diet, smoking status, alcohol consumption, and physical activity level on mortality adjusted for sex, age at baseline, number of years in education, body mass index (BMI), and study population (SENECA vs FINE). The sample consisted of 1507 men and 832 women without CHD, CVD, diabetes, and cancer at baseline. The results showed that Mediterranean diet, moderate alcohol consumption, moderate to high physical activity levels, and non-smoking were associated with lower mortality. The sample used in the analysis may not reflect the actual mortality of the older people, as it excluded subjects with chronic conditions at baseline. Moreover, the analysis ignored changes in diet and physical activities as the subjects aged. Overall, the study aimed to compare North/South Europe divide in mortality experience in relation to diet and lifestyle.

From the literature we have gathered that there are several factors that influence mortality at old age. These factors include age, gender, marital status, living arrangements, educational class, social class, health behaviours (smoking, drinking, and exercise) and functional disability (measured by failure in activities of daily living.), chronic conditions and others. These confounding factors influence mortality experience and are likely controls for the effect of ADL on mortality.

2.2.2 Unobserved death in care home

The studies discussed so far were on mortality in older age among people living in households. Very few studies considered mortality among older people living in care homes. This is particularly true for mortality in the UK care homes. The main reason is the lack of data that followed people in care home. Although it is possible to identify subjects who were admitted to care homes in ELSA, they were excluded from the baseline and second interview. Moreover, the number of ELSA respondents who were admitted to care home, and were followed up from the third interview was very small to allow for sound results.

Care home residents are vulnerable older people with high mortality. It might seem rational to assume that they live shorter to their household peers. Yet not many research has been conducted to support this hypothesis. Shah *et al.* (2013) compared between mortality rates of older care home residents and community residents within 1-year follow-up. He used data extracted from The Health Improvement Network (THIN, Cegedim Strategic Data Medical Research, UK). THIN database is a primary care database, which collects anonymised data from English and Welsh general practices and includes a full record of diagnosis, consultation and prescribing. The THIN primary care database includes records of 9,772 care home residents and 354,306 community residents aged 65 to 104 years old. The study examined 1-year all-cause mortality. Results showed that care-home residents have higher mortality than household residents do. People living in nursing care had higher risk of mortality when compared to people living in residential care homes. Chronic conditions (e.g. heart disease) and cognitive conditions (e.g. Dementia) had a higher effect on household residents mortality compare to its effect on care home residents mortality. Section 5.2 discusses this study and other studies in more depth.

Moreover, predictors of care home utilisation are argued to be the factors that prompt mortality. Hence, the high mortality rates observed among care home residents on admission (Oliver (2016)). There are other factors that affect the decision to move to care home, e.g. living with a partner, having an adult child (McCann *et al.* (2009); Noël-Miller (2010)), living with others (O'Reilly and Connolly (2009)), owning a house (O'Reilly and Connolly (2009)), or other factors including income and wealth.

The studies Hancock *et al.* (2002); McCann *et al.* (2009); O'Reilly and Connolly (2009) have commonly used demographics (age, sex, marital status), household composition (living alone, partners or adult children), health conditions (multi-morbidity in chronic conditions), limiting long-term illness, disability, cognitive function. The factors that predict care home admission were found to be older age, diagnosis with life threatening condition, cognitive impairment (e.g. dementia), disability (e.g. failing ADLs). These studies are not discussed any further in this section.

2.3 Methods

The underlying analysis of this paper aims at finding the factors which influence mortality among older persons living in households in England. In this section, a description of the datasets and the variables used in the analysis, together with the statistical methods are outlined.

2.3.1 Data

The English Longitudinal Study of Ageing (ELSA), an interview based longitudinal survey of a sample from the English population. ELSA survey collected information on health, social, wellbeing and economic circumstances of the English population aged 50 and older. The initial sample of ELSA was drawn from the 1998, 1999 and 2001 survey years of the Health Survey of England (HSE), and was first interviewed in ELSA between 1 March 2002 and 1 March 2003. The subjects were then interviewed in biennial waves in 2004/05, 2006/07, 2008/09, and 2010/11. Subsequently on third and fourth waves two refreshment cohorts were added to ELSA sample. The first refreshment cohort, added in the third wave, was of subjects aged 50 to 52 on 1 March 2006 from the 2001/02/03/04 HSE. The second refreshment cohort, added in the fourth wave, was of subjects aged 50 to 74 on 1 March 2008 and was taken from the 2008 HSE. Further details on ELSA are available in Scholes *et al.* (2009); Steptoe *et al.* (2012), also available online on the Institute of Fiscal Studies website (http://www.ifs.org.uk/elsa/). ELSA initial (baseline) sample was 11,392 subjects, who responded to wave 1 in 2002/03, and were followed up in subsequent waves. The first refreshment was 1,276 subjects (wave 3 refreshment). The second refreshment was 2,042 subjects(wave 4 refreshment).

All interviews covered questions about any difficulties the respondent has with motor skills, Activities of Daily Living (ADLs) and Instrumental Activities Daily Living (IADLs). Other information collected in ELSA interviews covered basic demographics (sex, age, marital status), health (respondents were asked about whether they have any longstanding illness, whether they have been diagnosed by a doctor with specific health conditions in particular cardiovascular (CVD) or related conditions, and other chronic illnesses and conditions (such as arthritis)), and health behaviour (smoking, alcohol intake). Additionally, questions that cover falls, fractures and joint replacements were asked to those aged 60 or older.

The questions about chronic and heart conditions included: pulmonary diseases (lung disease and asthma), muscloskeletal (arthritis and osteoporosis), cancer, neurological (Parkinson's, Alzheimer, dementia/senile) and psychiatric. Heart conditions included: high blood pressure (HBP), diabetes, cerebra-vascular diseases (Angina,heart attack, congestive heart failure, heart murmur, abnormal heart rhythm), and stroke.

Furthermore, in HSE subjects were asked about their highest educational qualifications. This was carried forward to ELSA dataset, and the subjects were only been asked to report any further qualifications they have obtained since HSE or previous interview.

Proxy interviews were conducted if an eligible respondent is unable to complete an individual interview due to physical or cognitive impairment or is away in hospital/temporary care throughout the fieldwork period.

Sample

The analysis sample consisted of a pool of ELSA participants aged 50 and older, who joined ELSA interviews at any time (initial cohort and refreshment cohorts). Participants were followed up till death, institutionalisation or last interview seen. The analysis sample included all ELSA members who had complete data at all interviews.

The sample members were 15,346 persons aged 50 and older living in households in England, and followed up by biennial interviews. The sample was made up of three cohorts: initial (wave 1) cohort of 11,391 individuals aged 50 and older on 1 March 2002, wave 3 (first refreshment) cohort of 1,427 [*] individuals aged 50 to 53 on 1 March 2006, and wave 4 (second refreshment) cohort of 2,577 individuals aged 50 to 74 on 1 March 2008.

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[*] including 49 subjects who reentered the study after dropping out in wave 2

Subjects living in institution, at the time of interview, were excluded from baseline interviews. Moreover, subjects who moved to institution in wave 2 (2004/05 interviews) were marked as institutionalised and were not contacted for interview, and were not followed-up. Beginning from wave 3 (2006/07 interviews) institutional interviews were introduced, and continued for subsequent interviews. There was a total of 188 institutional interviews, which were mostly proxy interviews (144 institutional interviews were by proxy), were collected between 2006 to 2010. The number of institutional interviews in each wave were 51 in wave 3, 66 in wave 4 and 71 in wave 5.

Table 2.1 shows the number of achieved interviews with eligible core members at each wave. Respondents to any wave were eligible in subsequent wave unless they had since died, had moved out of Britain or moved out of the private household (e.g. into a hospital, nursing care home or institution). An identifier of the cause of attrition is included in the outcome variable of each wave datasets.

A shorter interview was attempted with a proxy informant if the respondent was unable to respond because of a physical or mental ill health, or cognitive impairment. Eligibility for proxy interviews have changed with wave 4 to include respondents who were away in a hospital or nursing home throughout the whole field-work period, or because they had refused a self-interview. Proxy interviews were identified using the outcome variable given in the datasets. There were a total of 1,290 proxy interviews over the five waves, including institutional proxy interviews.

The proxy responses are likely to be excluded from some analyses, as particular information (e.g. alcohol consumption, smoking and Activities of Daily Living) were not collected at proxy interviews. Although there are only a small number of proxy interviews in each wave, it is important to be aware of their characteristics. A comparison of the characteristics of proxy and in person respondents is shown in table 2.2, which shows that there are considerable differences between the two. Proxy respondents are older and more likely to have a limiting long-standing illness.

Table 2.1: Numbers of achieved interviews in ELSA at each wave

	Wave 1		**Wave 2**		**Wave 3**		**Wave 4**		**Wave 5**	
	2002/03		**2004/05**		**2006/07**		**2008/09**		**2010/11**	
Household interviews										
in person	11,233	98.61%	8,726	98.74%	8,824	97.58%	9,888	96.31%	9,017	95.08%
by proxy	158	1.39%	111	1.26%	168	1.86%	313	3.05%	396	4.18%
Institutional interviews										
in person	-	-	-	-	18	0.20%	14	0.14%	12	0.13%
by proxy	-	-	-	-	33	0.36%	52	0.51%	59	0.62%
Total	**11,391**		**8,837**		**9,043**		**10,267**		**9,484**	

Table 2.2: Characteristics of proxy and in-person respondents to ELSA interviews

in person	**Wave 1 2002/03**		**Wave 2 2004/05**		**Wave 3 2006/07**		**Wave 4 2008/09**		**Wave 5 2010/11**	
Age										
median	64		66		64		64		66	
IQ range	[56, 72]		[58, 74]		[57, 73]		[58, 73]		[60, 74]	
Reported LSI‡										
No	4,873	43.42%	3,718	42.63%	3,960	44.82%	4,452	45.00%	4,013	44.50%
LSI‡	2,419	21.55%	1,873	21.47%	1,865	21.11%	2,032	20.54%	1,815	20.13%
Limiting LSI‡	3,932	35.03%	3,131	35.90%	3,011	34.08%	3,409	34.46%	3,190	35.37%
missing	9	0.08%	4	0.05%	6	0.07%	7	0.07%	11	0.12%
Total	**11,233**		**8,726**		**8,842**		**9,900**		**9,029**	

by proxy	**Wave 1 2002/03**		**Wave 2 2004/05**		**Wave 3 2006/07**		**Wave 4 2008/09**		**Wave 5 2010/11**	
Age										
median	71		73		73		68		69	
IQ range	[60.5, 80.5]		[61, 83.5]		[62.5, 85]		[60, 82]		[62, 81]	
Reported LSI‡										
No	38	24.05%	28	25.45%	49	24.38%	125	33.70%	162	35.85%
LSI‡	11	6.96%	8	7.27%	16	7.96%	39	10.86%	52	11.50%
Limiting LSI‡	109	68.99%	75	67.28%	136	67.66%	201	55.44%	241	52.65%
	158		**111**		**201**		**365**		**455**	

‡ LSI is long-standing illness

The face-to-face questionnaires changed from wave 2 onwards to reflect changes in collected information from previous waves, in order to reduce repetitiveness. They were shortened and some questions, e.g. questions about health related behaviour (alcohol drinking) and social participation, were moved to the self-completion questionnaire from wave 2 onwards. The self-completion questionnaire was concluded after the face-to-face interview was over and the interviewer had left the household, or while another respondent from the same household being interviewed. Respondents were eligible for the self-completion questionnaire if they had completed the main interview in person (i.e. not by proxy). About 9 in each 10 of all core respondents, eligible for the main ELSA interviews, responded to the self-completion questionnaire.

2.3.2 Statistical analysis

The underlying analysis examines if the use of baseline information in a competing risks model with 10 years follow up on mortality between 2002 to 2012 and 8 years follow up on care-home entry between 2002 to 2010 could bias the estimates (Freedman (1996)) compared with allowing for changes over time in the independent variables. Competing risks or the multiple modes of failure is the case when there is an event that prevents observation of the primary event of interest (in this analysis it is entry to care-home preventing observation of time of death). The analysis used data from the first five waves of ELSA.

For descriptive analysis, Kaplan-Meier's nonparametric estimates of survival function was used to obtain an estimate to the median age at death for each of the independent variables. For multivariate analysis, competing risk cox-proportional hazards has been used. Cox regression models have the advantage of accounting for censoring and allowing for modelling of time-varying covariates (time varying predictors). Proportional hazard estimates indicate the proportional effect on the hazard in the model fitted associated with having a particular characteristic, controlling for other variables in the model. Proportions higher than 1.0 indicate an increase in the hazard compared to baseline characteristics. The models allow for the inclusion of time-varying covariates, and their coefficients can be interpreted independent of time/age. The value of the time-varying covariates is assumed to be constant between follow-ups.

Backward elimination was used to eliminate non-significant variables from the regression models, and final models were obtained. Adjusted relative hazards were calculated as a measure of the increased risk in mortality due to each variable, and 95% confidence intervals were calculated as measures of the statistical significance and precision of the relative hazard.

The outcome variable

Data on mortality in ELSA is available for a period of 10 years follow-up between 2002 to 2012. Mortality is modelled using time-to-death which is based on date of birth, date of first interview, and date of death (or censoring for lost-to-follow up (LTF) subjects). The time-to-death is calculated as the difference between age at death (or age at censoring) and age at first interview.

Mortality of the vulnerable older persons is the primary outcome variable of interest in the analysis. The time of death after loss-to-follow up is not known, and is treated as censored. However, subjects lost to follow-up because of care home entry might have higher mortality. Older people move to care home when they are vulnerable and in need for care. Given that subjects who entered care homes were censored, and their mortality is of interest to the underlying question, care home entry is treated as a secondary outcome in the analysis. Time-to-entry to care home is assumed as a competing risk with time-to-death.

Age as the time scale

Using follow-up time from entry into the study (time-on-study) used to be the standard approach for survival analysis, with adjustment for age as a covariate. However, the ageing process and the risk factors related to it, e.g. disability, health deterioration etc., introduce bias in the results from models that use of time on-study as the time scale of the mortality analysis. This is mainly, because the factors are age-dependent, e.g. an oldest older person (age 85 and older) might be able to adapt to disability better than a young older person (age 70 to 80). Kom *et al.* (1997) showed that a proportional hazards regression model that uses age as the time-scale, with possible stratification on birth cohort is more appropriate. A simplification of this model is to use age as the time scale, without stratification for cohort effects. Simply, if the birth cohorts effects were significantly small, the results of the models with age as time-scale (with or without stratification) would be almost identical.

Although, Ingram *et al.* (1997); Korn *et al.* (1997) showed that models that used time-on-study produce statistically correct estimates, the use of age as time scale is deemed more appropriate for survival analysis of the elderly (Lamarca *et al.* (1998)). Age was used as the time variable, with 65 years old as the point of origin for the survival time with the purpose of studying the association of disability with the ageing process, following Lamarca *et al.* (1998, 2003) methodology. The use of this approach directly accounts for the age effect on mortality, without the need to adjust for the confounding effect of age. This allows individual inferences at specific ages (i.e., the survival probability will be based on an individual aged x years, and not of an individual who has spent n years in the study cohort). The fact that there is left truncation, resulting from late entries and those who died after age 65 and before the study started is dealt by incorporating delayed entry in the proportional hazard model.

There were 95 individuals aged 90 or older on wave 1 interview and their age and year of birth were coded 99 in the available data to avoid disclosure of their age. They were excluded from the analysis as their year of birth and age were unknown. If participants joined in wave 1 and they were younger than 90 years old their date of birth from wave 1 was used to calculate their age in later waves. All modelling was conducted on STATA SE version 12.

Demographic, socioeconomic and health characteristics

Demographic information (age, sex, marital status), socioeconomic status (education and social class), ADLs, IADLs, motor skills, Cerebra-vascular diseases,chronic illnesses, and health behaviours (smoking and alcohol intake) were included in the models. These factors are chosen based on existing literature to be associated with dynamics of disability in older people.

Sex was reported at first interview. Age, modelled as a continuous variable, was calculated at time of each wave interview from the date of birth. Both educational class and social class were based on information collected in the HSE and allocated to ELSA respondents as categorical variables. Education was measured as the highest qualification obtained and was categorised as university degree or equivalent, intermediate qualification, and no educational qualification. Social class was classified into three categories: managerial/ professional, intermediate, and semi-skilled/ non-skilled. Both education and social class were only measured at baseline, and were not allowed to vary in the model.

Both ADls and motor skills were categorised based on the severity of disability to zero difficulties , 1 or 2 difficulties, and 3 or more difficulties. Chronic conditions used for the analysis included pulmonary diseases (lung disease and asthma), arthritis, cancer, neurological (Parkinson's, Alzheimer, dementia/senile), psychiatric, cardiac diseases (Angina,heart attack, congestive heart failure, heart murmur, abnormal heart rhythm), and stroke. A dichotomous variable was created to reflect the presence or absence of each condition. A variable for the number of comorbidities was constructed to reflect the presence of multiple conditions together. Life threatening conditions were allowed to vary over time as subjects may report new diagnoses.

Smoking was assessed as never smoked, former smoker, and current smoker. Alcohol use was assessed according to alcohol consumption in the last year (never, weekly to monthly, and daily). Health behaviour questions,smoking and alcohol consumption, were excluded from the proxy interviews in first wave only. In later waves they were included in the self-completion questionnaire which was distributed on randomly chosen 90% of the respondents. Smoking and alcohol consumption were allowed to vary over time.

Self-reported disabilities

The main ELSA wave interview questionnaires asked respondents to self report difficulty with any of the motor skills, Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs). Respondent were shown a list of activities and were asked to choose from the list if they had any difficulty that would last more than 3 months.

The motor skills, provide information about difficulties with limb functions. The motor skills covered in ELSA interviews are lower limb functions (walking, sitting, getting up, climbing, stooping, kneeling, or crouching), and upper limbs functions (reaching or extending arms above shoulder level, pulling/pushing, lifting/carrying, and picking up a 5p coin). Loss of function in the motor skills indicated a problem with the limbs (upper or lower), which can give the rise of a need for care, but they are for very specific limb movements that do not give any details about the type of care needed. Hence, they are not usually used as triggers to begin disability claims. Instead they could be used as guide to predict disability.

The IADLs provide information about difficulties with tasks that require mental and physical capacity (e.g. reading a map, preparing a meal). Even though these can be used as indicators of further cognitive impairment, careful consideration of whether the reported difficulty is not due to other reasons. For example, a respondent who had never prepared a meal in their life might report a difficulty in preparing a meal. This could be seen as false reporting, as the respondent had not lost the ability to do the particular activity. The 7 IADLs reported in ELSA are using a map, preparing a hot meal, shopping for groceries, making telephone calls, taking medications, doing work around the house or garden, and managing money.

On the other hand, ADLs evaluate the individual ability to perform six basic activities independently such as dressing, bathing, dressing, transferring, eating, and grooming. ADLs were chosen for the analysis, as they are more commonly used amongst insurers. Moreover, in literature, for example Vlachantoni *et al.* (2011) highlighted that although IADL can diminish earlier than ADL, formal paid support and state support seemed to be more important need for ADL as most people get informal support for IADL.

Table 2.3 shows the covariates, how they were measured in the interview, and how they were categorised for the analysis. All variables were included in the models, then were investigated by re-fitting the model containing all covariates multiple times, each time removing a single covariate. Statistical significance was determined at $p < .05$.

Table 2.3: Variables sought as predictors of mortality for the analysis presented

Variables	**Source questionnaire**	**Source variables**	**Categories**
Socio-demographics			
Age†	main questionnaire	age	continuous
Sex	feed forward from HSE	sex	”male”,”female”
Married†	main questionnaire	marital status	”married”,”not married”
Living alone†	main questionnaire	no of people in household	”living alone”,”living with others”
Education	feed forward from HSE	last qualifications obtained	”higher than O-level” ”O-level equivalent” ”lower than O-level”
Social class	feed forward from HSE	NSSEC score	”Professional/ Managerial” ”Intermediate/ skilled” ”Semi-skilled/ Non-skilled”
Health behaviour†			
Smoking†	main questionnaire	smoking frequency	”Never smoked” ”ex-smoker”,”current smoker”

† time varying covariate

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Variables	Source questionnaire	Source variables	Categories
Alcohol drinking†	self-completion questionnaire	alcohol frequency	”Does not drink”
			”Drinks Occasionally”
			”Drinks Regularly”
Disability†			
Motor skills†	main questionnaire	9 self-reported motor skills	”No failure”
			”1 or 2 failures”
			”3 or more failures”
ADLs†	main questionnaire	6 self-reported ADLs	”No failure”
			”1 or 2 failures”
			”3 or more failures”
IADLs†	main questionnaire	7 self-reported IADLs	”No failure”
			”1 or 2 failures”
			”3 or more failures”
Life threatening conditions†	main questionnaire	self-reported diagnosis	
pulmonary			”Not diagnosed”
			”reported diagnosis”

† time varying covariate

Continued on next page

Variables	**Source questionnaire**	**Source variables**	**Categories**
arthritis			”Not diagnosed”
			”reported diagnosis”
cancer			”Not diagnosed”
			”reported diagnosis”
neurological			”Not diagnosed”
			”reported diagnosis”
psychiatric			”Not diagnosed”
			”reported diagnosis”
cardiac diseases			”Not diagnosed”
			”reported diagnosis”
stroke			”Not diagnosed”
			”reported diagnosis”
No of conditions	main questionnaire	self-reported diagnosis	0-6
† time varying covariate			

2.4 Results

ELSA sample consisted of 15,346 respondents (11,391 initial sample from 2002, and refreshment samples of 1,276 from 2006, and 2,290 from 2008). Between 2002 and 2012 there were 2,660 (17.78%) deaths and 4,446 (29.72%) lost to follow-up (refused interviews, changed address or lost contact). There are 230 (1.54%) individuals who moved to institution during the follow-up period. Respondents were removed from the sample once moved to institution, but institutionalised respondent were included from the 2006 interviews. Total achieved interviews was 50,017 interviews over the five waves, with only 2,577 (17.23%) respondents who were only seen once.

Analysis of predictors of mortality as observed on initial contact was compared to the analysis of the predictors of mortality when changes over time were observed. This was done by allowing time-varying covarite estimates in the proportional hazard model. Table 2.4 shows the number of subjects categorised by the factors sought for the model. There are 8,142 (53.06%) females and 7,204 (46.94%) males. The number of married respondents was 10,916 (71.13%). Unmarried women (2,941) were twice as much as the number unmarried men (1,489). Moreover, the women living alone (2,228) were slightly less than twice men living alone (1,209). Women are perceived to live longer than men which could explain more women live alone, and more women are unmarried at older age.

The median ages at death shown in table 2.4 are calculated using Kaplan-Meier's survival models. The numbers show that females live longer than males by 5 years. Additionally, non-married females outlive non-married single males by 9 years. The same difference of 9 years was shown for females living alone compared to males living alone.

Table 2.4: Demographic, socioeconomic, baseline health behaviour, disability and life threatening conditions of the analysis sample

							Median age at death	
	Males		Females		Total		Males	Females
Demographics								
Sex	7,204	46.94%	8,142	53.06%	15,346		82.67	87.42
Marital status								
Married	5,715	79.33%	5,201	63.88%	10,916	71.13%	83.92	85.83
Not married	1,489	20.67%	2,941	36.12%	4,430	28.87%	78.92	87.5
Residence								
Live with others	5,995	83.22%	5,914	72.64%	11,909	77.60%	83.75	86.58
Living alone	1,209	16.78%	2,228	27.36%	3,437	22.40%	78.92	87.75
Socio-economics								
Education								
Higher than o-level	2,210	30.68%	1,632	20.04%	3,842	25.04%	86.83	87.08
O-level or equivalent	1,644	22.82%	1,913	23.50%	3,557	23.18%	83.42	90.17
Lower than o-level	3,251	45.13%	4,532	55.66%	7,783	50.72%	81	86.67

* based on NS-SEC = The National Statistics Socio-economic Classification

Continued on next page

	Males		Females		Total		Median age at death	
							Males	Females
missing	99	1.37%	65	0.80%	164	1.07%		
Social class*								
Managerial/Professional	2,620	36.37%	2,008	24.66%	4,628	30.16%	84.92	89
Skilled/Manual	1,346	18.68%	2,128	26.14%	3,474	22.64%	82.67	88.5
Semi-skilled/non-skilled	2,940	40.81%	3,617	44.42%	6,557	42.73%	81.25	86.42
missing	298	4.14%	389	4.78%	687	4.48%		
Health behaviours								
Smoking								
Never	2,002	27.79%	3,542	43.50%	5,544	36.13%	84.67	88.75
Ex-smoker	3,737	51.87%	2,982	36.62%	6,719	43.78%	83.5	88.08
Current smoker	1,233	17.12%	1,455	17.87%	2,688	17.52%	75.58	79.75
missing	232	3.22%	163	2.00%	395	2.57%		
Alcohol drinking								
Regularly	4,706	65.32%	3,845	47.22%	8,551	55.72%	83.92	89.83
Occasionally	1,418	19.68%	2,719	33.39%	4,137	26.96%	81.92	88.33

* based on NS-SEC = The National Statistics Socio-economic Classification

Continued on next page

							Median age at death	
	Males		**Females**		**Total**		**Males**	**Females**
Not at all	511	7.09%	1,113	13.67%	1,624	10.58%	79.42	83.58
Do not drink	569	7.90%	465	5.71%	1,034	6.74%		
Disability at baseline								
Motor skills								
No failure	3,687	51.18%	3,086	37.90%	6,773	44.14%	87.83	89.41
1 or 2 failures	1,701	23.61%	2,210	27.14%	3,911	25.49%	84.33	89.5
3 or more failures	1,596	22.15%	2,689	33.03%	4,285	27.92%	76	84.75
missing	220	3.05%	157	1.93%	377	2.46%		
ADLs								
No failure	5,703	79.16%	6,427	78.94%	12,130	79.04%	85.5	88.58
1 or 2 failures	928	12.88%	1,143	14.04%	2,071	13.50%	77	85.92
3 or more failures	353	4.90%	415	5.10%	768	5.00%	68.75	80.25
missing	220	3.05%	157	1.93%	377	2.46%		
IADLs								
No failure	5,824	80.84%	6,192	76.05%	12,016	78.30%	85.42	89.42

* based on NS-SEC = The National Statistics Socio-economic Classification

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	Males		Females		Total		Median age at death	
							Males	Females
1 or 2 failures	599	8.31%	892	10.96%	1,491	9.72%	78.08	87.33
3 or more failures	559	7.76%	901	11.07%	1,460	9.51%	68.92	78.58
missing	222	3.08%	157	1.93%	379	2.47%		
Life threatening conditions								
Pulmonary								
No diagnosis	6,206	86.15%	6,855	84.19%	13,061	85.11%		
diagnosed	992	13.77%	1,279	15.71%	2,271	14.80%		
missing	6	0.08%	8	0.10%	14	0.09%		
Neurological								
No diagnosis	7,114	98.75%	8,072	99.14%	15,186	98.96%		
diagnosed	84	1.17%	62	0.76%	146	0.95%		
missing	6	0.08%	8	0.10%	14	0.09%		
Arthritis								
No diagnosis	5,528	76.74%	5,307	65.18%	10,835	70.60%		
diagnosed	1,670	23.18%	2,827	34.72%	4,497	29.30%		

* based on NS-SEC = The National Statistics Socio-economic Classification

Continued on next page

							Median age at death	
	Males		**Females**		**Total**		**Males**	**Females**
missing	6	0.08%	8	0.10%	14	0.09%		
Cancer								
No diagnosis	6,855	95.16%	7,584	93.15%	14,439	94.09%		
diagnosed	343	4.76%	550	6.76%	893	5.82%		
missing	6	0.08%	8	0.10%	14	0.09%		
Stroke								
No diagnosis	6,898	95.75%	7,886	96.86%	14,784	96.34%		
diagnosed	298	4.14%	251	3.08%	549	3.58%		
missing	8	0.11%	5	0.06%	13	0.08%		
Cardiac diseases								
No diagnosis	5,795	80.44%	6,900	84.75%	12,695	82.73%		
diagnosed	1,401	19.45%	1,236	15.18%	2,637	17.18%		
missing	8	0.11%	6	0.07%	14	0.09%		

Education and social class reflect the life-style and the living standard of the individual. It is expected that individuals with higher education and higher social class to live longer. Half of the sample (7,783 subject 50.72%) have no educational qualifications, the rest are distributed evenly on higher educational qualification and o-level and equivalent. There is not much difference between men and women in education. There are more men in the managerial/ professional social class than women. Both men and women are equally in semi-skilled and non-skilled occupations. The median ages calculated in these categories shows that female with intermediate education level and intermediate social class tend to have slightly higher median age compared with higher education and higher social class.

Half of the males were ex-smoker, and quarter of them had never smoked. On the other hand females were equally ex-smoker or have never smoked. There is only a fraction of a year difference between those who never smoked and ex-smokers in the median age at death. This suggest that quitting smoking is beneficial. On the other hand current smokers, who are 17.52% of the sample have 9 years shorter median ages at death. Moderate alcohol consumption (regularly: daily, more than once weekly and occasionally: once per month or less often) shows improvement in median age of 4 years for males and 5 years for females. There are more males who drink regularly (65.32% of the males), but non-drinkers are the same between males and females. This means women who drink, tend to drink less often compared to men.

Physical disability shown in table 2.4 are measured at the initial contact with the subject. There are many respondents (4,285; 27.92%) reported sever functional inability (3 or more failures) in the motor skills compared to 1460 (9.51%) who reported severe difficulties in IADLs and 768 (5%) who reported severe difficulties in ADLs. Individuals with higher levels of disability have shorter median life. Men were affected more than females, with reduction of 5 years when moderate ADL difficulty was present at initial contact, compared to 3 years in females. The reduction in median age increased to 17 years amongst men with sever difficulties in ADLs and IADLs. In women sever difficulty in ADLs reduced median life age by 8 years, and severe difficulties in IADLs reduced life by 11 years. Difficulties in motor skills had little influence on women median life, as moderate difficulties had no effect and sever difficulties decreased median life by 4 years only. For males, there was a reduction in median life by 3 years and 11 years for both moderate disability and sever disability in motor skills respectively. This indicates that possibly men die very soon after they incur disability, and women live longer but in disablement.

Two mortality models fitted to examine the loss of information due to the use of the information on predictors of mortality and care home admission on baseline. Table 2.5 show the difference in number of observations and number of subjects and observations. The two models are shown in table 2.6. The estimated sub-hazard ratios for model 1 showed that sex, education, social class, smoking, alcohol intake, being diagnosed with pulmonary disease, arthritis, cancer, and cardiac diseases, and reporting physical disability in motor skills, IADLs or ADLs are statistically significant predictors of mortality (with 95% to 99% confidence levels). Model 1 takes account of the changes in observed diagnoses and self-reported physical disability. On the other hand, when those predictors were fixed for observation at baseline; sex, diagnoses at baseline of pulmonary, cancer and cardiac diseases, smoking, alcohol intake frequency, physical disability in motor skills and IADLs only stayed significant. Education, social class diagnosis with arthritis, and reported ADLs at baseline had no significance at 95% confidence level.

In both models being male increased mortality by more than 80% (83.3% for model 1 and 81.8% for model 2). Education and social class are seen to be significant at 95% level only when medical diagnoses and reported disabilities were allowed to vary over time. They both stayed significant within the 90% confidence level, and the increase in mortality for lower education and lower social class was reduced (from 27.8% to 14.6% mortality hazard for subjects with lower education, and from 19.7% to 12.4% mortality hazard for subjects in lower social class). This indicates that the inequality in health deterioration between the socioeconomic groups is more distinguished when observed on longitudinal basis rather than on a cross sectional basis.

Table 2.5: Summary comparison of the two models

	Model 1	**Model 2**
Number of observations	28,575	27,412
Number of subjects	11,584	10,774
Deaths observed	1,066	1,066
Institutionalised	66	66
Log likelihood	-6,969	-7,909
AIC	13,976	15,857
BIC	14,133	16,014

Model 1 allowing covariates to vary over time
Model 2 fixed covariates to baseline values

Table 2.6: Competing risk proportional hazard regression models with main outcome variable is mortality

	Model 1			**Model 2**		
	Allowing covariates to vary over time			**Fixed covariates at baseline value**		
	SHR†	**p-value**	**95% CI**	**SHR†**	**p-value**	**95% CI**
Demographics						
Sex						
Female						
Male	1.838***	0.00001	[1.613, 2.091]	1.818***	0.00001	[1.604, 2.060]
Socio-economics						
Education						
Higher than o-level						
O-level, equivalent or lower	1.278**	0.002	[1.093, 1.493]	1.146	0.075	[1.093, 1.330]
Social class						
Managerial/Professional						
Skilled/Manual/non-skilled	1.197**	0.007	[1.051, 1.363]	1.124	0.067	[1.051, 1.273]

* p<0.05, ** p<0.01, *** p<0.001

†SHR is subdistribution hazard ratio

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	Model 1			**Model 2**		
	Allowing covariates to vary over time			**Fixed covariates at baseline value**		
	SHR†	**p-value**	**95% CI**	**SHR†**	**p-value**	**95% CI**
Life threatening conditions						
No diagnosis with any						
Pulmonary	1.441***	0.0001	[1.194, 1.739]	1.258*	0.022	[1.034, 1.532]
Arthritis	0.819*	0.034	[0.681, 0.985]	0.859	0.103	[0.716, 1.031]
Cancer	2.564***	0.00001	[2.106, 3.121]	2.126***	0.00001	[1.724, 2.623]
Stroke	1.191	0.065	[0.989, 1.433]	1.108	0.39	[0.877, 1.402]
Cardiac diseases	1.268***	0.0001	[1.119, 1.437]	1.393***	0.00001	[1.224, 1.586]
Multi-morbidity (no of conditions)	0.911	0.00001	[0.780, 1.065]	0.958	0.594	[0.819, 1.121]
Health behaviours						
Smoking						
Never						
Ex-smoker	1.176*	0.026	[1.020, 1.357]	1.179*	0.02	[1.027, 1.355]
Current	2.374***	0.00001	[1.977, 2.852]	2.511***	0.00001	[2.109, 2.991]

* p<0.05, ** p<0.01, *** p<0.001

†SHR is subdistribution hazard ratio

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	Model 1			Model 2		
	Allowing covariates to vary over time			**Fixed covariates at baseline value**		
	SHR†	**p-value**	**95% CI**	**SHR†**	**p-value**	**95% CI**
Alcohol drinking						
Regularly						
Occasionally	1.127	0.085	[0.984, 1.291]	1.151*	0.037	[1.008, 1.313]
Never	1.221*	0.017	[1.037, 1.438]	1.268**	0.004	[1.080, 1.489]
Disability						
Motor skills						
No failure						
1 or 2 failures	1.167	0.097	[0.972, 1.401]	1.045	0.616	[0.881, 1.238]
3 or more failures	1.412***	0.001	[1.150, 1.734]	1.372**	0.001	[1.131, 1.664]
ADLs						
No failure						
1 or 2 failures	1.177*	0.04	[1.007, 1.375]	1.11	0.183	[0.952, 1.295]
3 or more failures	1.252	0.055	[0.995, 1.576]	1.032	0.804	[0.805, 1.322]

* p<0.05, ** p<0.01, *** p<0.001

†SHR is subdistribution hazard ratio

Continued on next page

	Model 1			**Model 2**		
	Allowing covariates to vary over time			**Fixed covariates at baseline value**		
	SHR†	**p-value**	**95% CI**	**SHR†**	**p-value**	**95% CI**
IADLs						
No failure						
1 or 2 failures	1.468***	0.00001	[1.244, 1.732]	1.418***	0.00004	[1.200, 1.677]
3 or more failures	1.709***	0.00001	[1.416, 2.064]	1.759***	0.00001	[1.445, 2.141]

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

2.5 Discussion

The results obtained from the analysis showed strong/week predictors of mortality. Models for the institutionalisation were not statistically significant because the small number of subjects moved to institution during the follow-up period. This means that those with higher need, i.e. the most seriously disabled, are excluded from the sample. Ploubidis *et al.* (2011) discussed the under-representation of institutionalised individuals in ELSA sample. On the other hand, the socio-demographic characteristics of ELSA sample with national census data indicated that ELSA sample is a representative of the non institutionalised population. Further checks were carried out to examine ELSA sample representation of the mortality in the population. (see 2.B).

The most important characteristic of the analytical approach presented here is that it allowed changes in individual health status (medical diagnoses and physical disability) during the period under observation. For example, an individual independent at baseline is considered independent until the end of follow-up, even if she/he has become dependent during this period. The other model takes into account that elderly people are more likely to worsen their disability status than to improve it, this standard approach would tend to consider as independent individuals who would be actually dependent. As a consequence, the association between disability and the outcome variable, in this case death, is usually underestimated. There is controversy in studies assessing disability trends on ageing. These uncertainties may be partially explained by this miss-classification problem. Whether disability status will decline in parallel with mortality or whether the decline will be faster or slower is a key policy question for health services planning. This issue is better approached from a longitudinal point of view.

We included a wide range of potential confounding variables of demographic, health behaviours, health and socioeconomic characteristics in our analyses guided throughout by the results of previous research. However, as with any analysis, it is possible that there remains uncontrolled confounding in our models. Moreover, mild cognitive impairment may have been present in some respondents to ELSA and hence influenced their institutionalisation and mortality experience, without being fully captured by the measures of health status adjusted for. Throughout, most measures we included have been widely used in previous research. Although the measures used have been used previously, they rely on self-report and may be open to error and bias.

There are limits of applicability of the data presented, as the study was not concerned with groups with specific reasons to quit smoking or avoid alcohol, such as those on relevant medications. The data do not include those in institutions, where disabilities and use of interacting medications are relatively common. There also may be deleterious outcomes of alcohol use that this study has not been able to capture; heavier drinking may, for example, contribute to high blood pressure or to greater risk of motor vehicle accidents. health related behaviours shows that smoking and history of smoking had negative impact on health measured by reported ADLs. On the other hand alcohol showed to be beneficial. The benefits of being occasional or regular drinker of alcohol can be due to better social life for those who drink, or due to the fact that those who do not drink were asked to stop drinking by a doctor or a nurse due to serious illness. Other reasons could be because health benefits of moderate consumption of Alcohol.

The results of the analysis have showed that drinking might have a positive influence on health. Based on that, further look into literature was sought to build better understanding of the results relating to alcohol consumption and health. This section covers what was found in relation to this point.

Lang *et al.* (2007b) studied the effect of alcohol consumption on well-being and cognition. The study looked at alcohol misuse and abuse and it's association with health and social problems and substantial excess mortality. Ageing is associated with a number of physiological changes suggesting increased sensitivity to alcohol. Most of the studies agreed that moderate alcohol intake are associated with fairly better mortality risks than abstinence.This is linked mainly to a protective effect with regard to cardiovascular disease Mukamal *et al.* (2003b); Gaziano *et al.* (1996); Puddey *et al.* (1999).

Although hidden confounders may account for some of the abstinence effect, because older people have high rates of cardiovascular disease, the balance of risk and benefit from strictly moderate alcohol consumption may be positive or neutral (Jackson *et al.* (2005)). Heavier drinkers who developed health problems might have cut down their consumption at baseline, thus potentially inflating the risks of lower consumption categories.

Thomas and Rockwood (2001) showed that alcohol abuse increases the risk of dementia and mortality in older ages. Other studies by Lang *et al.* (2007a); Huang *et al.* (2002); LaCroix *et al.* (1993) showed that moderate alcohol consumption is associated with better mobility, cognition and well-being this suggest that moderate alcohol consumption acts to reduce the rate of moving into care homes at old ages. It also showed that among those who do not drink alcohol there is no difference between quitters and those who never had alcohol.

Lang *et al.* (2007a) highlighted that moderate levels of alcohol consumption are often associated with socialising. This can prove that social interaction other than moderate drinking can be the reason for better mobility, cognition and well-being. Mukamal *et al.* (2003a) also commented that social factors and psychological benefits associated with moderate alcohol use may contribute positively to the improvements in mobility, cognition and well-being.

Alexander and Duff (1987); Adams *et al.* (1996) both looked at the consumption of alcohol in retirement houses and they concluded that residents of retirement houses communities tend to drink more compared to the elderly persons in the population as a whole. Furthermore, the studies identified that social isolation can be linked to heavy drinking, as heavy drinkers admitted to drinking alone. On the other hand, the studies found a strong relationship between greater social interaction and alcohol use. This can be a result of the build of social life of the retirement communities. This also can be explained by the fact that people living in retirement houses tend to have higher incomes and greater education, hence can afford to drink alcohol more often than those with lower incomes and less education. Evidence on the association of alcohol and social life was examined in Peele and Brodsky (2000); Baum-Baicker (1985).

The survival analysis with age as the basic time variable and delayed entry offers several advantages, compared to the predominant survival analysis strategies, which define the survival time as the elapsed time from entry into the study until death. First, the methodology for delayed entry assured that the estimated survival experience from the sample matched that of the study base. Second, any confounding by age was directly handled using age as time variable, and by using age-dependent covariates allowance is made for age-dependent exposure variables and for age as an effect modifier.

As the design of ELSA survey was based on household resident, the sample excluded care-home residents at baseline wave 1 and wave 2. Those moved to care home in wave 2 are non-random loss of follow up, which creates left censoring problem. From wave 3 onwards any respondents moved to care home were contacted to follow-up. The number of interview taken from individuals living in care-home starting from wave 3 is very small to produce any significant statistical evidence. This study shows the predictors of mortality in old age, and contrasts with models that look into the predictability of mortality if changes in health has been taken into account. It has been shown that health deterioration at old age increases the risks of mortality and admission to care home.

Appendices

2.A Description of Longitudinal Datasets

Table 2.A.1 shows summary of longitudinal studies that we have looked at in literature. These studies had the outcome variable as death and/or care-home entry. What makes their results different are the datasets used, the predictor of question in relation to the outcome variable, and the statistical analysis used. The common analysis among the studies summarised in the table is the cox-proportional hazard, and the logistic regression comes next. O'Reilly and Connolly (2009) used the Poisson model as it was concerned about geographical variation in numbers of admission to care-homes in Northern Ireland.

The studies used for literature have looked at several longitudinal surveys, that interviewed individuals from different age groups, living arrangement (care-home residents/ household residents), geographical areas (USA, UK and Europe), and different measures of health and health behaviour. Understanding these differences is needed to make valued comparison of the results from these studies and the analysis conducted in this paper. Table 2.A.1 shows the datasets used in each study, sample size, years data collected and age range.

Table 2.A.1: Datasets used in literature for studying predictors of death and care home entry

Datasets	**Sample size**	**Years covered**		**Age range**	**Population represented**
		From	**To**		
Longitudinal Study	92,931	1971	1991	55 to 77	England
ELSA	11,391	2002	2008	50+	England
SHARE	27,444	2004	2008	50+	Europe
HRS	10,229	1998	2008	50+	USA
MRC CFAS	13,004	1992	2003	65+	England and Wales
ORLS	90,922	1970	1999	65+	Oxford
BHPS	3,726	1996	2002	50+	Britain
THIN	364,078	2009	2010	65+	Britain
longitudinal cohort study	775	1996	2002	65+	North Carolina
BCSA	1,606	1997	2002	60+	Bambui, Brazil
DRGP	28,064	1993	1998	65+	Northern Ireland

The following is a brief description of the datasets from table 2.A.1:

- Medical Research Council Cognitive Function and Ageing Study (MRC CFAS) is a longitudinal study of 13,004 people aged 65 and older in 1991, selected from 5 centres (Urban: Newcastle, Nottingham, Oxford; Rural: Cambrisgeshire and Gwynedd), with those aged 75 and older oversampled (equal numbers of respondents in the 65-74 and 75 and older age groups). The study originally aimed at understanding cognitive functioning at older age, but included information about health, socio-economics, etc. The initial screening interview was carried out between 1991 and 1994 on the entire sample. Further interviews were conducted with all participants remaining in the study 2 and 10 years after the screening interview.

- The Longitudinal Study (LS) is a study linking data from successive censuses from 1971, 1981, and 1991. At any one time the study represents 1% sample of the population. Mortality data were taken from National Health Service Central Register (NHSCR).

- The Health Improvement Network (THIN, Cegedim Strategic Data Medical Research, UK) database is an established primary care database, which collects anonymised data from UK general practices and includes a full record of diagnosis, consultation and prescribing. The THIN primary care database includes records of 9,772 care home and 354,306 community residents aged 65 years in 293 English and Welsh general practices in February 2009.

- Health and Retirement Study (HRS) is a biennial longitudinal survey study started in 1992. It aimed at interviewing people aged 50 and older living in household in the United States of America. Refreshment samples of younger cohorts are added regularly to the study to keep representation of younger aged members. The goal of the study is to investigate the implications of health changes at older ages for economic well-being, family dynamics, and reliance on formal and informal support systems.

- The Northern Ireland Longitudinal Study (NILS) is a census-based longitudinal study of variations in survival amongst residents of nursing and residential homes in Northern Ireland on 2001. The sample is approximately 28% of the population of Northern Ireland. The sample formed from a cohort of 51,619 people aged 65 or over at the time of the census not living in a care home.
- Data Retrieval in General Practice (DRGP) is a study cohort that was based on the patient lists of general practitioners‘ (GPs) practices distributed across Northern Ireland. The initial population of 255,403 people (15% of the Northern Ireland population). A total of 31,202 (12%) were aged 65 and over and not living in a care home at the outset of the study, and were followed for five years.
- The Survey of Health, Ageing and Retirement in Europe (SHARE) is a longitudinal study that is similar in design to HRS and ELSA, carried out in Europe and started in 2004.
- The Oxford Record Linkage Study (ORLS) began in 1963, collecting hospital data from a representative sample from England and Wales, linking it to birth and death certificates.
- The British Household Panel Survey (BHPS) started in 1991 by interviewing each adult member of around 5,000 British households. They have subsequently been followed up each year.
- longitudinal cohort study followed patients aged 65 years and older who were enrolled in a Medicare HMO in North Carolina.
- Bambui Cohort Study of Ageing (BCSA) Brazil, baseline data collected on (1997) and subsequent 5 years of follow-up, that is ongoing in Bambui City (15,000 inhabitants), Brazil. The cohort study participants comprise 92% (1606) of total inhabitants aged 60 years and over on January 1, 1997.

2.B Age at death

The question being asked here is whether ELSA sample mortality rates and ageing structure represent England population of people aged 50 and older? In order to answer the question whether ELSA sample is representative sample of England population, a comparison between estimated mortality from the sample and estimated mortality from England population on 2002 was conducted.

Mean age and Median age at death for people Aged 50 and older have been calculated for ELSA sample. Additionally, It was compared to the mean and median age at death from the published population estimates from Office of National Statistics (ONS) for the people aged 50 and older on the year 2002. The definition of mean and median age at deaths together with the calculation steps are shown in Appendix 2.C.

The reasons why ELSA mean and median age at death could be different from the population mean and median are either the difference in ageing structure between the sample and the population, or the difference in mortality rates between the sample and the population. Examination of the ageing structure of the sample and the population can be done by comparing the percentages of individuals at age groups in people aged 50 and older.

The comparison of percentages of individuals in each year of age for ELSA sample males and England population estimates of males aged 50 and older on 2002. The figure shows that there is not much differences between the sample and the population ageing structure. The biggest difference being at age 50, this can be due the difference of age definitions. In ELSA, individuals were eligible to the interview if they were aged 50 or older on March 2002. On the other hand, ONS population estimates were based on age mid-year on 2002. Otherwise, the ELSA sample ageing structure mimics the ageing structure of the English population estimates.

The comparison of percentages of individuals in each year of age for ELSA sample females and the England population estimates of females aged 50 and older on 2002 obtained from ONS. Again the difference in age 50 is biggest due to differences in age definitions in ELSA sample and ONS estimates. Otherwise, the ELSA sample ageing structure estimates mimics the ageing structure estimates of the English population estimates.

To further check the effect of difference in ageing structure on mortality estimates from ELSA sample compared to the English population estimates. Additionally, to check the effect of different mortality experiences between the ELSA sample and the English population, the mean and median age of deaths were calculated using the following three sets of assumptions were used:

i: ONS mortality rates applied to ONS population.

ii: ONS mortality rates applied to ELSA sample.

iii: ELSA mortality rates applied to ELSA sample.

In order to get a better understanding of the effect of difference in ageing structure on mortality experience, results obtained from sets of (i) and (ii) assumptions were compared. Also, for the purpose of visualising the difference in mortality estimates, results from sets (ii) and (iii) assumptions were compared.

2.B.1 Results

Table 2.B.1 shows the calculated mean and median ages at death using ONS published estimates of cohort mortality of people aged 50 and older. The first row shows the mean age at death for ELSA sample ageing structure, and the second row is for ONS estimates ageing structure on year 2002. As previous comparison between ageing structure suggested that the ageing structure of ELSA mimics the English population ageing structure, it is expected that applying the same mortality rates to both would make much differences. The mean age of death is slightly lower for ELSA sample than for the English population.

Additionally, the median age at death has been calculated and shown in table 2.B.1 in the third and fourth rows. The median showed to be slightly lower than the mean, but carried the same patter when comparing between ELSA sample ageing structure and ONS published estimates ageing structure. This suggests that the difference in ageing structure between ELSA sample and the English population has negligible effect on mortality experience.

Table 2.B.1: Mean and Median ages at death calculated using ONS published cohort mortality rates

	Mean age at death		
Ageing Structure	Males	Females	Persons
ELSA	84.85	87.66	86.25
ONS	84.78	87.84	86.31

	Median age at death		
Ageing Structure	Males	Females	Persons
ELSA	84.02	87.32	85.63
ONS	84.16	87.19	85.66

Another point that was tackled is checking if mortality rates estimated from ELSA sample are different form the English population mortality rates. Table 2.B.2 shows the mean and median ages at death for ELSA sample, using ELSA sample mortality rates, and ONS population mortality rates estimates. The first and second rows show the mean ages at death using ELSA mortality, and ONS mortality rates respectively. The mean ages obtained using ELSA mortality rates are higher than the mean ages using the ONS mortality. This shows that mortality for ELSA sample is lighter than the general population. As mentioned above in the description of ELSA, individuals were eligible to join the survey if they live in households, and they were not interviewed if they moved into residential/nursing care-homes. This introduces selection effect on the mortality estimates from ELSA sample.

Additionally, in the third and fourth rows the median ages are shown, and the median ages had similar pattern as shown by the mean ages.

One thing to highlight here is that the median ages are higher than the mean ages when calculated for ELSA sample using mortality rates estimated from the sample itself. This indicates that the age at death distribution is skewed to the left. This can be due to the fact that individuals in older ages tend to be

Table 2.B.2: Mean and Median ages at death for ELSA sample ageing structure with different mortality rates

	Mean age at death		
Mortality Rates	Males	Females	Persons
ELSA	88.85	90.56	89.56
ONS	84.85	87.66	86.25

	Median age at death		
Mortality Rates	Males	Females	Persons
ELSA	87.08	91.75	90.00
ONS	84.02	87.32	85.63

censored from observations, which makes the average future life shorter than the time taken to observe half of the deaths, given deaths were observed.

2.C Calculation of Mean and Median Age at death

This appendix describes the calculation of the mean and median age at deaths used in Appendix 2.B. The calculation of the mean and median life at death followed from the definitions used by Office of National Statistics (ONS) (2012).

Life expectancy or mean age at death, is the age at which a person is expected to die. The mean age at death is the sum of "current“ age and the arithmetic average of future life years survived till death. Another measure of life expectancy is the median age at death, which represents that age at which exactly half the deaths in a given time period were below that age and half the deaths were above that age. In other words, starting from a hypothetical population aged x, the median age at death is the age $x + t$ such that half of the population died.

Life expectancy (mean or median) is calculated using a life table, which is a statistical description of the course of mortality. Life tables can be period or cohort tables. Period life tables represent age-specific mortality rates for a given time period with no allowance for any later actual or projected changes in mortality. In practice, death rates are likely to change in the future so period life tables does not therefore give the mortality that someone could actually experience. Cohort life tables represent age-specific mortality rates which allow for known or projected changes in mortality in later years and are thus regarded as a more appropriate measure of mortality experience of a person of a given age.

The purpose for the calculations is to compare mortality experience of the ELSA sample and England population. Therefore, cohort tables were used in the calculation of life expectancy. The following is explanation of the calculations used in Appendix A:

Definitions of notation, for $x = 50$ and older

w_x^E	is the proportion of people aged x from ELSA sample on year 2002
w_x^{ONS}	is the proportion of people aged x from published ONS population estimates mid year 2002
q_x^E	is the estimated mortality rate from ELSA. Estimated using life table method from STATA
$q_{x,t}^{ONS}$	is the published ONS population cohort mortality estimates
$l_{x,t}^E$	is the number of lives aged x on year t, based on ELSA sample ageing structure and ONS cohort mortality
$l_{x,t}^{ONS}$	is the number of lives aged x on year t, based on ONS ageing structure and ONS mortality estimates

Starting with a hypothetical population of $100,000$ individuals (males, females or persons), the number of individuals at each year of age on calendar year 2002 is the product of the estimated proportion and $100,000$. On subsequent calendar years, the number of lives $l_{x,t}^*$ was estimated by applying the specific cohort mortality estimates as follows:

i: ONS mortality rates applied to ONS population.

The calculation was done using the ONS published cohort mortality rates, applied to the ONS published population structure on mid year 2002 of people aged 50 and older. The estimates $l_{x,t}^{ONS}$ for $x \geq 50$ and $t \geq 2002$, were used to estimate the weighted average mean and median ages of deaths.

The mean ages at death were calculated for each year of age separately, so a male aged 50 would have a mean age at death of 83.84, and a male aged 80 would have a mean age at death of 87.38. These numbers are mean ages calculated for specific age year, hence a summary of these mean ages is calculated. Calculation of the arithmetic average of the mean ages at death, would cancel the ageing structure effect, so a weighted average mean was calculated with the weights being the proportions at each year of age w_x^{ONS}.

Let $e_x^{ONS} = \frac{\Sigma_{y=x,t} l_{y,t}^{ONS}}{l_{x,2002}^{ONS}}$, be the mean age at death for a person aged x on year 2002,so that $e_{50}^{ONS} = 83.84$ and $e_{80}^{ONS} = 87.38$. Finally the mean age at deaths for all individuals aged 50 and older μ is calculated using:

$$\mu^{ONS} = \Sigma_{x=50} w_x^{ONS} \cdot e_x^{ONS} \tag{2.1}$$

The calculations of median age at death started by constructing a life table of a hypothetical population that has the age structure on year 2002 and has an average age of 65 on that year. Then, the time spent till half of the hypothetical population was dead is calculated and added to the average age on 2002.

Let $L_t = \Sigma_{x=50+(t-2002)} l_{x,t}^{ONS}$ be the total individuals from a hypothetical population of people aged 50 and older on 2002, 51 and older on 2003, ...
Let the weighted average age $\bar{x}_{2002} = x \cdot w_x^{ONS}$.

The median time spent till have of the death occurred is $\{\tau : L_\tau = \frac{L_{2002}}{2}\}$, hence the median age is $\bar{x}_{2002} + \tau$

ii: ONS mortality rates applied to ELSA sample.

The calculation was done using the ONS published cohort mortality rates, applied to the ELSA ageing structure estimates on year 2002 of people aged 50 and older. The estimates $l_{x,t}^{E}$ for $x \geq 50$ and $t \geq 2002$, were used to estimate the weighted average mean and median ages of deaths in similar manner as explained above.

The mean ages at death were calculated for each year of age separately. Calculation of a weighted average mean was calculated with the weights being the proportions at each year of age w_x^{E}.

Let $e_x^{E} = \frac{\Sigma_{y=x,t} l_{y,t}^{E}}{l_{x,2002}^{E}}$, be the mean age at death for a person aged x on year 2002 and the mean age at deaths for all individuals aged 50 and older μ is calculated using:

$$\overset{E}{\mu} = \Sigma_{x=50} \overset{E}{w_x} \cdot \overset{E}{e_x} \tag{2.2}$$

The calculations of median age at death is calculated as explained above from adding the time spent till half of the hypothetical population was dead to the average age on 2002.

Let $L_t = \Sigma_{x=50+(t-2002)} \overset{E}{l_{x,t}}$ be the total individuals from a hypothetical population of people aged 50 and older on 2002, 51 and older on 2003, ... Let the weighted average age $\bar{x}_{2002} = x \cdot \overset{E}{w_x}$.

The median time spent till have of the death occurred is $\{\tau : L_\tau = \frac{L_{2002}}{2}\}$, hence the median age is $\bar{x}_{2002} + \tau$

1. ELSA mortality rates applied to ELSA sample.

   For the calculation of median age at death, the Kaplan-Meier estimates were calculated using STATA. For the mean age at death the life estimates were calculated.

Chapter 3

Dynamics of the reported Activities of Daily Living: results from the English Longitudinal Study of Ageing

Abstract

Activities of daily living (ADLs) are significant disability measures, and used as claim triggers for insurance that covers long-term costs. Observation of self-reported ADLs in longitudinal studies showed a changing pattern. Subjects report improvements as well as deterioration in ADLs. This chapter uses data on self-reported ADLs from the English Longitudinal Study of Ageing (ELSA) to investigate the factors that predict improvement and deterioration of ADLs at older age. Data from 8,276 subjects aged 60 and over, who responded to at least two waves of ELSA with complete ADL information, is used to estimate pooled panel logistic regression random effects models. Two sets of models were estimated. Initially, models on improvements in ADLs, i.e. reporting less ADLs at follow-up. Subsequently models on deterioration, i.e. reporting more ADLs at follow-up, were estimated for comparison. The predictors used in the models are previous ADLs, age, sex, marital status, education, social class, cardiac diseases, other chronic illnesses, recent joint replacement, smoking and alcohol drinking. Subjects report improvement twice as likely as they would report deterioration in ADLs. Old age, difficulties in motor skills, neurological diseases and multi-

morbidity contribute to the vulnerability to disability and reduce the chance of improvement. Arthritis had no association with improvement in ADLs, but had a protective effect against deterioration. In conclusion disability is not static, and it is not a one direction route. The elders experience recurrent disability and improvement. Insurers may require regular assessment of disability levels of their claimants. Moreover, flexible benefits systems that offer additional services during times of moderate disability could potentially reduce the costs of long-term care.

3.1 Introduction

Activities of Daily Living (ADLs) are sensitive and more meaningful measure of the burden of disease at older age than individual diagnoses, because the older people often have multiple diagnoses with varying severity. Additionally, ADLs are significant measures of disability as they relate to care needs. ADLs include activities such as dressing (including putting on shoes and socks), eating (such as cutting up your food), using the toilet (including getting up and down), bathing and showering, getting in and out of bed, and walking across a room. They are essential to maintaining independence at old age. The loss of function in one or more of these activities indicates a need for personal care from another person. Moreover, difficulty in performing ADLs has been found to be a significant predictor of nursing home use and mortality (Boult *et al.* (1994); Liu *et al.* (1990)). In England, recent suggestions of insurance policies, that will provide funding of costs of long-term care, rely on ADLs to trigger claims (Mayhew *et al.* (2010); Kenny and Barnfield (2013)). The claims are set to commence by ADL trigger, i.e. by failing in a number of ADLs (e.g. at least 3 ADLs).

Disability measured by self-reported difficulties in the activities of the daily living (ADLs) at older age is observed to take on two directions. Observation in longitudinal studies showed a changing pattern. Subjects report improvements as well as deterioration in ADLs both in short period follow-ups (Hardy *et al.* (2005); Hardy and Gill (2004)), and in longer periods of follow-up (Verbrugge *et al.*

(1994); Anderson *et al.* (1998)). It is uncertain whether the reported improvement in disability status, yet with risk for subsequent deterioration, inherit patterns of recovery and recurrent disability, or the reported improvements were short-term gains in functioning that were realised from adaptations to disability (Anderson *et al.* (1998)). Older persons successfully adapting to disability may gain ability to function, and this could lengthen the time spent without severe disability. There is an appreciable instability in disability at old age, which is intriguing from a health care and policy perspective. The ability to understand those instabilities and the factors that contribute to their occurrence supports decisions on the provision of health and social care at old age. Moreover, insurance claims designed to continue until death once triggered by ADLs, mean that insurers might end up paying for their claimants whereas they are not in need. Hence, understanding the factors that influence the nature of changing ADLs at older ager between deterioration and improvements is important in understanding the need for care, and the costs associated.

This paper investigates socioeconomic, demographic, and health conditions that are associated with the deterioration and improvement in the ADLs. It uses data on self-reported ADLs from the English Longitudinal Study of Ageing (ELSA) to investigate the factors that predict improvement and deterioration of ADLs at older age. The analysis Sample consisted of 8,276 subjects aged 60 and over, who responded to at least two waves of ELSA with complete ADL information. Two sets of pooled panel logistic regression random effects models estimated, with the outcome once is improvements in ADLs, then deterioration in ADLs. The predictors used in the models are ADLs reported at previous interview, age, sex, marital status, education, social class, cardiac diseases, other chronic illnesses, recent joint replacement, smoking and alcohol drinking.

This paper is organised as follows: section 3.2 provides discussion of previous literature on the dynamics of disability in older age. It starts with studies that had long periods of follow-ups (e.g. yearly or biennially), then studies with short periods of follow-ups (e.g. monthly follow-ups), followed studies that examined disability using the English Longitudinal Study of Ageing (ELSA), and finally discussion of improvements in disability measured by the Instrumental Activities of Daily Living (IADLs). Section 3.3 layouts the data, sample, variables and models used in the analysis. Descriptive statistics and modelling results are shown in section 3.4. Finally, discussion of the results, shortcomings of the modelling, and how the results could inform policymaking and insurance design are in section 3.5. Appendix 3.A shows a list of all ADLs and IADLS and motor skills reported in ELSA interviews. Appendices 3.B & 3.C show sensitivity models using improvements in motor skills instead of ADLs.

3.2 Dynamics of disability in older age

The progression of disability among older English people has been a topic of discussion in literature with the availability of multiple waves of data from longitudinal studies, such as the English Longitudinal study of Ageing, ELSA (d'Orsi *et al.* (2014)), and the Med Research Council Cognitive Functioning and Ageing Study I, CFAS I (Seidel *et al.* (2009)). Both d'Orsi *et al.* (2014); Seidel *et al.* (2009) studies examined the progression of disability measured using the Instrumental Activities of Daily Living (IADLs). Although ELSA and CFAS surveys covered self-reported disability measured using Activities of Daily Living (ADLs), but there is not any study that looked at dynamics of ADLs, whether the subsequent development in disability was worsening, or recovery (partial or total recovery of independence).

The literature of the dynamics of ADLs in the US provides several explanatory hypotheses that might help understand similar dynamics observed in England. Some of US based longitudinal studies that examined progression of ADLs include: Established Populations for Epidemiological Studies of the Elderly (de Leon *et al.* (1997, 1999)), the Longitudinal Study on Ageing (Rudberg *et al.* (1996); Anderson *et al.* (1998); Dunlop *et al.* (1997)), and the National Long-Term Care Survey (Manton and Gu (2001)). Moreover, the dynamics of recovery are seen when subjects were followed up more frequently; e.g. monthly interviews (Hardy and Gill (2004); Hardy *et al.* (2005)).

Although, longitudinal surveys have long periods between follow-ups (e.g. one year or two years) the analysis of self-reported disability has shown dynamics of deterioration, improvements, recovery. The Established Populations for Epidemiologic Studies of the Elderly (EPESE) studies are US based longitudinal survey, where subjects interviewed annually from 1982 to 1991. Subjects responded to EPESE were representative samples of US household residents aged 65 and older. Annual interviews collected information about health status. Beckett *et al.* (1996) examined the changes in self-reported disability using baseline and 5 years of follow-up data from four EPESE communities (East Boston, Massachusetts, Iowa; New Haven, Connecticut; and five counties in North Carolina). Disability was self-reported using ADLs (bathing, dressing, walking across a room, transferring from a bed to a chair, eating, and toileting), motor skills (walking half a mile, climbing stairs, and doing heavy work around the house), and limb functions (bending, stooping or crouching, pushing or pulling an object like a chair, and reaching above the shoulders). The study examined the progression of disability (disablement and recovery) controlling for age and sex. The transitions between states of 'disability ' and 'no disability ' in successive years were tested using Markov model. Two separate logistic models were used to model transition from 'no disability ' to 'disability ' and from 'disability ' to 'no disability ' (recovery). Disability at baseline was more common in older age and with greater prevalence among women. The average rate of incurring disability is lower for men than for women. Moreover, getting older increased the probability of incurring disability, and decreased the probability of recovery. Women were at higher risk of disability and less likely to recover than men. Subjects who died within the follow up period were observed to have faster rate of disablement, and were less likely to have reported recovery.

The Longitudinal Study on Ageing (LSOA) is a US based longitudinal survey of individuals aged 70 and older living in household between 1984 and 1990. In 1984, 5,151 subjects took the baseline interview, who then were followed up with biennial interviews. Rudberg *et al.* (1996) examined a six-year follow-up period of ADL limitations with death as a competing risk, adjusting for gender and age. Self-reported five ADLs: bathing, dressing, eating, getting in/out of bed/chair, and toileting were used to measure disability. Disability was measured as the number of ADLs failures. Subjects had missing ADL data at any wave or missing ADL data before death were excluded from the analysis sample, leaving 3,890 subject who had complete ADL records. Binary logistic regression was used to model the relationship between ADLs and death, and ordinal logistic regression was used to model transition among levels of ADL. Both models controlled for age, and ADL score at outset of each wave, and gender. At each given wave, the subjects were more likely disability free, ranging from 80% at baseline to

58% at sixth follow-up. Preliminary counting of ADLs on longitudinal paths exemplified range of ADL experiences in the sample. The binary model showed that mortality increased with age, and younger males had higher risk of death at each level of ADL disability. The gender-effect disappeared in the oldest age group. Subjects failed in 1 more ADL are at higher risk of death. The ADL-effect increased with age, except among subjects with only 1 ADL. The ordinal regression model showed no gender differences in the transition between ADL states. Age and ADL score reported at preceding wave predicted ADL transition in succeeding wave. Subjects with no ADL at preceding wave are more likely to remain disability free at succeeding wave. The probability of staying disability free decreased at older age. The same applies to subjects within the highest disability state, i.e. failing all the 5 ADLs. Movement between disability states is shown among subjects in ADL states somewhere between these two extremes. Observed trend in movement between disability states suggest that subjects with ADL score 1 to 3 at preceding wave are more likely to improve with a big chance of full recovery. On the other hand, subject with ADL score of 4 or 5 at preceding wave were more likely to deteriorate, and a significantly small chance of total recovery. The effect of previous ADL increased with age.

Dunlop *et al.* (1997) is another paper that used data from LSOA. This study focused on hierarchy of disability and aimed to establish the order of loss of ADLs. It acknowledged that partial recovery in ADLs (i.e. improvement in ADLs) existed, but it did not go further. The time spent in disability state was defined including time to full recovery, death or end of the study. The paper did not discuss recovery beyond that.

National Long Term Care Surveys (NLTCS) is a longitudinal survey of the chronically disabled people aged 65 and older living in households sampled from Medicare in 1982, and followed up in 1984. Chronic disability is defined as having at least one ADL or IADL impairment, which had lasted or was expected to last at least 90 days. In 1982, two-stage interview was conducted firstly by identifying the chronically disabled among the household residents and then interview them in detail. Those without chronic disability in 1982 were not interviewed further but (some/all) were eligible for follow-up in 1984. In 1984, subjects with detailed interviews in 1982 (i.e. chronically disabled in 1982) were followed up, and some of the remaining (i.e. those who were disability free) went through a repeated two stages interview. Manton (1988) used data from the NLTCS to examine sex differentials in disability at old age taking into account longitudinal changes in disability severity. This study was concerned mainly with recovery from chronic disability. The analysis sample consisted of 20,485 people aged 65 and over at the time of the 1982 survey and who were eligible for follow-up in 1984. It included 12,100 who were not chronically disabled in 1982 (of whom 970 had died by 1984); 6,393 people who were chronically disabled in 1982 and living in the community, of whom (1,383 had died); and 1,992 people who were in institutions in 1982 (of whom 810 had died). The analysis examined the two-year mortality and disability transitions stratified by institutional status, and 5 levels of disability reported in 1982. The five levels of disability are 'no disability', '1 or more IADLs but no ADLs', '1 or 2 ADLs', '3 or 4 ADLs', and '5 or 6 ADLs'. Most of the non-disabled in 1982 remained non-disabled in the follow-up. There is a significant probability of improvement even at very high levels of disability. Subjects with moderate disability levels (i.e. with 3 or 4 ADLs) has the highest probability of deterioration and improvements. Moreover, they had the highest risk of institutionalisation, even higher than the severely disabled. Females had higher risk of disablement, lower probability of improvement, and much higher survival than males. As a consequence of lower mortality, lower probability of improvement and higher hazard of disablement females reported more disability.

Factors that influence progression of disability are not limited to age and sex. Dynamics of disability are affected by several factors (e.g. smoking, and drinking habit) that could influence the vulnerability of older person to disability, and events (e.g. a fracture or a stroke) that could contribute to the onset of disability (Verbrugge (1992); Matthews *et al.* (2005); Boult *et al.* (1994)). The relationship between these factors and deterioration, improvement and full recovery of ADLs have been examined in longitudinal studies. Multi-morbidities hold a primary position in predicting the dynamics of disability (Anderson *et al.* (1998);

de Leon *et al.* (1997)), where the number of comorbidities is associated with the prevalence and the incidence of disability. Moreover, different diseases were found to influence the progression and dynamics of disability (Fried and Guralnik (1997)). Cardiovascular diseases (CVD) including coronary heart disease, stroke, or angina; and musculoskeletal diseases (MSD) including osteoporosis, arthritis, or whether the respondent ever had a broken hip, are the main two categories of most common morbidities at old age (Manton (1989)). These disease groups have a high prevalence among older adults in general and were shown to affect the dynamics of disability in Manton (1989); Verbrugge (1992). CVD disease group was shown to produce a relatively fast pace of functional decline, while MSD was shown to produce a relatively slow pace of decline.

'Project safety' is a probability sample of disabled older people in New Haven, Connecticut in 1989. The initial sample was 1,436 subjects aged 72 and older living in household. 44 subjects were not eligible for assessment, and 289 refused to participate. The remaining 1,103 (79%) agreed to participate and undertook comprehensive assessments in their homes by trained nurses at baseline in 1989, and 1 year later. Subjects were followed up by telephone interview 3 years later. Subjects who reported dependence in one or more from seven ADLs (bathing, dressing, transferring, walking, eating, toileting, and grooming) were eligible for the study. Only 138 subject reported ADL dependence at baseline, and 100 reported dependence at the 1-year assessment. From the 238 subject who reported ADL dependence, 14 moved to care homes and were removed from the sample, and 11 were lost to follow-up. The remaining 213 disabled older adults were used in the analysis in Gill *et al.* (1997) to examine the predictors of recovery of total independence in ADLs among older adults living in household. The analysis assessed demographics, psychosocial (depressive symptoms), sensory (hearing and visual impairment), motor skills, cognitive status (measured using MMSE), physical performance (walking test), clinical (self-perceived health, diabetes, heart disease, stroke, arthritis, any medication and urinary incontinence) and BMI index as predictors of recovery. Two outcome variables were examined, full recovery of independence in all ADLs, and broader recovery of net improvement of two or more ADLs in the follow-up. Multi-variable binomial regression was used to estimate the relative ratio of recovery. Subjects who recovered ADL ability reported greater improvement in IADLs, physical activity and social activity. Recovery was high among subjects younger than 85 years old. Disability in only 1 ADL, higher MMSE score (indicating good cognition), good motor skills, high score in physical test, few medications and good nutritional status were all strong predictors of recovery. The main limitations of the study were that it ignored the causes of the development of disability, the sample was limited to subjects who reported disability at baseline, and the follow-up period was only 2 years.

Anderson *et al.* (1998) used four waves data from the LSOA to study disability transitions over multiple two years intervals. Both IADLs and ADLs were used as measured of disability. LSOA covered five IADLs; prepare meals, shop, manage money, use a telephone, do heavy housework, and do light housework and five ADLs; bathe/shower, dress, eat, transfer, and use a toilet. Subjects were put into four disability categories: IADL only disability, 1 or 2 ADL limitations, more than 2 ADL limitations and independent. Both institutionalisation and death were used as additional categories. Multivariate logistic regression model was used to examine gender, race, marital status, age at baseline, living arrangements (i.e. if unmarried living alone or with others), baseline functional status, self-rated health, number of illnesses, and comorbidities as predictors of transitions between the 6 states and 1 additional unknown state (for missing status). Results showed death and institutionalisation were higher among the severely disabled, men were more likely than women to die with follow-up, and women were more likely to move to institution. Transitions between disability states ranked from higher to less 'likely' were unchanged, improvement and decline. There is was no longitudinal ageing effect on the transition between disability states. Age at baseline, self-rated health and precedent disability state were strong predictors of change of state in the follow-up. Precedent disability predicted further decline was more likely than improvement or independence. For all states of disability except severe disability, unchanged state was the most likely outcome. Improvement in ADL limitations, institutionalisation and death were more likely to happen after severe disability when compared to recovery of full independence. Musculoskeletal and cardiovascular diseases strongly predicted further disability, and were unlikely associated with independence. Moreover, musculoskeletal diseases predicted a disabled person was more likely to move to institution than die. Additionally, the authors investigated the effect of previous transitions between disability states on succeeding disability. It was found that stability (reporting the same level of disability in two different interviews) was a strong predictor of continuing stability in subsequent interview. Both improvement in disability and recovery of independence in previous periods were associated with higher probability of worsened disability status (i.e. increase in ADL limitations). The odds of improvement decreased with severity of disability status, and odds of decline increased. In conclusion, previous improvement or deterioration is an indication of further deterioration.

Racial differences in disability and recovery was investigated in de Leon *et al.* (1997) among blacks and whites aged 65 years and over in two sites of the EPESE project (nine waves of data from the New Haven, Connecticut and seven waves of the North Carolina) collected between 1982 and 1992. The analysis sample consisted of 2,748 respondents to baseline interview in 1982 from New Haven and 4,136 respondents to baseline interview in 1986 from North Carolina. The study used pooled logistic regression models to estimate the yearly disablement and recovery rates. The models examined racial differences and preceding disability status as predictors of disablement/recovery controlling for age, sex, education, income, body mass index (BMI), cognitive performance, and chronic conditions. Disability was defined as a self- or proxy-report of needing help with or being unable to perform one or more of 6 ADLs: bathe, dress, eat, use the toilet, walk across a small room, and transfer from bed to chair. Estimated odds ratios were for disablement, recovery and mortality separately for each site. Preliminary results showed that one-fifth of the subjects recovered from disability each year of the follow-up. Racial difference were observed in disability risk and in recovery from disability. Incidence of disability were higher among blacks, and blacks recovery was lower than whites. Whites incidence of disability increased with age, and the racial differences faded. There was no racial difference in mortality from disability state. Socioeconomic indicators (lower education and lower income) and health status (higher body mass index, poor cognitive function, and chronic illnesses) were all significantly associated with the increased risk of developing disability and reduced likelihood of recovery. The study concluded that the racial differences in disability progression and mortality from disability were attributed to socioeconomic health related factors, and geographical area. The study did not account for improvement (i.e. partial recovery) in disability.

In summary, improvement and full recovery are not uncommon. Disabled older people may go through improvement followed by deterioration. age, sex, socioeconomic characteristics, multi-morbidity, and previous disability level are responsible for the differential in disability dynamics.

3.2.1 Short term dynamics of disability

In contrast to studies, which have followed-up subjects at annual or biennial intervals, some studies have followed-up subjects more frequently such as monthly (Hardy *et al.* (2005); Hardy and Gill (2004)). Development of disability from complete independence to severe disability, and dynamics of recovery and deterioration were observed over short follow-ups.

Precipitating Events Project (PEP) is a longitudinal study of 745 non-disabled subjects aged 70 and older living in household in New Haven, Connecticut. The subjects were fully independent at baseline in four key ADLs - bathing, dressing, walking inside the house, and transferring from a chair. Information on demographics, cognitive status, and self-reported, physician-diagnosed chronic conditions were collected at baseline between March 1998 and October 1999. The information on chronic conditions, namely, hypertension, myocardial infarction, congestive heart failure, stroke, diabetes, arthritis, hip fracture, chronic lung disease, and cancer (other than minor skin cancers); and cognitive function were collected during home interview at baseline, 18 months and 36 months. Subjects were followed-up by monthly phone interviews to assess their disability levels until February 2004. This section provides a discussion of the three studies, Gill and Kurland (2003); Hardy and Gill (2004); Hardy *et al.* (2005), that examined the dynamics of disability using the PEP sample.

Gill and Kurland (2003) examined the quantity, number and duration of episodes, severity, and dynamics of disability observed over 2 years of the PEP study. The number of subjects with ADL disability for at least 1 month, and the average number of months disabled measured the quantity of disability. The number of consecutive months of continued disability measured duration. The number of subjects with severe disability (3 or more ADLs), and the average number of ADLs during months of disability measured severity of disability. Subjects were categorised into seven different groups using quantity, number and duration of episodes and severity to examine the dynamics of disability. Moreover, disability was categorised into persistent disability (at least 1 ADL lasting at least 2 consecutive months), chronic disability (at least 1 ADL lasting at least 3 consecutive months), and severe disability (3 or more ADLs lasting at least 1 month). Kaplan-Meier estimates were used to examine the time spent in each of the three disability categories. Number and duration of disability episodes showed great diversity in disability experience of the sample members. The study showed that transitions into and out of disability were common over short periods, and these transitions would likely go undetected by conventional long interval follow-ups.

Both rate and time to recovery of independence in ADLS of the newly disabled older people from PEP sample were the focus of the analysis in Hardy and Gill (2004). The analysis focused on subjects who incurred disability, who were then followed-up until recovery, death or lost-to-follow-up. Recovered subjects were followed-up until they developed recurrent disability, died or were lost-to-follow-up. Kaplan-Meier estimates of recovery over time were calculated for all subjects. Three subjects, who recovered after more than 12 consecutive months of disability, were excluded from the analysis. Kaplan-Meier estimates were estimated for the whole sample and repeated for two disability categories; persistent disability, chronic disability (as defined above). Moreover, Kaplan-Meier estimates were calculated for subgroups defined by age at onset of disability, sex, cognitive function (as measured by the MMSE), physical frailty, and severity of disability at onset, each reported at the most recent in home interview. Subjects who reported disability at follow-ups were older, physically frail, had lower cognitive function, and more chronic conditions than subjects who stayed disability free. The study found that the vast majority of newly disabled older persons recovered independent function, usually within the first 6 months after disability onset. Most of the subjects with persistent or chronic disability recovered independence within 12 months. Additionally, those who recovered mostly stayed independent for at least 6 months. Age and sex had very little effect on differential recovery. Cognitive impairment, physical frailty and severe disability slowed recovery. In conclusion, persons who recover from disability are in high risk of recurrent disability. Distinguishing the causes of onset of disability is crucial to determining the appropriate intervention to lengthen the periods of recovery.

Hardy *et al.* (2005) used PEP data to model the transitions between four states of disability; no disability, mild disability (i.e. 1 or 2 ADLs), severe disability (i.e. 3 or 4 ADLs) and death and the time spent in each state. Periods of continued disability, referred to as episodes, were mild episodes (subject experienced only mild disability), severe episodes (subject experienced only severe disability), and mixed episodes (subject experienced both mild and severe disability). Episodes of disability start when a subject incurred disability and stopped when subject recovered, died or completed to follow-up. A person who transits between severe and mild disability would still be recognised as disabled and contributes to the same disability episode. The number of transitions and episodes per subject per year, and the percentage of time spent in each state were used to compare between frail and non-frail subjects. Standardised rates of transitions between states and duration of episodes were calculated for each transition between the four states. Results showed that the majority of subjects spend most of the time in non-disabled state. Frail subjects had tendency to transit between states more often than non-frail subjects did. Moreover, frail subjects spent longer durations in episodes of disability than their non-frail peers did. Frail subjects had higher rates of transition towards increased disability, and lower rates towards decreased disability or independence. Death was equally likely for both frail and non-frail subjects, but frail subjects in severe disability had higher mortality than non-frail subjects in severe disability. The most common disability episodes were mixed episodes from severe to mild to no disability, mild to severe to death, and mild to severe to mild to no disability consecutively by frequency of occurrence. It was found that the transition rate of recovery of independence was high from any episode of disability regardless of the episode being mild or severe. However, recovery from severe disability happened 75% of the time after an episode of severe disability that lasted for only 1 month. Mortality rates were doubled with disability compared to being non-disabled. The death rate was strongly significant after a severe episode of disability. The results of this study confirm the dynamic nature of disability in short intervals of follow-ups.

When subjects were followed up on a monthly basis; the vast majority of newly disabled older persons were observed to recover independent function, usually within the first 6 months after disability onset (Hardy and Gill (2004)). Moreover, it was found that the transition rate of recovery of independence was high from any disability regardless of the disability being mild or severe (Hardy *et al.* (2005)). Because of the nature of monthly data for almost 6 years, that study demonstrated that short disability episodes (i.e., 1-2 months) are common among older persons. These short episodes would often be missed by studies using long assessment intervals (biannual, annual and biennial). Although, these disability episodes are very short, they bear the development of subsequent disability and death. The short interval dynamic nature of disability raises important questions on the studies of longer follow-up intervals (biannual, annual or biennial). Subjects of longer intervals of follow-up likely experienced multiple transition between disability and independence, and between disability levels within each interval without being observed. Moreover, studies of the onset of disability, where subjects were followed up 6 months or more after baseline, may assess subjects during or after a recurrent disability rather than the initial onset.

3.2.2 Disability in ELSA

The English Longitudinal Study of Ageing (ELSA) is a longitudinal sample of English household residents ages 50 and older on 21 March 2002. Subjects were interviewed biennially and had self-reported disability in ADLs, IADLs and motor skills. Although ADL disability in ELSA has been a discussion in literature, there is no work focusing on changes in ADL disability overtime. Literature on ADLs in ELSA tend to use cross-sections of ELSA, which does not represent the dynamics of disability that older people go through. The literature does not have any study examining the longitudinal dynamics of ADLs reported in ELSA. There are three main streams of analysis that studied ADLs in ELSA; studies that compared the prevalence of disability among ELSA respondents with other international longitudinal surveys, studies of prevalence of disability, and studies of predictors of disability.

ELSA was designed to be comparable to Health and Retirement Survey (HRS), a US based longitudinal sample of American household residents aged 50 and older. Moreover, the Survey of Health, Ageing and Retirement (SHARE) is a European based longitudinal datasets (12 European countries) were established using similar design to ELSA and HRS. The three longitudinal samples cover demographics, socioeconomics, health and disability of their subjects. Studies that examined disability reported in ELSA usually compared between disability prevalence or incidence in the English population and the Americans or Europeans. For example, Chan *et al.* (2012) compared the ADLs reported at first ELSA interview (Mar 2002 to Mar 2003) with ADLs reported in HRS (in calendar year 2002) and the SHARE (in calendar year 2004). Also, Clarke and Smith (2011) compared the socioeconomic characteristics and the 'psychological and social wellbeing' as predictors of ADLs disability between ELSA (Mar 2006 to Mar 2007) and sub-sample of the HRS (2006). Lang *et al.* (2007a) compared the disability and mortality experience and their relationship with the levels of alcohol consumed between ELSA and HRS respondents. These studies are not discussed any further as they are not relevant to the context.

Gjonca *et al.* (2009) investigates the association of socioeconomic position (measured by education, social class and wealth) and prevalence of disability in ADLs, IADLs and motor skills reported in the first interviews of ELSA (Mar 2002 to Mar 2003). Disability in ADLs, IADLs and motor skills were aggregated together to make one measure of three levels of disability no disability, mild disability and severe disability. Separate multinomial logistic regression models for males and females were estimated to examine the relationship between disability and socioeconomic position. Women reported more disability (ADLs, IADLs or motor skills) than men did. More men than women had higher education achievements, from managerial/professional occupational classes and owned more wealth. In older ages, both men and women reported higher levels of disability in ADLs, IADLs and motor skills. The multinomial logistic models showed that older age, lower education achievement, lower social class and less wealth were all associated with higher prevalence of disability. The three factors had similar but slightly weaker effect at oldest old ages. Moreover, the results suggest that low socioeconomic status (low education, low occupational class, and lower wealth) not only makes people vulnerable to acquiring some disability but also to inhibit those disabilities.

The Health Survey of England (HSE) is an annual cross-sectional survey of the English household population. ELSA initial sample and refreshment samples were taken a sub-sample of HSE respondents who were aged 50 and older at the time of giving their first interview in ELSA. Baseline sample of ELSA was taken from the years 1998, 1999 and 2001 of subjects who were aged 50 and older living in household on 21 March 2002. Some of the HSE survey included an interviewer and a nurse visit, with measurement of height, weight (WT), waist circumference (WC), and hip circumference (HC). BMI and waist-hip ratio (WHR) were also calculated from these measurements. There are some studies that examined obesity as predictor of disability among ELSA baseline respondents using obesity reported at HRS Angleman *et al.* (2006); Lang *et al.* (2008).

Angleman *et al.* (2006) studied obesity measured in the HSE 1998 as a predictor of disability among subjects who responded to the first ELSA aged 65 and older. The analysis compared between the use of five different measures of obesity; waist circumference, hip circumference, body mass index (BMI), weight, and waist/hip ratio to predicting disability. Disability measured by ADLs was defined as reporting a limitation in at least 1 ADL. The model used was logistic regression, and controlled for age, social class, education, and smoking. The results showed that waist circumference as a measure of obesity predicted disability with higher statistical significance compared to other obesity measures.

Lang *et al.* (2008) focused on BMI (measured in HSE 1998, 1999 and 2001) influence on disability and mortality among ELSA respondents. Subjective disability measure, i.e. 1 or more limitation in 6 ADLs: dressing, walking across a room, bathing or showering, eating, getting in or out of bed, and using the toilet; and objective measures: balance, gait speed, and chair stands; and mortality were used as the outcome variables in multinomial logistic regression models. Physical impairment were higher in women, and mortality levels were higher in men. Excess body weight has stronger associations with physical impairments than with mortality. Increased physical impairment was observed among the overweight and the obese.

IADL recoveries in ELSA

Instrumental Activities of Daily Living (IADLs) are higher order activities that are needed to support independent life style. IADLs are generally highly reliant on cognitive ability. They include activities like using a map to get around in a strange place, preparing a hot meal, shopping for groceries, making telephone calls, taking medication, doing work around the house or garden, and managing money. The dynamics of IADLs disability (decline and recovery) at older age have been observed in longitudinal studies (Manton (1988); Seidel *et al.* (2009); Anderson *et al.* (1998)). Moreover, a recently published study d'Orsi *et al.* (2014) examined the incidence and recovery of total independence in IADLs among ELSA subjects who responded to five follow-ups between 2002 and 2011. The study was restricted to subjects who were both ADLs and IADLs disability free, i.e. excluded persons who had reported any difficulties in ADLs or IADLs at baseline interview (wave 1 of ELSA 2002). The analysis focused on two outcomes incidence of disability, and subsequent recovery. Firstly, the outcome of interest was reporting at follow-up at least one difficulty out of seven IADLs. In succession, second analysis focused on reporting of no difficulty in any of the seven IADLs in a given follow-up after having reported at least 1 IADL in the preceding interview (i.e. total recovery of independence in IADLs after observed incidence). The two outcomes measured at each of the five follow-up interviews. The models used socioeconomic position as the main predictor of incidence and recovery controlling for education, sociodemographic variables (sex and age), physical activity, paid work in the last month, use of Internet or e-mail, smoking, alcohol consumption, social contacts, and going out. Additionally, self-reported doctor-diagnosed diabetes mellitus, cardiovascular disease (including hypertension), arthritis, the eight-item scale from the Centre for Epidemiologic Studies Depression Scale (CESD) and the Control, Autonomy, Self-realisation and Pleasure (CASP-19) scale were used as control variables. 2-year lagged Poisson regression generalized estimating equation (GEE) models were used to investigate the variables in question. The analysis showed that the incidence of IADL disability increased with age. Older persons spent longer time in IADL disability before recovery. There was no gender difference in the time spent in IADL disability, but women had higher incidence rate. Wealth and education affected the IADL disability experience of the subjects. Wealthier subjects had lower incidence and spent less time that their counterparts. The same for those with higher educational qualification compared with lower qualifications. Physical activities, working, participating in cultural activities, and social activities reduced incidence and duration of IADL disability. Subject who use the internet or email were less likely to incur IADLs than those who did not. Moreover, age, no education, being a current smoker, and abstention from alcohol increased the incidence of IADL impairments, as did the presence of depressive symptoms, diabetes mellitus, arthritis, or cardiovascular disease. The study concluded that healthier lifestyle, represented by physical activity and no smoking, high quality of life, paid work, cultural activities, and digital literacy could influence positively IADLs experience in older age (i.e. reduce incidence and shorten time spent in IADL disability). Wealth differentials in IADL experience was only prominent when quality of life and physical activity were ignored.

Although IADLs are significant health indicators and evident predictors of mild cognitive impairment and dementia, the definition of an IADL impairment only group is subject to the question of whether or not certain IADL impairments are gender biased (e.g. using a map (Chang and Antes (1987); Brown *et al.* (1998))). Moreover, IADL disabilities may be caused, not only by physical or mental limitation, but also by cultural expectations, environmental obstacles, or lack of motivation and training. For example, a traditional elderly widower who has developed weakness after a stroke may be physically able to cook but, because his late wife always did the cooking, he does not attempt it. His IADL disability in cooking is caused by a combination of his weakness and his past experiences (Boult *et al.* (1994)).

The analysis presented in this paper focuses on the investigation of ADL deterioration and improvement among individuals aged 60 and older living in the household in England. This study adds to the literature on the recovery from ADLs using ELSA. This is the first English based study of the ADL dynamics in older age. The analysis presented follows the changes in reported ADLs, and examine precedent ADLs, chronic illnesses, health related behaviours, and socioeconomic characteristics as predictors of improvement, and contrasts them with predictors of deterioration.

3.3 Methods

The underlying analysis of this paper aims at finding the factors which influence reported changes in ADLs among older persons living in households in England. In this section, a description of the datasets and the variables used in the analysis, together with the statistical methods are outlined.

3.3.1 Data

The English Longitudinal Study of Ageing (ELSA), described elsewhere (in chapter 2 section 2.3.1), is longitudinal survey of English persons aged 50 and older living households. ELSA survey collected information on health, social, wellbeing and economic circumstances of the English population aged 50 and older. Baseline wave took place between 1 March 2002 and 1 March 2003. The subjects were then interviewed in biennial waves in 2004/05, 2006/07, 2008/09, and 2010/11. Two subsequent refreshment cohorts were added on third and fourth waves. ELSA initial (baseline) sample was 11,392 subjects, and the two refreshment samples were 1,276 subjects (wave 3 refreshment), and 2,042 subjects (wave 4 refreshment). Proxy interviews were conducted when a sample member was unable to complete the interview.

ELSA waves gathered information about difficulties in motor skills, ADLs and IADLs. Subjects were asked to report their difficulties on every interview wave, and changes in difficulties in any of the three measures can be obtained by comparing their reporting at consecutive waves. Appendix 3.A gives the full list of the motor skills, ADLs and IADLs. The dataset included information on demographics, socioeconomic characteristics, chronic conditions, health behaviour. Additionally, subjects aged 60 and older were asked about falls, fractures and joint replacements.

Sample

The analysis sample consisted of a pool of ELSA participants aged 60 [*] and older, who joined ELSA interviews at any time (initial cohort and refreshment cohorts). Participants were included if they have participated at least in two waves of ELSA. To study improvement in disability, the sample was restricted to subjects who reported at least 1 ADL at the entry wave. Furthermore, the sample was restricted to subjects who had reported changes in number of ADLs. Death and institutionalisation at the subsequent wave were firstly treated as competing outcomes, and then were excluded to contrast their effect on predictors of ADLs deterioration.

Deterioration and improvement in ADLs

Difficulties in ADLs were self-reported in all ELSA waves. All interviews included a question whether, "because of physical, mental, emotional, or memory problems", the respondent had "any difficulty" (yes/no) with ADL. Respondents were shown cards that listed 6 ADLs: dressing (including putting on shoes and socks), eating (such as cutting up your food), using the toilet (including getting up and down), bathing and showering, getting in and out of bed, and walking across a room. The inability to perform one or more of these activities requires personal care from another person. Respondents were asked to exclude any disabilities that are expected to last less than three months.

The number of reported difficulties in ADLs was used to define the severity of disability. This variable ranges from 0 (indicating no difficulties) to 6 (indicating difficulties with all six ADLs). Moreover, 0 ADLs indicating no disability (no need for care), 1 or 2 failures in ADLs indicating mild disability (possibly in need for care), and 3 or more failures in ADLs indicate severe disability (probably in need for care).

The changes in self-reported number of ADLs has been categorised into: improvement, stability, deterioration, institutionalisation, death, loss-to-follow up

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[*] It is anticipated that joint replacement plays major role in ADLs changes, hence subjects aged 50 to 59 were excluded as they were not asked about joint replacement

(LTF) and missing. The changes were measured by the difference in the number of difficulties in ADLs reported in subsequent waves. Two dichotomous variables were constructed to represent improvement only and deterioration only in ADLs.

Deterioration and improvement in motor skills

Difficulties in motor skills were self-reported. All interviews included a question whether, "because of a health problem,"the respondent had "any difficulty" (yes/no) with any of the motor skills. Respondents were shown cards that listed 10 skills; six questions covered skills dependent mainly on using lower limbs, hips and waist (walking, sitting, getting up, climbing stairs, and stooping), and four skills dependent mainly on using upper limbs (reaching, pulling/pushing, carrying/lifting, and picking a coin). Although any difficulty in these activities does not imply loss of independence, but they indicate problems that can lead to the need for care. They were used for comparison with the ADLs models.

In similar manner to ADLs, the number of reported difficulties in motor skills was used to define the severity of disability. This variable ranges from 0 (indicating no difficulties) to 10 (indicating difficulties with all ten skills). Moreover, 0 failures in motor skills indicating no disability, 1 or 2 failures indicating mild disability, and 3 or more failures indicate severe disability.

The changes in number of difficulties in motor skills has been categorised into: improvement, stability, deterioration, institutionalisation, death, loss to follow up and missing. The changes were measured by the difference in the number of difficulties in ADLs reported in subsequent waves. Two dichotomous variables were constructed to represent improvement only and deterioration only in motor skills.

3.3.2 Statistical analysis

ELSA study design, with five biennial interviews, enabled us to characterise the changes in disability over time. Previous longitudinal studies suggest that disability tends to have a dynamic pattern of deterioration and improvement with factors that could influence the vulnerability of older person to disability, and events that could contribute to the onset of disability. Those factors and events are sought to act as predictors of improvements as well as deterioration in ADLs. In this paper, we first emphasise the change of disability over time, by looking at percentage of reported deterioration and improvements between waves. subsequently we addressed the possibility that the pattern of change over time reflected transitions into and out of disability. This was accomplished by using a panel logistic regression random effects models. The panel logistic regression random effects model fits subject-specific or conditional probabilities for the individual respondents. Hence, the estimated conditional odds ratios tell how much the odds for a given respondent decrease or increase with a particular predictor. All panel logistic regression models were fit using STATA 12 SE edition. Results from these models are presented in terms of the odds ratios along with their p-value and 95% confidence intervals.

Three models were tested. In Model 1, investigated previous disability status, age, sex, marital status, education, social class, Cerebra-vascular diseases, chronic illnesses, whether the participant have had joint replacement within two year before the interview, smoking and alcohol intake as predictors of improvements in ADLs. Model 2 excluded joint replacement from the covariates, and Model 3 added respondents who died or were institutionalised to the sample. The same three models were repeated for the deterioration in ADLs outcome.

Backward elimination was used to eliminate non-significant variables from the regression models, and final models were obtained. Adjusted relative hazards were calculated as a measure of the increased risk in mortality due to each variable, and 95% confidence intervals were calculated as measures of the statistical significance and precision of the relative hazard.

Interaction terms were included in the models to investigate the possible effect modifications between initial disability status and each of the following covariates: age, sex, Cerebra-vascular diseases, chronic illnesses.

Independent variables

Demographic information (age, sex, marital status), socioeconomic status (education and social class), preceding ADLs (i.e. reported in the previous wave), preceding motor skills, Cerebra-vascular diseases, chronic illnesses, whether the participant have had joint replacement within two year before the interview and health behaviours (smoking and alcohol intake) were included in the models. Based on existing literature these factors are expected to be associated with dynamics of disability in older people.

Sex was reported at first interview. Age, modelled as a continuous variable, was calculated at time of each wave interview from the date of birth. Both educational class and social class were based on information collected in the HSE,and allocated to ELSA respondents as categorical variables. Education was measured as the highest qualification obtained and was categorised as university degree or equivalent, intermediate qualification, and no educational qualification. Social class was classified into three categories: managerial/ professional, intermediate, and semi-skilled/ non-skilled.

Both preceding ADLs and motor skills were categorised based on the severity of disability to zero difficulties , 1 or 2 difficulties, and 3 or more difficulties. Chronic conditions used for the analysis included pulmonary diseases (lung disease and asthma), arthritis, cancer, neurological (Parkinson's, Alzheimer, dementia/senile), psychiatric, cardiac diseases (Angina,heart attack, congestive heart failure, heart murmur, abnormal heart rhythm), and stroke. A dichotomous variable was created to reflect the presence or absence of each condition. A variable for the number of comorbidities was constructed to reflect the presence of multiple conditions together.

Smoking was assessed as never smoked, former smoker, and current smoker. Alcohol use was assessed according to alcohol consumption in the last year (never, weekly to monthly, and daily). All variables were included in the models, then were investigated by re-fitting the model containing all covariates multiple times, each time removing a single covariate.

3.4 Results

ELSA sample of 15,505 participants aged 50 and older (11,391 joined at initial wave on 2002, 1,473 joined at refreshment sample on 2006, 2,502 joined at second refreshment sample on 2008, and 139 joined as new partner or young partner to ELSA respondent). There were 8,404 respondents aged 60 and older. 128 were excluded because of lack of information on ADLs, resulting in a sample of 8,276. Out of them 1,589 (19.20%) have been interviewed only once (433 (5.23%) died after first interview; 37 (0.45%) moved to institution after wave 1; 1,067 (12.89%) lost to follow up after first interview and 52 (0.63%) were new sample members at wave 5). Lost participants had no difference in education, social class, sex or age. Those who died were predominantly older males, and those who moved to institution were predominantly older females.

The sample for preliminary analysis was consisting of 3,913 (47.28%) males and 4,363 (52:72%) females. Median age was 69 with inter-quartile range of (64 to 75) years old. Table 3.1 shows a breakdown of the number of sample respondents by sex in each wave. The median age is shown with the inter-quartile range of ages in the sample. The demographic characteristics (median age at 70 years and male/female percentages at approximately 46%/54%) were maintained at the same level for each wave of ELSA. The table also shows the break down of sex at each wave of a sub-sample of respondents aged 60 and older who reported at least 1 failure in ADL at the given wave interview. The sub-sample data are used in fitting the panel logistic regression models.

Attrition from death in the subsequent interviews (waves 2 to 5), resulted in the loss of participants who: reported some level of motor skills impairment, more likely to have difficulties in ADL compared to their peers, and had been diagnosed with 2 or more comorbidities. On the contrary, attrition from lost to follow up showed no difference to the study sample.

Table 3.1: Sex and Age of ELSA respondents at each wave

	Wave 1	**Wave 2**	**Wave 3**	**Wave 4**	**Wave 5**
Sex					
males	3,113	2,774	2,636	3,322	3,401
	45.65%	44.63%	44.99%	45.88%	45.77%
females	3,707	3,442	3,223	3,919	4,030
	54.35%	55.37%	55.01%	54.12%	54.23%
Age					
median	70	70	70	69	70
IQ range	[65,76]	[65,77]	[64,77]	[64,76]	[64,76]
Total sample	**6,820**	**6,216**	**5,861**	**7,241**	**7,431**
	respondents with at least 1 ADLs at baseline				
	Wave 1	**Wave 2**	**Wave 3**	**Wave 4**	**Wave 5**
Sex					
males	691	632	594	716	665
	43.71%	41.23%	42.16%	43.47%	41.67%
females	890	901	815	931	931
	56.29%	58.77%	57.84%	56.53%	58.33%
Age					
median	73	74	74	73	74
IQ range	[66,80]	[67,80]	[67,81]	[66,79]	[67,81]
Total sample	**1,581**	**1,533**	**1,409**	**1,647**	**1,596**

Institutional interviews started from wave 3 onwards. Hence, only subjects that moved to institution after the first wave were lost to follow up on. Those subjects were more likely to have worsened changes in ADLs. They have not been followed up in ELSA, and information about changes in their health is missing.

3.4.1 Reported changes in ADLs

Table 3.2 shows the number of reported difficulties in ADLs in ELSA. At each wave 75% of the respondents reported to be completely independent in ADLs. Additionally, approximately 18% of respondents at each wave have reported mild disability (one or two difficulties in ADLs), leaving about 7% of the respondents with severe disability (3 or more difficulties in ADLs). It is possible to hypothesise that individuals who have reported no or low number of failure in ADLs can show recovery over future waves, as they adapt to these difficulties. Another hypothesis is that disability process is highly dynamic in ELSA sample and the number of improvements and deterioration in ADLs are equal over the intervals between interviews.

The percentage of respondents transitioning between difficulties in different ADLs, and in the change in total number of difficulties in ADLs between consecutive waves were investigated in order to spot any patterns. This showed that the predominant is the stability, i.e. respondents reported being in on ADL state at one wave, are more likely to report the same state at subsequent wave. Most of the Sample stayed at total independence in ADLs for the length of the follow-up period. Moreover, the number of transitions to worse or better states were equal. Subjects reporting low ADL score (1 or 2 ADLs), are more likely to report total independence compared to their peers who reported high score (e.g. 5 or 6 ADLs). Further investigation of dynamics particular ADL, e.g. a person with difficult in dressing has equal chance with a disability free person to report no difficulty at the subsequent interview.

Table 3.2: Number of failures in ADLs from ELSA waves 1 to 5 respondents aged 60 and older

	Wave 1		**Wave 2**		**Wave 3**		**Wave 4**		**Wave 5**	
Number of ADLs										
No ADL failures	5,114	74.99%	4,681	75.31%	4,448	75.92%	5,593	77.24%	5,828	78.43%
1 ADL	815	11.95%	795	12.79%	708	12.08%	853	11.78%	797	10.73%
2 ADLs	367	5.38%	352	5.66%	301	5.14%	371	5.12%	359	4.83%
3 ADLs	185	2.71%	180	2.90%	187	3.19%	197	2.72%	178	2.40%
4 ADLs	122	1.79%	98	1.58%	97	1.66%	104	1.44%	103	1.39%
5 ADLs	69	1.01%	70	1.13%	63	1.08%	61	0.84%	90	1.21%
6 ADLs	23	0.34%	38	0.61%	53	0.90%	61	0.84%	69	0.93%
proxy*	115	1.68%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
missing	10	0.15%	2	0.03%	2	0.03%	1	0.01%	7	0.09%
Total	**6,820**		**6,216**		**5,861**		**7,241**		**7,431**	

* Respondents to proxy interview were not asked ADL questions at wave 1 only

Changes in ADL disability are improvement (decrease in the number of the difficulties in ADLs), stability (staying in the same level of ADLs status), and deterioration (increase number of difficulties in ADLs). Additionally, subjects who moved to institution and were not followed up can be seen as another level of deterioration. Subjects that leave the observation for death or loss of contacts can be put in separate category. All these 7 categories are shown in table 3.3 that shows the changes in self-reported number of failures in ADLs between consecutive waves. Subjects reporting improvements in ADLs were about 9% of the respondent in each given wave, and subjects reporting deterioration were about 10% of the respondents. the most frequent state is stability at 54% to 65% of respondents. The percentage of people reporting the stability in ADLs between consecutive waves is large due to the large number of respondent staying fully independent in ADLs for the whole follow-up period of ELSA.

To clear any doubt, it is best to look at the changes in reported ADLs among those who reported at least one difficulty in ADL at the beginning wave. Table 3.4 shows the numbers and percentages of changes in ADLs reported at subsequent wave for respondent reporting at least one difficulty in the preceding wave. The number of improvements in ADLs are the same in tables3.3 and 3.4, this because the excluded respondents were the one with no difficulties in ADLs. The percentage of subjects reporting stability in ADLs status is now relatively lower. What is more interesting is the improvement and deterioration states in ADLs. The percentage of subjects reporting improvement in ADLs more than double the percentage of subjects reporting deterioration, e.g. transition from wave 1 to wave 2 respondents reporting recovery are 35.61% more than double of the 13.41% reporting deterioration. There are two factors that contribute to this differences; the first is exclusion of subjects with full independence in ADLs at the beginning wave, the second is the percentage of subjects reporting moderate disability is more than triple the percentage of subjects reporting sever disability. Those reporting moderate disability are more likely to adapt to their disability, or recover from that disability.

Table 3.3: Changes in self-reported number of failures in ADLs for respondents aged 60 and older at beginning wave

	Wave 1 to 2		**Wave 2 to 3**		**Wave 3 to 4**		**Wave 4 to 5**	
Changes in ADLs								
improvement	563	8.26%	598	9.62%	524	8.94%	623	8.60%
no changes	3,798	55.69%	3,696	59.46%	3,512	59.94%	4,715	65.12%
deterioration	729	10.69%	689	11.08%	706	12.05%	825	11.39%
institution	54	0.79%	8	0.13%	8	0.14%	10	0.14%
death	422	6.19%	292	4.70%	331	5.65%	374	5.17%
LTF*	1201	17.61%	929	14.95%	778	13.28%	691	9.54%
proxy	22	0.32%	0	0.00%	0	0.00%	1	0.01%
missing	31	0.45%	4	0.06%	0	0.00%	2	0.03%
Total	**6,820**		**6,216**		**5,859**		**7,241**	

* LTF = Lost on Follow up

Table 3.4: Changes in number of reported failures in ADLs for respondents aged 60 and older at beginning wave who had reported at least one failure in ADLs

	Wave 1 to 2		**Wave 2 to 3**		**Wave 3 to 4**		**Wave 4 to 5**	
Changes in ADLs								
improvement	563	35.61%	598	39.01%	524	37.19%	623	37.83%
stability	311	19.67%	342	22.31%	297	21.08%	378	22.95%
deterioration	212	13.41%	212	13.83%	227	16.11%	275	16.70%
institution	26	1.64%	5	0.33%	5	0.35%	8	0.49%
death	180	11.39%	128	8.35%	161	11.43%	203	12.33%
LTF*	288	18.22%	247	16.11%	195	13.84%	160	9.71%
missing	1	0.06%	1	0.07%	0	0.00%	0	0.00%
Total	**1,581**		**1,533**		**1,409**		**1,647**	

* LTF = Lost on Follow up

Changes in ADLs after the onset joint replacement

Fracture and joint replacement are sought to be main cause of disability. Hence, further investigation is needed to understand the effect of joint replacement on deterioration, stability or improvements in ADL status. Table 3.5 shows the changes in number of reported ADLs after the onset of joint replacement (identified by subjects reporting having joint replacement between interviews). As the report of joint replacement occurs at the succeeding wave interview, those information wont be available for those who died, moved to institution or lost to follow-up. Additionally, the number of subjects reporting having joint replacement before the succeeding wave are 156 (2.29% of respondent to wave 1), 161 (2.59% of respondents to wave 2), 162 (2.76% of repondent to wave 3) and 235 (3.25% of respondents to wave 4). The number of subjects reporting joint replacement is very small, hence it is difficult to generalise. Moreover, the figures and percentages shown in table 3.5 showed no difference between those group and their peers in changes of ADLs status. Comparing tables 3.4 and 3.5 shows that the percentage of improvement in ADLs status from all respondents aged 60 and older lies around 9%, while it is around 27% among subjects who had joint replacement. This could be an indication of the recovering some of the ADLs after the joint replacement. Overestimation of the benefits of joint replacement is possible consequence of not knowing if those who lost at follow-up or died had any joint replacement.

Preliminary analysis has showed that a non-deteriorating ADL status (e.g., same or improved status) was more common than deterioration, death and institutionalisation for subjects at each wave of ELSA. A large majority of persons who were non-disabled in 2002 remained non-disabled over the eight-years period of follow up in spite of the high median age (69) of the sample in 2002. In addition, there is a significant probability of a long-term improvement in ADL status, even at very high levels of disability.

Table 3.5: Changes in number of reported failures in ADLs for respondents aged 60 and older who had joint replacement between interviews.

	Wave 1 to 2		**Wave 2 to 3**		**Wave 3 to 4**		**Wave 4 to 5**	
Changes in ADLs								
improvement	43	27.56%	47	29.19%	38	23.46%	57	24.26%
stability	82	52.56%	76	47.20%	94	58.02%	124	52.77%
deterioration	31	19.87%	37	22.98%	30	18.52%	54	22.98%
missing	0	0.00%	1	0.62%	0	0.00%	0	0.00%
Total	**156**		**161**		**162**		**235**	

* LTF = Lost on Follow up

3.4.2 Predictors of changes in ADL status

Pooled panel data for 8,276 subjects aged 60 years and older who responded to ELSA interviews and had complete ADLs data was used in the analysis. The sample consists of 3,913 (47.28%) males and 4,363 (52.72%). Median age was 69 with inter-quartile range of (64 to 75) years old.

Both educational class and social class were based on information collected in the HSE. Table 3.6 shows the sample subjects education and social class. Education was measured as the highest qualification obtained and was categorised as university degree or equivalent (19.57% of the subjects), intermediate qualification (18.1% of the subjects), and no educational qualification (61.16%). Three quarter (75%) of the subjects reported at least 1 difficulty in ADLs had no educational qualification. Social class was classified into three categories: managerial/ professional (19.57% of the subjects), intermediate (41.66%), and semi-skilled/ non-skilled (34.86%). There was no big difference between the socioeconomic position of the subjects with reported difficulties in ADLs and their healthier peers.

Both previous ADLs and motor skills were categorised based on the severity of disability to zero difficulties , 1 or 2 difficulties, and 3 or more difficulties. Tables 3.7 shows the numbers of subjects by reported difficulty at each wave. 77% of ELSA subjects were totally independent in the ADLs at baseline, and less than 40% were independent in motors skills. This could be explained by the hierarchical order of motor skills and ADLs. As most of the motor skills are related to movements of upper, or lower limbs or both together, while ADLs are activities that are needed to maintain autonomy of the individual. When subjects with no ADL difficulties were excluded, the remaining subject had high prevalent motor skills disability (more than 80%). On the other hand most of the subjects had moderate ADL disability (more than 70% reported 1 or 2 difficulties in ADLs).

Table 3.6: Socioeconomic class of subjects aged 60 and older responded to ELSA

	Males		**Females**		**Total**	
Educational qualification						
No qualification	2,168	55.41%	2,894	66.33%	5,062	61.16%
Intermediate	728	18.60%	770	17.65%	1498	18.10%
University degree or equivalent	959	24.51%	661	15.15%	1620	19.57%
missing	58	1.48%	38	0.87%	96	1.16%
Social class						
Managerial/ professional	1,043	26.65%	577	13.22%	1,620	19.57%
Intermediate/ skilled	1,490	38.08%	1,958	44.88%	3,448	41.66%
Semi/non-skilled	1,259	32.17%	1,626	37.27%	2,885	34.86%
missing	121	3.09%	202	4.63%	323	3.90%
Total	**3,913**		**4,363**		**8,276**	

Table 3.7: Functional limitations among subjects aged 60 and older at each given Wave

Level of difficulty

	No difficulty		**Moderate**		**Sever**		**missing**		**Total**
All aged 60+			**1 or 2 ADLs**		**3 or more**				
Motor Skills									
Wave 1	2,423	35.53%	1,871	27.43%	2,401	35.21%	125	1.83%	**6,820**
Wave 2	2,124	34.17%	1,758	28.28%	2,241	36.05%	93	1.50%	**6,216**
Wave 3	2,055	35.06%	1,617	27.59%	2,022	34.50%	167	2.85%	**5,861**
Wave 4	2,666	36.82%	1,989	27.47%	2,300	31.76%	286	3.95%	**7,241**
Wave 5	2,759	37.13%	1,972	26.54%	2,328	31.33%	372	5.01%	**7,431**
ADL									
Wave 1	5,114	74.99%	1,182	17.33%	399	5.85%	125	1.83%	**6,820**
Wave 2	4,652	74.84%	1,118	17.99%	353	5.68%	93	1.50%	**6,216**
Wave 3	4,389	74.88%	972	16.58%	333	5.68%	167	2.85%	**5,861**
Wave 4	5,460	75.40%	1,174	16.21%	321	4.43%	286	3.95%	**7,241**
Wave 5	5,629	75.75%	1,090	14.67%	341	4.59%	371	4.99%	**7,431**

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Level of difficulty

	No difficulty		**Moderate**		**Sever**		**missing**		**Total**
All aged 60+			**1 or 2 ADLs**		**3 or more**				
1 ADL at least									
Motor Skills									
Wave 1	57	3.61%	213	13.47%	1,311	82.92%	-	-	**1,581**
Wave 2	46	3.13%	208	14.14%	1,217	82.73%	-	-	**1,471**
Wave 3	33	2.53%	181	13.87%	1,091	83.60%	-	-	**1,305**
Wave 4	51	3.41%	214	14.31%	1,230	82.27%	-	-	**1,495**
Wave 5	46	3.21%	183	12.79%	1,202	84.00%	-	-	**1,431**
ADL									
Wave 1	-	-	1,182	74.76%	399	25.24%	-	-	**1,581**
Wave 2	-	-	1,118	76.00%	353	24.00%	-	-	**1,471**
Wave 3	-	-	972	74.48%	333	25.52%	-	-	**1,305**
Wave 4	-	-	1,174	78.53%	321	21.47%	-	-	**1,495**
Wave 5	-	-	1,090	76.17%	341	23.83%	-	-	**1,431**

Subject in ELSA had reported high prevalence of pulmonary diseases (lung disease and asthma 17%), arthritis (53%), and cardiac diseases (25% of subject reported one of Angina,heart attack, congestive heart failure, heart murmur, abnormal heart rhythm). Cancer, psychiatric and stroke were present at 5% to 10% among all subjects. The least common chronic conditions were neurological disease (Parkinson's, Alzheimer, dementia/senile) less than 1%. This could be a result of the restriction of ELSA sample older people living in the household. As people with neurological diseases would be in frequent need for care. The variable for the number of comorbidities was constructed to reflect the presence of multiple conditions together. Table 3.8 shows the percentages of subjects reporting being diagnosed with any of the conditions and reports the number of comorbidities. About 55% of the subject had 1 or 2 conditions, and 5% had 3 chronic conditions. Subjects with at least 1 difficulty at preceding wave had higher prevalent chronic conditions with 70% of the sample had 1 or two conditions together, and 10% had 3 chronic and cardiac conditions. Respondents who have reported at least 1 difficulty at the preceding wave had more than double the chances of having joint replacement between interviews (see table 3.9).

Health related behaviours (shown in table 3.10) include smoking and alcohol use. Smoking habits and alcohol consumption did not seem to have any differences between the disabled and their non-disabled peers. The respondents whom reported at least 1 ADL failure seem to consume less alcohol compared with the sample. There are little differences in smoking consumption.

Table 3.8: Medicaly diagnosed conditions of subjects aged 60 and older at each given Wave

	All aged 60+						**sample with 1 ADL at leaset**					
	No		**Yes**		**missing**		**No**		**Yes**		**missing**	
Chronic diseases												
Pulmonary												
Wave 1	5,713	83.77%	1,099	16.11%	8	0.12%	1,175	74.32%	405	25.62%	1	0.06%
Wave 2	5,125	82.45%	1,088	17.50%	3	0.05%	1,093	74.30%	376	25.56%	2	0.14%
Wave 3	4,724	80.60%	1,135	19.37%	2	0.03%	950	72.80%	355	27.20%	-	-
Wave 4	6,128	84.63%	1,107	15.29%	6	0.08%	1,136	75.99%	356	23.81%	3	0.20%
Wave 5	6,284	84.56%	1,134	15.26%	13	0.17%	1,077	75.26%	352	24.60%	2	0.14%
Neurological												
Wave 1	6,722	98.56%	90	1.32%	8	0.12%	1,538	97.28%	42	2.66%	1	0.06%
Wave 2	6,101	98.15%	110	1.77%	5	0.08%	1,422	96.67%	46	3.13%	3	0.20%
Wave 3	5,694	97.15%	165	2.82%	2	0.03%	1,248	95.63%	57	4.37%	-	-
Wave 4	7,035	97.16%	201	2.78%	5	0.07%	1,424	95.25%	69	4.62%	2	0.13%
Wave 5	7,192	96.78%	226	3.04%	13	0.17%	1,350	94.34%	79	5.52%	2	0.14%

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	All aged 60+						**sample with 1 ADL at leaset**					
	No		**Yes**		**missing**		**No**		**Yes**		**missing**	
Arthritis												
Wave 1	3,482	46.86%	3,933	52.93%	16	0.22%	289	20.20%	1,141	79.73%	1	0.07%
Wave 2	3,103	49.92%	3,108	50.00%	5	0.08%	340	23.11%	1,128	76.68%	3	0.20%
Wave 3	2,498	42.62%	3,361	57.35%	2	0.03%	236	18.08%	1,069	81.92%	-	-
Wave 4	3,523	48.65%	3,708	51.21%	10	0.14%	348	23.28%	1,144	76.52%	3	0.20%
Wave 5	3,482	46.86%	3,933	52.93%	16	0.22%	289	20.20%	1,141	79.73%	1	0.07%
Cancer												
Wave 1	6,323	92.71%	489	7.17%	8	0.12%	1,450	91.71%	130	8.22%	1	0.06%
Wave 2	5,668	91.18%	544	8.75%	4	0.06%	1,333	90.62%	136	9.25%	2	0.14%
Wave 3	5,275	90.00%	584	9.96%	2	0.03%	1,153	88.35%	152	11.65%	3	0.20%
Wave 4	6,811	94.06%	423	5.84%	7	0.10%	1,377	92.11%	115	7.69%	-	-
Wave 5	6,894	92.77%	524	7.05%	13	0.17%	1,293	90.36%	136	9.50%	2	0.14%
Stroke												

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	All aged 60+						sample with 1 ADL at leaset					
	No		Yes		missing		No		Yes		missing	
Wave 1	6,415	94.06%	399	5.85%	6	0.09%	1,401	88.61%	178	11.26%	2	0.13%
Wave 2	5,941	95.58%	268	4.31%	7	0.11%	1,340	91.09%	128	8.70%	3	20.00%
Wave 3	5,457	93.11%	402	6.86%	2	0.03%	1,150	88.12%	155	11.88%	-	-
Wave 4	6,806	93.99%	428	5.91%	7	0.10%	1,327	88.76%	166	11.10%	2	0.13%
Wave 5	6,981	93.94%	436	5.87%	14	0.19%	1,259	87.98%	171	11.95%	1	7.00%
Cardiac disease												
Wave 1	5,150	75.51%	1,663	24.38%	7	0.10%	1,022	64.64%	557	35.23%	2	0.13%
Wave 2	5,027	80.87%	1,183	19.03%	6	0.10%	1,034	70.29%	434	29.50%	3	0.20%
Wave 3	4,245	72.43%	1,614	27.54%	2	0.03%	786	60.23%	519	39.77%	-	-
Wave 4	5,647	77.99%	1,587	21.92%	7	0.10%	992	66.35%	501	33.51%	2	0.13%
Wave 5	5,678	76.41%	1,739	23.40%	14	0.19%	903	63.10%	527	36.83%	1	0.07%
Psychiatric												
Wave 1	6,465	94.79%	347	5.09%	8	0.12%	1,475	93.30%	105	6.64%	1	0.06%
Wave 2	5,776	92.92%	435	7.00%	5	0.08%	1,328	90.28%	140	9.52%	3	0.20%

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	All aged 60+						**sample with 1 ADL at leaset**					
	No		**Yes**		**missing**		**No**		**Yes**		**missing**	
Wave 3	5,349	91.26%	510	8.70%	2	0.03%	1,158	88.74%	147	11.26%	-	-
Wave 4	6,725	92.87%	509	7.03%	7	0.10%	1,338	89.50%	154	10.30%	3	0.20%
Wave 5	6,815	91.71%	603	8.11%	13	0.17%	1,267	88.54%	162	11.32%	2	0.14%
Recent joint replacement												
Wave 1	6,722	95.51%	108	1.58%	198	2.90%	1,481	93.67%	55	3.48%	45	2.85%
Wave 2	5,981	96.22%	229	3.68%	6	0.10%	1,368	93.00%	102	6.93%	1	0.07%
Wave 3	5,662	96.60%	196	3.34%	3	0.05%	1,211	92.80%	94	7.20%	-	-
Wave 4	6,887	95.11%	351	4.85%	3	0.04%	1,356	90.70%	139	9.30%	-	-
Wave 5	7,104	95.60%	320	4.31%	7	0.09%	1,318	92.10%	113	7.90%	-	-

Table 3.9: Number of comorbidities diagnosed of subjects aged 60 and older at each given Wave

	all		**1 ADL**			**all**		**1 ADL**	
Nu of chronic conditions					**Nu of chronic conditions**				
Non					**4 conditions**				
Wave 1	2,587	37.93%	252	15.94%	Wave 1	77	1.13%	46	2.91%
Wave 2	2,199	35.38%	188	12.78%	Wave 2	68	1.09%	39	2.65%
Wave 3	1,664	28.39%	126	9.66%	Wave 3	126	2.15%	62	4.75%
Wave 4	2,594	35.82%	192	12.84%	Wave 4	108	1.49%	63	4.21%
Wave 5	2,547	34.28%	158	11.04%	Wave 5	112	1.51%	67	4.68%
1 condition					**5 conditions**				
Wave 1	2,556	37.48%	597	37.76%	Wave 1	13	0.19%	8	0.51%
Wave 2	2,420	38.93%	607	41.26%	Wave 2	14	0.23%	12	0.82%
Wave 3	2,242	38.25%	451	34.56%	Wave 3	25	0.43%	13	1.00%
Wave 4	2,788	38.50%	593	39.67%	Wave 4	8	0.11%	5	0.33%
Wave 5	2,778	37.38%	517	36.13%	Wave 5	15	0.20%	11	0.77%

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	all		1 ADL			all		1 ADL	
Nu of chronic conditions					**Nu of chronic conditions**				
Non					**4 conditions**				
2 conditions					**6 conditions**				
Wave 1	1,244	18.24%	500	31.63%	Wave 1	-	-	-	-
Wave 2	1,149	18.48%	440	29.91%	Wave 2	-	-	-	-
Wave 3	1,278	21.81%	428	32.80%	Wave 3	1	0.02%	1	0.08%
Wave 4	1,323	18.27%	448	29.97%	Wave 4	1	0.01%	1	0.07%
Wave 5	1,454	19.57%	449	31.38%	Wave 5	1	0.01%	1	0.07%
3 conditions					**missing**				
Wave 1	333	4.88%	175	11.07%	Wave 1	10	0.15%	3	0.19%
Wave 2	355	5.71%	179	12.17%	Wave 2	11	0.18%	6	0.41%
Wave 3	523	8.92%	224	17.16%	Wave 3	2	0.03%	-	-
Wave 4	407	5.62%	189	12.64%	Wave 4	12	0.17%	4	0.27%
Wave 5	507	6.82%	226	15.79%	Wave 5	17	0.23%	2	

Table 3.10: Health behaviour (smoking and alcohol consumption) of subjects aged 60 and older at each given Wave

	Smoking status							
	Never smoked		**Ex-smoker**		**Current smoker**		**missing**	
All aged 60+								
Wave 1	2,327	34.12%	3,371	49.43%	995	14.59%	127	1.86%
Wave 2	2,205	35.47%	3,124	50.26%	792	12.74%	95	1.53%
Wave 3	2,071	35.34%	2,942	50.20%	681	11.62%	167	2.85%
Wave 4	2,610	36.04%	3,482	48.09%	803	11.09%	346	4.78%
Wave 5	2,541	34.19%	3,749	50.45%	770	10.36%	371	4.99%
1 ADL at least								
Wave 1	477	30.17%	842	53.26%	262	16.57%	-	-
Wave 2	473	32.15%	789	53.64%	209	14.21%	-	-
Wave 3	430	32.95%	706	54.10%	169	12.95%	-	-
Wave 4	479	32.04%	798	53.38%	202	13.51%	-	-
Wave 5	457	31.94%	792	55.35%	182	12.72%	-	-

Continued on next page

	Alcohol drinking behaviour							
	Teetotal		**Occasional**		**Regular**		**missing**	
All aged 60+								
Wave 1	946	13.87%	2,119	31.07%	3,629	53.21%	126	1.85%
Wave 2	685	11.02%	1,531	24.63%	3,060	49.23%	940	15.12%
Wave 3	617	10.53%	1,377	23.49%	2,736	46.68%	1,131	19.30%
Wave 4	763	10.54%	1,630	22.51%	3,593	49.62%	1,255	17.33%
Wave 5	855	11.51%	1,848	24.87%	3,713	49.97%	1,015	13.66%
1 ADL at least								
Wave 1	350	22.14%	550	34.79%	681	43.07%	-	-
Wave 2	238	16.18%	393	26.72%	544	36.98%	296	20.12%
Wave 3	207	15.86%	323	24.75%	470	36.02%	305	23.37%
Wave 4	257	17.19%	383	25.62%	541	36.19%	314	21.00%
Wave 5	290	20.27%	391	27.32%	532	37.18%	218	15.23%

Results from regression models

Physical disability reported in ELSA has a dynamic pattern of deterioration, stability and improvement. An observable high rate of improvement and stability can be observed in measures of disability, particularly in ADL states. Factors affecting the vulnerability of older person to disability, and events that could contribute to the onset of disability are sought to act as predictors of deterioration, stability and improvements in ADLs as a measure of disability. Three models were tested. In Model 1, investigated previous disability status, age, sex, marital status, education, social class, Cerebra-vascular diseases, chronic illnesses, whether the participant have had joint replacement within two year before the interview, smoking and alcohol intake as predictors of improvements in ADLs. Model 2 excluded joint replacement from the covariates, and Model 3 considered the respondents who died or institutionalised to the sample. The outcome variable considered was a dichotomous variable indicating whether a respondent have reported improvements in ADL status against both deterioration and stability.

The same three models were repeated for the deterioration in ADLs outcome, where deterioration is measured by a dichotomous variable indicating reporting increase in the number of difficulties in ADLs against stability and improvement.

The initial model included all the variables chosen priori to the model: demographics (sex and age), socioeconomic status (education and social class), motor skills and ADLs, chronic diseases (pulmonary, neurological, arthritis, cancer, stroke, cardiac and psychiatric), a variable indicating the number of comorbidities, whether the respondent had joint replacement and health behaviour (smoking and alcohol consumption). Stability of model parameter estimates and associated variances were investigated by re-fitting our final model containing all covariates multiple times, each time removing a single covariate from all variables contained in the final model. Statistical significance was determined at $p < .05$ to maintain variables in the model.

Table 3.11: Random effects cross-sectional panel logit regression models for improvements in ADLs reported in ELSA

	Model 1	**Model 2**	**Model 3**
Nu. of Observations	4,166	3,750	3,750
Nu. Of respondents	2,638	2,357	2,357
Log-likelihood	-2,780	-2,536	-2,536
Wald χ^2 (d.f.)	176.08 (d.f.=12)	115.68 (d.f.=9)	116.19 (d.f.=10)
AIC	5,588	5,094	5,096
BIC	5,677	5,163	5,170
Odds ratio, (p-value) & [Confidence Interval]			
Demographics			
Male	referent	-	-
Female	1.212**	-	-
	[1.059,1.387]	-	-
Age	0.975***	0.988**	0.988**
	[0.967,0.983]	[0.980,0.996]	[0.980,0.996]
Education			
¡ o-level	referent	-	-
o-level or higher	1.13 (0.072)	-	-
	[0.989,1.292]	-	-
ADLs			
1 or 2 failures	referent	referent	referent
3 or more failures	1.555***	1.775***	1.773***
	[1.332,1.815]	[1.504,2.095]	[1.503,2.093]
Chronic conditions			

95% confidence intervals in brackets []

* p<0.05, ** p<0.01, *** p<0.001

d.f. = degrees of freedom

Continued on next page

	Model 1	**Model 2**	**Model 3**
No conditions	referent	referent	referent
Pulmonary	0.854 (0.071)	-	-
	[0.719,1.013]	-	-
Neurological	0.426***	0.433***	0.434***
	[0.280,0.648]	[0.282,0.667]	[0.282,0.668]
Cancer	-	1.311*	1.311*
	-	[1.023,1.679]	[1.023,1.679]
Stroke	0.765*	-	-
	[0.599,0.976]	-	-
Number of comorbidities	0.846***	0.796***	0.796***
	[0.781,0.917]	[0.742,0.854]	[0.742,0.854]
Recent joint replacement			
No	-	-	referent
Yes	-	-	1.103 (0.434)
	-	-	[0.863,1.409]
Health behaviour			
Smoking			
Never	referent		
Quitter	0.831*	0.851*	0.853*
	[0.719,0.960]	[0.735,0.985]	[0.737,0.988]
Smoker	0.800*	0.863 (0.175)	0.867 (0.191)
	[0.652,0.983]	[0.697,1.068]	[0.700,1.074]
Alcohol consumption			
Teetotal	referent	referent	referent
Occasionally	1.281**	1.264*	1.262*

95% confidence intervals in brackets []

* p<0.05, ** p<0.01, *** p<0.001

d.f. = degrees of freedom

Continued on next page

	Model 1	**Model 2**	**Model 3**
	[1.072,1.530]	[1.049,1.524]	[1.048,1.521]
Regularly	1.445***	1.360***	1.357***
	[1.213,1.721]	[1.137,1.627]	[1.134,1.624]

95% confidence intervals in brackets []

* p<0.05, ** p<0.01, *** p<0.001

d.f. = degrees of freedom

The results from the final three panel logistic regression random effects models are presented in terms of the odds ratios along with their p-value and 95% confidence intervals in table 3.11. The results shown are for models obtained after the elimination of the independent variables with high p-value. Social class was removed from the model as showed no association. Some chronic conditions; arthritis, cancer and cerebro-vascular disease were eliminated based on their p-value, but they are taken account for in the number comorbidities variable.

Variables that showed significant statistical association with improvement are being female of older age, with severe difficulties in motor skills or ADLs (3 or more failures), being diagnosed with neurological condition, quitting smoking, consumption of alcohol regularly or occasionally. When included motor skills in the analysis (see table 3.C.1 in 3.C), statistical significance was shown for older age, severe difficulties in motor skills or ADLs (3 or more failures), being diagnosed with neurological condition, and drinking alcohol regularly or occasionally.

Old females, reporting more than 3 difficulties in ADLs, drinking alcohol improve the chances of improvement in ADL status. On the other hand a reporting being diagnosed with any chronic condition were associated with decreased improvements in ADLs status. Compared to healthy subjects, being diagnosed with neurological diseases reduces the chance of reporting ADL improvement by 57%. This is more than double the decrease caused by stroke 23.5%. Other conditions combined decrease the chance of improvement by 15.4%. Having reported pulmonary condition shows some evidence of lower chances of reporting recovery but not statistically significant with p-value 0.071. Comparison of the improvement (table 3.11) and deterioration (table 3.C.1) models shows that: deterioration in ADLs increases with age. Gender differential on deterioration or improvement were only prominent when death and institutionalisation were included in the model, and the same for education differential. Sever disability in motor skills increased the chance of deterioration in ADLs to double of those who have no disability, while reduced improvement by less than 40%. On the contrary, severe ADL disability increased the chance of improvement by 50% and reduced the chance of deterioration by less than 20% only.

Being diagnosed with neurological conditions doubled the possibility of deterioration and halved the chance of improvements, even after removal of death and institutionalised respondents from the analysis. Pulmonary disease was associated with reduction in improvements in ADL, but had no association with deterioration in ADLs. Arthritis had protective effect against deterioration in ADLs, but had no association with improvements. Additionally, arthritis protective effect was not prominent when the death and institutionalisation were removed from the analysis. Cancer increase deterioration in ADLs. Stroke reduced improvement and increased deterioration, its effect was not significant (p-values between 0.05 and 0.15). Cardiac disease were not associated with improvements in ADLs. Moreover, cardiac diseases did not have significant association with deterioration when deaths and institutionalisation were included, but their effect was reduction of deterioration was still not significant (p-values between 0.05 and 0.10).

When subjects reported being diagnosed with number of comorbidities, this increased deterioration and reduced improvements in ADLs. These results are in accordance with Boult *et al.* (1994).

Joint replacement was not associated with improvements or deterioration in ADLs. This is highly like because of the small number of subjects reporting that they had joint replacement (only 717 subjects during 8 years follow-up).

Ex-smokers and current smokers had lower chance of improvement in ADLs, and increased chance of deterioration. The increase chance of deterioration because of smoking was only prominent when deaths and institutionalisation were included in the model. Alcohol had a prominent protective effect against deterioration in ADLs and was strongly associated with increase in improvements. The protective effect of alcohol has been shown in other studies (Lang *et al.* (2007a)).

3.4.3 Probabilities of improvements in ADLs

This section aims to explore further the effect of life threatening conditions, gender, and disability reported previously on improvement in disability. Predicted probabilities of improvement were calculated over age of the respondents using the models fitted above. The calculations were repeated for males/females and for reported mild and severe disability. The probabilities shown in figure 3.1 are predicted probabilities of improvement in ADLs, calculated using estimated panel logit regression model assuming three scenarios (worst, best and average).

- Worst scenario is a male, with no education, reported 1 or 2 failure in ADLs at baseline diagnosed with pulmonary and neurological conditions and had a stroke, a current smoker and a teetotal
- Best scenario is a female, with some education, reported 3 or more ADLs at baseline, has no diagnosis of chronic conditions, never smoked, and consumes alcohol regularly
- Average scenario is allocated average values for each factor.

In each sub-figure of figure 3.1 the probabilities were calculated for respondents who had never been diagnosed with any chronic conditions, and those who had been diagnosed with one condition: neurological, cardiovascular and pulmonary, and finally those who are diagnosed with all three conditions. The chances of reporting improvements in ADLs for those who reported sever disability in previous wave are higher, and females have higher probabilities of improvement in both mild and severe disability at previous wave. Probabilities of improvement were reduced by more than 0.2 for diagnosis of neurological condition, and they fall by about less than 0.1 for both pulmonary and cardiovascular conditions.

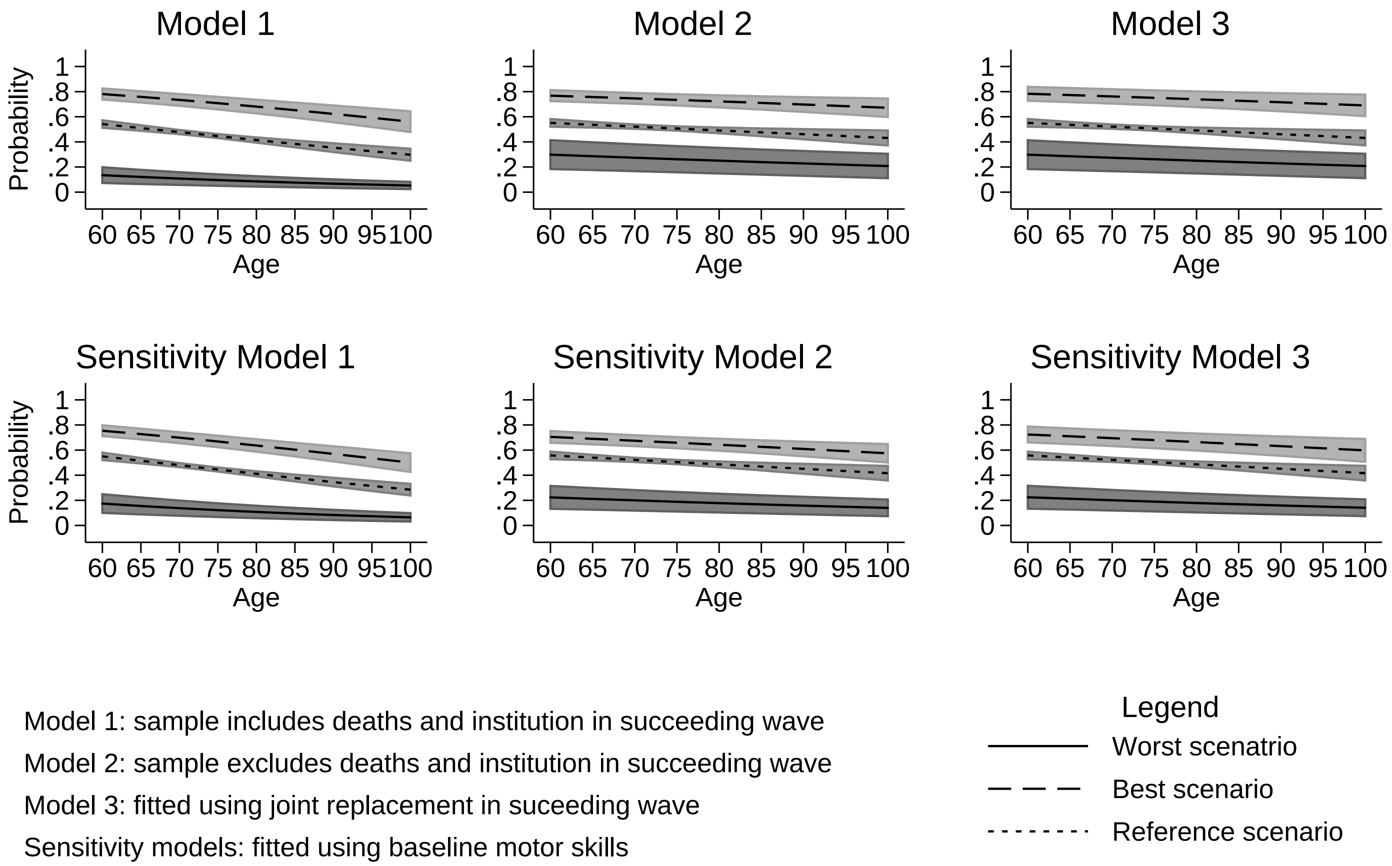


Figure 3.1: Estimated probabilities (with 95% confidence intervals) of reporting improvement in ADLs using different panel logit regression models based on three scenarios (worst, best and reference)

The first row of graphs in figure 3.1 are probabilities of improvement based on the panel logistic regression models shown in table 3.11. The first figure on the left shows the probabilities calculated using model 1. Probabilities of improvement in ADLs based on model 1 were lower than those based on models 2 and 3. This could be the result of the inclusion of deaths and institutions in the succeeding interviews. Moreover, in model 1 both pulmonary disease and stroke were significant predictors of lower rate of improvement. On the other hand, when subjects who died/ or institutionalised were excluded from the sample, both pulmonary disease and stroke were seen non-significant. This can explain the relatively higher probability of improvement based on models 2 and 3. Additionally, subjects with cancer have 30% higher probability of improvement compared with subjects reporting other diseases.

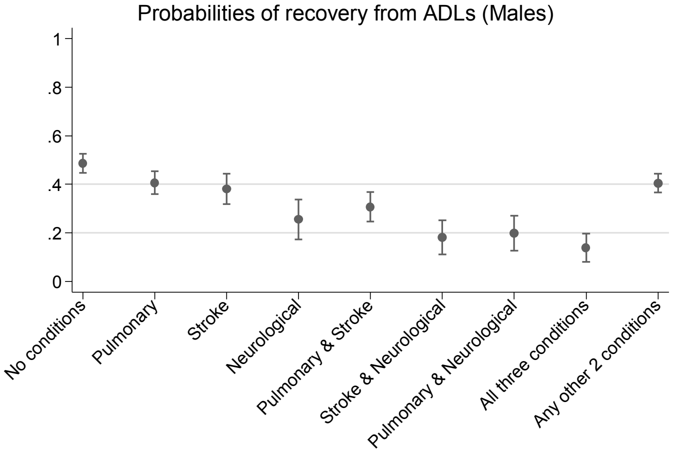
The second row of graphs in figure 3.1 shows similar pattern in the probabilities based on sensitivity models. Sensitivity models are panel logistic regression models, where the model adjusted for baseline disability in motor skill instead of baseline ADLs. Probabilities of improvement in ADLs based on sensitivity model 1 were lower than those based on sensitivity models 2 and 3. The similarities of probability pattern changes between model 1, 2 and 3, and the corresponding sensitivity models 1, 2 and 3 shows that the effect of excluding deaths and institutions has a significant impact on the results obtained from the model. A probable hypothesis is that statistically significant factors that reduce improvement probabilities based on model 1, are acting as proxy to swift deterioration in health that leads to deaths or institutionalisation.

Table 3.C.1 in 3.C show that stroke and smoking are both significant predictors of deterioration when deaths and institutions were considered. When excluded deaths and institutions diagnosis with stroke has lower statistical power (p-values increased from 0.06 to more than 0.10). Smoking status was only significant in model 1. Finally, pulmonary disease had no statistical significance in deterioration models. The results from deterioration models conform with our hypothesis.

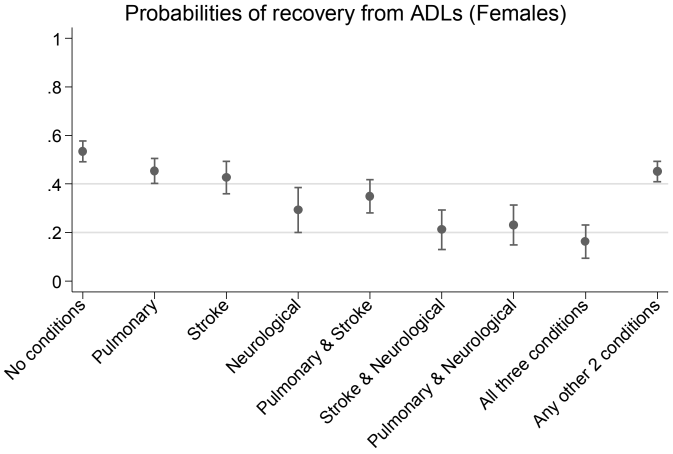
The effect of comorbidities

The interaction between comorbidities in reducing the probabilities of improvements is illustrated by the probabilities in the graphs from figure 3.2. These graphs show the predicted probabilities (and 95% confidence intervals) of improvement in ADLs based on model 1 (shown in table3.11). The probabilities given are conditional on the number of chronic conditions. Additionally, the probabilities are predicted for subjects who are aged 75 with lower than o-level education, former smokers who drink regularly, and whom reported moderate disability (failure in 1 or 2 ADLs). The probabilities shown are calculated for males (figure 3.2a) and females (figure 3.2b).

The category ‘All three conditions ’ refers to respondents who are diagnosed with the three conditions; pulmonary, neurological and stroke. This shows the combined effect of all three conditions if a respondent is diagnosed with all on the probability of reporting recovery. The last category in figures 3.2 a and b, ‘any other 2 conditions ’ is the predicted probability of reporting recovery given the respondent had been diagnosed with any 2 of the conditions: cancer, psychiatric, cardiovascular disease or arthritis. These conditions are accounted for in the model using the number of conditions diagnosed as a predictor, but they are not included in the estimated model as independent predictors.



(a) Interaction of comorbidities on improvement in ADLs: Males



(b) Interaction of comorbidities on improvement in ADLs: Females

Figure 3.2: Estimated ADLs improvement probabilities (with 95% confidence intervals) for given comorbidities

3.5 Discussion

Disability in older age measured using ADLs is dynamic, i.e. adaptation to the disability, and improvements in some of the activities has been observed. Moreover, total recovery in all ADLs is not rare occasion. Treating disability as a static condition means that we are overestimating disability and its impact on costs of social care. Viewing disability as a static condition ignores the fact that, depending on the basic underlying causes (i.e. factors and events leading to disability), disability may begin abruptly, progress slowly, remain stable, and may even diminish over time. To study disability dynamics and to identify the risk factors for improvements and decline in disability, repeated measures of disability are needed. Large-scale panel studies (e.g. English Longitudinal Study of Ageing, and Cognitive Functioning and Ageing Study), obtained several waves of disability. Although, short term dynamics are missed when data are spaced at intervals of one year or longer, improvements and recovery to independence has been observed.

As Activities of Daily Living (ADLs) are used by insurance firms as triggers to initiate claims from Long-Term Care (LTC) insurance, then it is important to understand this measure and understand the impact of different factors on ADLs their dynamics. The conventional assumption is that once a policy holder hits the ADLs trigger and starts claiming, the insurance com- pany will continue paying for their LTC till death. The observed recoveries in ADLs in survey datasets might suggest that a insurance companies might benefit from reassessment of their claimants' ADLs, and this would have an impact on LTC insurance premium. In order to conclude whether reassessment of claimants is needed a longitudinal analysis of the reported changes in ADLs is needed. Preliminary analysis in this paper has showed that a non-deteriorating ADL status (e.g., same or improved status) was more common than death and institutionalisation at each level of disability for subjects at all levels of functional status, at each wave. A large majority of persons who were non-disabled in 2002 (75%) remained non-disabled over the two-year period in spite of the high median age (69) of the sample in

2002. In addition, there is a significant probability of a long-term improvement in ADL status, even at very high levels of disability. This is consistent with results obtained in other studies study where transitions into and out of ADL dependence were assessed (Rudberg *et al.* (1996)). The findings match with those of Anderson *et al.* (1998), in which reporting either unchanged or improved disability status was high for both men and women.

It is important to note that the increase in improvement transitions is higher than the increase in deterioration transition as those who had reported zero failures at the preceding wave has been excluded. The reported improvement seems very high,and this could be for different reasons. This can be due to adaptation to the difficulty in performing the activity, or the reported difficulty at particular wave was temporary. The chance of false reporting shouldn't be ignored in trying to understand these numbers. Of the control variables used in the regression models education, and social class shown no significance as predictors of future deterioration or improvements in ADLs. In previous longitudinal studies (see Beckett *et al.* (1996); Rudberg *et al.* (1996); Manton (1988)). While education has been widely perceived as a major influence on health through lifestyle, health behaviour, problem-solving abilities, social relations, self-esteem and stress-management, in ways which, with regard to health, are to the advantage of the more educated, this was not present in the analysis we conducted. On the other hand, previous research (de Leon *et al.* (1999)) has shown that this effect may weaken with age.

In addition, gender differences are generally greater for mobility-related activities (Jette and Branch (1981)) or instrumental activities of daily living (Markides (1989)) than for basic ADLs. The results of this study suggest that gender differentials are not present in deterioration, stability or improvement in ADLs status. Although, the preliminary analysis has shown that women had higher prevalence of disability, and that men die younger. Women on average both are at greater risk of developing disability than men and live longer than men, but higher levels of disability (i.e. deterioration in ADLs) could be sought to increased risk of death among older persons. Cardiovascular diseases including coronary heart disease, stroke, or angina; and musculoskeletal diseases including arthritis, or whether the respondent ever had joint replacement, are the main categories of most common morbidities at old age (Manton (1989)). These disease groups have a high prevalence among older adults in general and were shown to impact affect the dynamics of disability in Manton (1989); Verbrugge (1992). Cardiovascular disease group was shown to produce a relatively fast pace of functional decline followed by death. That can explain the lack of significance of the cardiac dis- ease in our model. On the other hand, arthritis was shown to produce a relatively slow pace of decline. The results from the regression models contradicts with the findings of Boult *et al.* (1994); Manton (1989) in that arthritis has a protective role against further deterioration. Our results provide no evidence that pulmonary conditions, cancer, or diabetes lead to deterioration orf improvement in ADLs. Additionally, the contribution of joint replacement approached but did not attain statistical significance (p-value more than 0.30). Alcohol showed a protective effect which corresponds with the protective effect of alcohol on health (Mukamal *et al.* (2003b,a); Gaziano *et al.* (1996); White *et al.* (2002)). It is shown in Verbrugge (1992) that arthritis was associated with slower functional status declines than non-arthritic illnesses over a 6-year period in the LSOA. Moreover, arthritis patients who are disability free were more likely to incur disability than persons with other illnesses, but arthritis patients were more likely to regain ADLs. This reflects the medical nature of arthritis being with moderate impact.

One possible extension of the analysis is the use of severity classification used by Rudberg *et al.* (1996). In that study it was shown that persons with severe disability (reporting 5 to 6 ADL difficulties) at baseline, and persons with low disability (reporting 1 or 2 ADL difficulties) were more likely to stay in the same ADL status after two years. It also showed that the group with 3 to 4 ADL impairments has the lowest level of stability; that is, they had the lowest percentage of staying in the same ADL status (still had 3 to 4 ADLs) after two years. Another study Anderson *et al.* (1998) found that death and institutionalisation both increased with more severe disability at the beginning of the period; however, men were more likely than women to die at each level of disability. Moreover, in Anderson *et al.* (1998) women reporting any level of disability were more likely to have been institutionalised during the two-year period than men. Also, individuals who lived with others were more likely to report severe ADL disability than being institutionalised during the study period.

There were also some limitations to the analysis in this Chapter. Information about physical activity, functional capacity, digital literacy, diabetes mellitus, and cardiovascular disease were self-reported.

In conclusion, disability in ADLs is reversible. Healthy behaviour, represented by no smoking and moderate drinking can reduce the risk for deteriorating ADLs at older age. Ageing showed that recovery is significantly lower as the respondent is older. Respondents who had reported many ADLs at previous interviews have more than 50% chances of reporting less fewer ADLs in the next interview, which might suggest recovery, adaptation, or possible false recovery. While we had anticipated that chronic conditions; particularly neurological, arthritis, stroke and cerebrovascular diseases to be influential on ADLs. The analysis had showed that the individual chronic conditions were not strongly significant. However, a respondent diagnosed with a group of conditions had more significant lower chances of recovery. With respondent reported diagnosed with neurological conditions being the worse off, and respondents who had stroke come second worse in chances of recovery from ADLs. The one condition that had shown a positive influence on recovery was diagnosis with cancer.

Health related behaviours shows that smoking and history of smoking had a negative impact on health measured by reported ADLs. On the other hand alcohol was shown to be beneficial in other studies. The benefits of being an occasional or regular drinker of alcohol can be due to better social life for those who drink, or due to the fact that those who do not drink were asked to stop drinking by a doctor or a nurse due to serious illness. Other reasons could be because health benefits of moderate consumption of Alcohol.

Our results indicate that many older persons experience recurrent episodes of disability followed by a return of independence. In planning for the care needs of disabled older persons, progressive deterioration in function and increase in need for assistance are not inevitable. From a policy perspective, flexible systems are warranted that can provide the additional services older persons need during episodes of disability. Furthermore, among older persons with a history of disability, interventions are needed to decrease the frequency and duration of future disability episodes.

Finally, although our disability assessment was highly reliable , some transitions could have been due to measurement error rather than true changes in function.

Appendices

3.A Self-reported disability measures used in ELSA

In all five waves of ELSA interviews respondents were asked included several questions that required the respondents to self-report any difficulty with Activities of Daily Living (ADL), Instrumental Activities of Daily Living (IADL) and motor skills (or functional mobility). For each question the respondent was shown a list of different activities.

3.A.1 Activities of Daily Living (ADLs)

The ADLs is a measure of the basic day to day activities, and finding difficulty in one of them shows that there is an underlying disability. ADLs list included the following 6 activities:

- dressing, including putting on shoes and socks,
- walking across a room,
- bathing or showering,
- eating, such as cutting up your food,
- getting in or out of bed, and
- using the toilet, including getting up or down

3.A.2 Instrumental Activities of Daily Living (IADLs)

The IADLs covered activities that include the need for cognitive wellness. The list used in ELSA interviews includes:

- using a map to get around in a strange place,
- preparing a hot meal,
- shopping for groceries,

- making telephone calls,
- taking medications,
- doing work around the house or garden, and
- managing money, e.g. paying bills & keeping track of expenses

3.A.3 Motor skills

Motor skills are more specific skills to upper and lower limbs. Because they are more specific respondents wont necessarily have disability. Motor skills included:

- walking 100 yards,
- sitting for about two hours,
- getting up from a chair after sitting for long periods,
- climbing several flights of stairs without resting,
- climbing one flight of stairs without resting,
- stooping, kneeling, or crouching,
- reaching or extending arms above shoulder level,
- pulling/pushing large objects like a living room chair,
- lifting/carrying over 10 lbs, like a heavy bag of groceries, and
- picking up a 5p coin from a table

3.B Reported changes in Motor skills

Table 3.B.1: Number of failures in motor skills in waves 1 to 5 from ELSA respondents aged 60 and older

Number of Motot skills	**Wave 1**		**Wave 2**		**Wave 3**		**Wave 4**		**Wave 5**	
0	2,423	36%	2,124	34%	2,055	35%	2,666	37%	2,759	37%
1	1,157	17%	1,041	17%	945	16%	1,124	16%	1,174	16%
2	714	10%	717	12%	672	11%	865	12%	798	11%
3	613	9%	517	8%	501	9%	578	8%	549	7%
4	458	7%	434	7%	371	6%	443	6%	420	6%
5	336	5%	351	6%	312	5%	367	5%	352	5%
6	284	4%	299	5%	244	4%	301	4%	322	4%
7	267	4%	234	4%	225	4%	263	4%	271	4%
8	230	3%	221	4%	184	3%	184	3%	208	3%
9	156	2%	141	2%	137	2%	117	2%	140	2%
10	57	1%	44	1%	48	1%	47	1%	66	1%
missing	125	2%	93	2%	165	3%	286	4%	372	5%
Total	6,820		6,216		5,861		7,241		7,431	

Table 3.B.1 shows the number of reported failures in motor skills. It shows that around 35% of ELSA respondents had reported no difficulty in motor skills, as opposed to 75% had reported no difficulty in ADLs. One thing to keep in mind while looking at these numbers is that motor skills are more specific skills, that requires flexibility and functionality of group of muscles and joints. This can explain why the number of self reported difficulties in motor skills are much higher than the number of self reported disability. While motor skills can give good indication of disability, it does not give any idea about the type of care needed. It is useful to look at motor skills as indicator of deterioration of health.

Table 3.B.2 shows high reported recoveries from difficulties in motor skills, and high deterioration. This is what we expected as the number of respondents who reported no difficulties in motor skills were much smaller. One reason could be the fact that motor skills are very specific tasks, which are possibly temporary. By looking into the number of changes in reported difficulties in motor skills amongst respondents whom reported at lease 1 difficulty in the given wave shown in table 12. The percentage of recovery from the respondents with at least 1 failure

Table 3.B.2: Changes in self-reported number of failures in motor skills for respondents aged 60 and older at beginning wave

Changes in Motor skills	W1 to W2		W2 to W3		W3 to W4		W4 to W5	
decrease	1,301	19%	1,334	21%	1,191	20%	1,384	19%
same	1,990	29%	1,998	32%	1,909	33%	2,591	36%
increase	1,755	26%	1,510	24%	1,426	24%	1,882	26%
institution	54	1%	8	0%	8	0%	10	0%
death	422	6%	292	5%	331	6%	374	5%
LTF	1,201	18%	929	15%	778	13%	691	10%
proxy	66	1%	105	2%	159	3%	243	3%
missing	31	0%	40	1%	57	1%	66	1%
Total	6,820		6,216		5,859		7,241	

in motor skills is around 30% while only 20% of all respondents had reported recovery. On the other hand, percentage of respondents reporting deterioration is the same amongst respondents with one failure in motor skills and the general sample.

Table 3.B.3: Changes in number of reported failures in motor skills for respondents aged 60 and older at beginning wave who had reported at least one failure in motor skills

Changes in	W1 to W2		W2 to W3		W3 to W4		W4 to W5	
Motor skills								
decrease	1,301	30%	1,334	33%	1,191	33%	1,384	32%
same	743	17%	770	19%	699	19%	910	21%
increase	1,093	26%	1,007	25%	943	26%	1,250	29%
institution	44	1%	7	0%	5	0%	2	0%
death	320	7%	218	5%	243	7%	261	6%
LTF	739	17%	586	15%	474	13%	387	9%
proxy	31	1%	57	1%	62	2%	77	2%
missing	1	0%	20	1%	22	1%	18	0%
Total	4,272		3,999		3,639		4,289	

3.C Results of models for sensitivity analysis

Table 3.C.1: Random effects cross-sectional logit regression models for improvements in ADLs - with motor skills at baseline as a confounder

Nu. of Observations	4172		3763		3763	
Nu. Of repondents	2643		2359		2359	
Log-likelihood	-2786.6352		-2559.1445		-2559	
Wald test	5599.3		5140.3		5141.6	
AIC	5681.6		5208.9		5216.4	
BIC						
Demographics						
Male						
Female	1.263***		1.124	0.097	1.119	0.112
	[1.103,	1.447]	[0.979	1.291]	[0.974	1.286]
Age	0.972***		0.986***		0.986***	
	[0.965,	0.980]	[0.978	0.994]	[0.978	0.994]
Motor skills						
1 or 2 failures						
3 or more failures	0.637***		0.663***		0.662***	
	[0.539	0.754]	[0.557	0.790]	[0.556	0.788]
Chronic conditions						
No conditions						
Pulmonary	0.830*	0.842	0.058	0.846	0.066	
	[0.700	0.985]	[0.705	1.006]	[0.708	1.011]
Neurological	0.459***		0.470***		0.471***	
	[0.303	0.694]	[0.306	0.721]	[0.307	0.723]
Stroke	0.764*	0.813	0.114	0.819	0.129	
	[0.598	0.975]	[0.628	1.051]	[0.633	1.060]
Number of comorbidities	0.913*		0.921	0.056	0.919	0.052
	[0.842	0.990]	[0.846	1.002]	[0.844	1.001]
Recent joint replacement						
No	-		-		referent	
Yes	-		-		1.109	0.406
	-		-		[0.869	1.416]
Health behaviour						
Smoking						
Never	referent	-	-			
Quitter	0.832*	-	-			
	[0.720	0.961]				
Smoker	0.824	0.063	-	-		
	[0.672	1.011]				
Alcohol consumption						
Teetotal						
Occasionally	1.223*		1.188	0.067	1.186	0.069
	[1.025	1.460]	[0.988	1.428]	[0.987	1.426]
Regularly	1.337***		1.229*		1.225*	
	[1.125	1.588]	[1.029	1.468]	[1.026	1.464]

Chapter 4

Onset of disability and mortality: results from the Medical Research Council Cognitive Functioning and Ageing Study I

Abstract

Disability affects older people lives by limiting their independence. The onset of disability may be used by insurance providers as a trigger for claims from long-term care insurance or as a trigger to increase payments from disability linked annuity. Understanding the impact of disability onset on mortality in older age is a key factor in planning for the funding of care needs. In this chapter, data from the Cognitive Functioning and Ageing Study I (CFAS I) is used to assess the relationship between the onset of disability in the Activities of Daily Living (ADLs), Instrumental Activities of Daily Living (IADLs), motor skills and subsequent mortality. Data from 8,827 subjects, who lived in household at baseline and responded to second wave interviews 2 years into the study, is used to estimate cox-proportional hazard models. The analysis presented uses number of ADLs to measure onset of disability. The analysis samples consisted of subjects who are disability free at baseline. The models controlled for sex, marital status, years in full-time education, occupational class, cardiac diseases, arthritis and health behaviour (smoking and alcohol drinking). At older ages, single divorced or widowed women have the highest rate of onset of disability. Onset of disability

in ADLs, IADLs and motor skills are significantly associated with mortality. The use of tighter definition of disability, increased statistical significance and stemmed higher hazard. In conclusion, gender differences in mortality may be a result of the differentials in experience of old age factors and events between men and women. Insurers may use the health events that prompted disability onset as proxy for gender pricing of a product that covers long-term care costs. Moreover, the results shown here adds to the evidence to support disability linked pension annuity.

4.1 Introduction

The pension freedom, introduced on April 2014 by the UK government, grants easier access to pension savings, which is an opportunity for insurers to introduce long-term care saving as an integral part of pensions annuity or as a disability linked annuity (DLA). The pension add-on allows the flexibility of switching between pension and long-term care benefits as the policyholder circumstances change (Kenny and Barnfield (2013)). Such product is based on the hypothesis that the onset of disability reduces life expectancy.

The onset of disability is the loss of ability to perform tasks that are necessary for maintaining person's independence (e.g. dressing including putting on socks and shoes). It is usually a result of chronic of acute condition (e.g. fracture or a stroke). Risk factors that cause onset of disability have been studied as determinants of mortality. Therefore, chronic conditions and multi-morbidities are seen responsible for the differential mortality patterns among disabled older people (e.g. Kattainen *et al.* (2004); Richardson *et al.* (2011)). On the other hand, fewer research has been exploring of the mortality associated with the onset of disability (Majer *et al.* (2011)). This paper aims to add an evidence to whether the onset of disability shortens older person life. Hence, the results of this paper would support the hypothesis that an older person in need for care at older age may live shorter than her/his non-disabled peers.

This paper aims to assess the hypothesis that the onset disability is a strong determinant of higher mortality among older adults. Data on 8,827 subjects from the Cognitive Functioning and Ageing Study I (CFAS I), who were disability free at baseline interview, and responded to interviews 2 years later, is used to assess the relationship between the onset of disability in the Activities of Daily Living (ADLs), Instrumental Activities of Daily Living (IADLs), motor skills and subsequent mortality. Cox proportional hazard models were estimated with disability as the main predictor and controlling for sex, marital status, years in full-time education, occupational class, cardiac diseases, arthritis and health behaviour (smoking and alcohol drinking).

This paper is organised as follows: section 4.2 provides literature review of studies that have examined the association between disability and mortality and distinguish the analysis on onset of disability and prevalent disability. Section 4.3 outlines the data, sample, variables and models used in the analysis. Descriptive statistics and modelling results are shown in section 4.4. Finally, discussion of the results, shortcomings of the modelling are outlined in section 4.5.

4.2 Onset of disability and mortality

The onset of disability might indicate health deterioration and vulnerability to life threatening conditions. This means that mortality might likely increase for older people after the onset of disability. Studies that investigated disability examined prevalence of disability Chan *et al.* (2012), or predictors of disability incidence Lang *et al.* (2007a); Clarke and Smith (2011), and did not examine mortality. Studies that examine what happens after the onset of disability have usually focused on deterioration, or recovery from disability (e.g. de Leon *et al.* (1997, 1999) and others), or examined death as a competing outcome to disability (e.g. Lamarca *et al.* (2003); Jagger *et al.* (2007)). There are studies that examined the relationship between the prevalence of disability and mortality, (e.g. Majer *et al.* (2011); Scott *et al.* (1997)). Other studies have examined the effect of using subjective health rating as confounders of disability prevalence on predicting morality Bernard *et al.* (1997); van den Brink *et al.* (2005). This section provides discussion of the literature on the relationship between disability and mortality contrasting the analysis presented in this paper from other studies that focused on the effects of disability prevalence, rather than onset, on mortality.

The Permanent Onderzoek LeefSituatie (Ongoing Population Survey;POLS) is an annual survey of 15,208 non-institutionalised people aged 55 and older in the Netherlands. POLS interviews took place between 2001 and 2006. Majer *et al.* (2011) used data from POLS to examine the mortality risk associated with disability. Data on mortality covered the period to 31 December 2007, and covariates of the analysis were measured only once at baseline. The study examined different measures of disability; severe disability indicators Activities of Daily Living (ADLs) and motor skills, and mild disability indicator used by the Organization for Economic Co-operation and Development (OECD). The severe disability indicators consisted of 5 ADLs (eating and drinking, dressing, washing hands and face, washing oneself completely, transfer from chair), and 5 motor skills (moving indoors, moving outdoors, walking stairs, transfer from bed, entering or leaving room). The mild disability indicators consisted of seven OECD measures (conversing, reading small letters, recognising faces, biting, carrying objects, walking 400 m, bending). Subject was considered disabled in ADLs, motor skills or in OECD if at least 1 item answered with major difficulty or not able to perform or only with help. The analysis of the relationship between disability and mortality controlled for lifestyle and sociodemographic risk factors (educational status, marital status, smoking status, and obesity), chronic diseases (diabetes, stroke, myocardial infarction or other severe heart disorder, any form of cancer, and diseases of the respiratory system), and other indicators of health status (self-rated health status and hospitalisation in the past year). Two separate sets of cox regression models for men and women were used to compare mortality risk of the disabled and the non-disabled. Age was used as the time-scale and the analysis was controlled for survey year to account for different cohorts. Moreover, the model included age- disability interaction. Disability measured by each of the three indicators ranked from most to least common were OECD disability, motor skills and ADLs. Mortality rates were highest among subjects with ADL disability, and lowest among subjects with OECD disability. Interaction between age and disability showed that the effect of disability on mortality decreased with age. Marital status, education, chronic conditions and smoking status in men and only chronic conditions and smoking status in women were significant control predictors of mortality. Men life expectancy was shortened by an average 10 years if they had disability in ADLs, motor skills or OECD disability. Women on the other hand had shortened life expectancy of 7.5 years if disabled in ADLs or motor skills, and only by 3.5 years if disabled in OEDC measure. The study approaches disability as a static process and measures prevalence of disability at baseline. The main issue to prevalence is that there is no distinction between recent and old disability. The higher mortality trends were partially explained by the confounding factors, particularly health factors, i.e. chronic conditions. Overall, the study does not answer the question on how the mortality experience differs after onset of disability.

The National Health Interview Survey Functional Health Supplement (NHIS-FHS) is part of National Health Interview Survey (NHIS), which was administered to 7,192 individuals, aged 65 and older living in household in the US, with death data available up to 31 December 1991. Scott *et al.* (1997) used data on 5,320 self-respondents to the NHIS-FHS (1986) to analyse the effect of ADLs and IADLs on mortality. The analysis excluded proxy responses (1,516) and non-white, non-black subjects (81 subjects). Subjects self-reported 13 ADL/IADL items bathing, dressing, moving from bed to chair, walking, toileting, preparing meals, shopping, doing heavy housework, doing light housework, going outside, managing money, using the telephone, and eating. Subjects were asked if they had difficulty with any of the 13 items and rated their difficulty on a 4 point scale (0 indicated no difficulty, 3 indicated inability to preform). ADL/IADL disability score was calculated by adding the score from each individual item. Cox-proportional hazard model for the effect of disability measured by ADL/IADL on mortality controlling for socio-demographics (ethnicity, age at interview, marital status, living alone, annual income, having a telephone in the residence, and educational level); and health status (self-rated health, BMI, and incontinence). Separate models were used for males and females. The results showed gender differences as men were more likely to be married than women do. More women lived alone, and at the end of the study there were more women still alive. Gender differences were seen in reported disability as more women reported disability, but men were more likely to report cognitive ADLs. The results of the proportional hazard models showed that the ADL/IADL disability scores are strong independent predictors of mortality. In women, ADL/IADL score, body mass index, age, and self-rated health predicted mortality. In men, ADL/IADL score, marital status, age, and self-rated health predicted mortality. Low body mass index was an important covariate in women, but not in men. Marital status was an important covariate in men. Self-rated health was significant for both men and women. Finally, the increase in mortality caused by disability decreased with age. The results indicate that a combined ADL/IADL scale, is predictive of mortality. The study measures prevalence of disability at baseline. This ignores when the disability was incurred and whether the non-disabled at baseline have incurred any disabilities later in life.

Other studies that focused on the confounding effect of subjective health rating include Bernard *et al.* (1997) which used data from the 1990 baseline of the National Survey of Self-Care and Ageing (NSSCA), and three years of follow-up mortality data, to examine the association between self-rated functional ability and mortality among older adults. NSSCA is a longitudinal survey of non-institutionalised Medicare beneficiaries in US who were 65 years and older in 1989. Baseline interview was conducted during autumn and winter 1990/91 with 3,485 subjects with approximately equal numbers in each of three age categories, 65-74, 75-84, and 85 and over, and equal number of men and women. Mortality data was traced up to 31 December 1993. The aim of the study was to examine if self-rated health prediction of mortality was explained by self-rated functional ability. Self-rated functional ability was measured by asking subjects to rate their independence on a 0 to 10 scale. This scale was categorised into four categories completely able (score 10, and reference group), mostly able (scores 8 or 9) somewhat able (scores 4 to 7), unable (scores 0 to 3). Additionally, subjects were asked if they had difficulties in performing 4 ADLs (eating, bathing, dressing, and maintaining continence), 4 motor skills (walking, getting in and out of bed, getting outside, and getting to the toilet), and 6 IADLs (managing money, using the telephone, shopping, preparing meals, doing light housework, and doing heavy housework). Disability for each item was rated as “no difficulty” performing any of the activities, “slight or mild” difficulty performing one or more of the activities, and “moderate or severe” difficulty in performing one or more of the activities. Other factors considered from the analysis were socio-demographic variables (age, race, household composition, gender, geographic residence, income, and education), chronic conditions (hypertension, coronary heart disease including angina and myocardial infarction, stroke, hip fracture, or cancer of any kind), assistance from others, self-care coping strategies (use of equipment, clothing, or devices e.g. cane), modifications in behaviour (e.g. avoiding stairs), and changing the environment (e.g. moving to residence with more services, moving items to lower shelves). Cox proportional hazard models were used to estimate the hazard associated with self-rated functional ability and with each of the confounders.

There was a confounding relationship between self-rated functional ability and self-rated health. This was seen in the reduction in hazard at the worst categories (i.e. poor self-rated health and scores 0 to 3 in self-rated functional ability) when comparing unadjusted models to the adjusted models. Receiving help in ADLs and self-care coping strategies did not have any confounding effect on self-rated functional ability. This suggest that their effect was explained in the reported disabilities. Both sever disability in IADLs and ADLs were strongly associated with increased mortality. On the other hand, disability in mobility activities were evidently associated with mortality. The study used baseline data on disability, and focused on subjective measures confounding effects rather than disability.

van den Brink *et al.* (2005) used date from the Finland, Italy and the Netherlands Elderly (FINE) study to examine the relationship between disability and mortality, adjusted for self-rated health and depressive symptoms. FINE study is a longitudinal study with baseline interview took place in 1985 and follow-up interviews in 1989, 1990, and 1991, respectively, with a mortality follow-up to 2000. FINE sample members were 2,285 men (716 from Finland, 887 from the Netherlands, and 682 from Italy) aged 65 to 85 in 1985. The study used data for 1,141 men aged 70 to 89 years who were interviewed in 1990 and had complete information on disability, self-rated health and depressive symptoms. Disability was measured in 6 ADLs (walking indoors, getting in and out of bed, using toilet, washing and bathing, dressing and undressing, and feeding oneself), 3 IADLs (preparing meals, doing light housework, and doing heavy housework), and 4 motor skills (moving outdoors, using stairs, walking 400 meters, and carrying a heavy object 100 meters). Disability was defined in ADLs, IADLs and motor skills as inability to perform at least one item within the each category separately. Furthermore, the three disability measures were grouped together in one scale: no disability, mild disability (IADLs only disability), moderate disability (IADLs and motor skills disability), and sever disability (IADLs, motor skills and ADLs disability). If someone reported disability in ADLs, they were included in the highest category regardless of whether they had reported motor skills or IADLs disability or not. The analysis controlled for self-rated health, Self-rating Depression Scale (SDS), chronic conditions (myocardial infarction, stroke, angina pectoris, heart failure, intermittent claudication, cancer, diabetes mellitus, and asthma and chronic obstructive pulmonary disease). Cox proportional hazards model was estimated to inspect the confounding effect of subjective health rating (i.e. self-rated health and SDS) on the relationship between severity of disability and mortality. The study did not distinguish between new and continuing disability. The Netherlands had the lowest prevalence of severe disability, majority of subjects in Finland did not rate themselves as healthy, and Italians had the highest prevalence of depression. Asthma and chronic obstructive pulmonary disease were more common in Italy compared to the other two countries, making prevalence of chronic conditions the highest in Italy. The proportional hazard model results show that severity of disability increased mortality hazard by 3 times the hazard for non-disabled. Severely disabled men were twice as likely to rate themselves as unhealthy as non-disabled men do. Depression was more common among the severely disabled men than the non-disabled men. Self-rated health and depression had confounding effect on disability, but the mortality hazard remained high for the severely disabled. The prevalence of chronic diseases have a very small confounding effect on disability prevalence, self-rated health, and depressive symptoms. Chronic disease and disability prevalence were both associated with mortality independently. Disability prevalence had a stronger association with mortality than self-rated health and depressive symptoms. The study was limited to men only, and the results might not apply for women. The geographical variation in disability, self-rated health and depression experiences might have influenced the results. There time spent in disability before the 1990 interview is not included.

Ramos *et al.* (2001) uses data on community-based older population in Brazil: the Epidemiologia do Idoso (EPIDOSO) Study. The EPIDOSO Study consisted of 2 interviews; baseline (between 12 December 1991, and 22 December 1992), and a 2-years follow-up (between 20 February 1994, and 31 May 31 1995). Subjects of EPIDOSO Study were aged 65 and older living in the district of Saude, Sao Paulo, Brazil. Baseline personal interviews collected information on sociodemographic characteristics, informal support, self-perception of health, presence of chronic disease, use of health services, dependence in ADLs, mental health status, and cognitive functioning. Disability was measured as the number of ADLs from 13 activities (shopping, using public transport, handling finances, taking medicines, walking a short distance, remaining continent, dressing, going to the toilet, grooming, cutting toe nails, bathing, eating, getting in and out of bed). Cognitive status was assessed using the Mini-Mental State Examination (MMSE). Follow-up interview was conducted by phone calls. The analysis investigated mortality of 1,667 older adults aged 65 and older living in household. Logistic regression model of ADLs disability and cognitive function at baseline as predictors of death adjusted for all other factors collected at baseline. Dependence in ADLs, measured by requiring help for at least seven of the 13 ADLs, was strongly associated with death. Those reporting dependence in ADLs had odds ratio nine times the rate of those who were totally independent. Gender and age were independent predictors of mortality. The risk of death was significantly higher for very old males (80 years). The age effect was reduced when controlled for other covariates, particularly chronic conditions. History of hospitalisation in the last 6 months before baseline increased the risk of death. Subjects highly dependent in ADLs, or had poor cognitive function had higher mortality than their counterparts had. No chronic health condition appeared as a significant risk factor for mortality. ADL scale and the MMSE, proved to be the strongest independent predictor of death, together with age and gender. The study has a very short follow-up (2 years only). Consequently, the effect of treatment of chronic conditions on disability is not observed and subsequently the effect on mortality experience in the long term is not represented in the analysis.

The Health Interview Survey of Barcelona (HISB) is a sample of 1,632 non-institutionalised people aged 65 and older in 1986 in the city of Barcelona. The interview in 1986 covered sociodemographic characteristics, self-perceived health, ADLs, health behaviours, chronic conditions, and health services use. RUIGÓMEZ *et al.* (1993) assessed disability in ADLs as predictors of mortality among 1,317 from HISB. Disability was measured by self-reported ability to perform nine ADLs (walking, grooming, sitting, bathing, using the toilet, dressing, eating, going up/down stairs, and going outside), and four IADLs (cooking, shopping, managing money or bills and using the telephone). Subjects were categories into dependent (unable to perform at least 1 activity), independent with difficulty (at least 1 difficulty), and independent (no difficulties). Dependence in ADLs and in LADLs were studied separately. Other variables used in the analysis included perceived health status, multi-morbidity, hospital admission in the previous year, living alone and other socio-demographic characteristics. Kaplan-Meier and cox proportional hazard regression models were examined across different disability levels in ADLs and IADLs. Majority of the sample reported independence in ADLs and IADLs at baseline. Women rated their health worse than men rate, more likely to report dependence in ADLs and IADLs, and less likely to have been admitted to hospital in the year before the interview than men have. Mortality was higher in men than in women. Older age (75+ years), living alone, low rated health, dependency in ADLs or IADLs, and hospital admission the year before interview all were significant predictors of higher mortality within the follow-up period. Being unmarried and reporting poor health were statistically associated with higher mortality among women, but not among men. Dependence in ADLs and IADLs increased mortality risk significantly among men and women, the risk for men being higher than that for women. The study shows that disability play a major role in predicting mortality of older people. The study does not follow-up on changes in ADL or IADL dependence as the subjects aged, and the estimated effects might not represent actual experience (e.g. subject who develop further disability or recover).

Last but not least, Lamarca *et al.* (2003) used data from the HISB to analyse the relationship between disability and mortality, while disability was allowed to change over the time of the study. The study estimated cox-proportional hazard model, with age as the time scale, using data from 1,294 subjects aged 65 and older living in household in Barcelona 1986. Disability was measured by asking subjects the level of difficulty (none, a little, moderate, and unable to perform without help) to carry out nine ADLs: walking, going up/down stairs, bathing, using the toilet, brushing hair/shaving, dressing, sitting, going outside, and eating. Subjects then were categorised based on their disability into: ADL independent, ADL difficulty (at least 1 difficulty, but not needing help), and ADL dependent (needing help in at least 1 ADL). To study the effect of changes in disability additional information on ADLs were collected retrospectively at the follow-up interview in 1993. Change of disability was defined as change of category (independent, with difficulty, dependent). Cox proportional hazard model was used to estimate the hazard from disability and changes in disability on mortality adjusting for gender, marital status, education level, living alone, self-rated health status, comorbidity, sleep hours per day, smoking status, alcohol intake, body mass index (BMI), chronic limitation of activity, and physical activity. Women reported high prevalence of dependence at baseline and at follow-up. Men reporting independence at baseline were more likely to stay independent at 8 years follow-up than women do. Recovery from being dependent was less likely among women than among men. Subjects reported difficulty in ADLs at baseline were more likely to report a change (independence or dependence) in the follow-up than to stay in the same category. Smoking habit, level of physical activity, body mass index, comorbidity, and chronic limitation of activity were strong predictors of mortality for men. Level of physical activity, chronic limitation, self-rated health status, and alcohol consumption were strong predictors of mortality for women. The study examines disability decline over age and provides basis for understanding the parallel relationship with mortality. The relative risk of mortality among ADL dependent subjects was decreasing over age when disability was allowed to change. In other words, oldest elders spend longer periods of severe disability than the young elders. Moreover, dependent subjects who remained dependent at follow-up had decreasing mortality. This might be a results of coping strategies or adaptation to the disability. Although the study accommodates for the effect of change in disability, and implicitly accounts for new disability, it does not investigate the influence of onset of disability. Changes in disability were observed retrospectively, hence changes in disability for those who died before follow up is missed. Death of the new disabled subjects at follow-up was not observed, and the mortality estimates were more dependent on the prevalent disability. Moreover, the changes of disability between the baseline and follow-up are not observed.

The literature focused on studies that examined disability and mortality in older age. The onset of disability as predictor of mortality has not been studied yet, as far to our knowledge. Although the literature presented was not directly comparable to the analysis presented in this paper, but it gives idea of what confounder could be used in the analysis. It also provides indicators on how the anticipated results should be.

The Medical Research Council Cognitive Functioning and Ageing Study I (MRC CFAS I) is longitudinal study of 13,004 persons aged 65 and older in England and Wales. CFAS I baseline was conducted in 1991 to identify cognitively frail subjects who were then followed up on biennial interviews. Mortality among CFAS I subjects was interest of research, but non of the published studies attempt to establish the relationship between disability and mortality. Mostly the studies examined other predictors of mortality, which are considered for confounding effect in the analysis presented in this paper (Xie *et al.* (2008b,a); Valenzuela *et al.* (2011)). All previous studies of mortality in CFAS I the models were adjusted for socio-demographic characteristics (age, gender, marital status, years of full time education, social class and Townsend deprivation score), ADLs, self-reported medical history (heart attack, stroke, diabetes, transient ischaemic attack, angina, intermittent claudication, depression and anxiety) and health related behaviour (medication use, and smoking history). Other studies controlled for other factors like level of cognitive impairment (Neale *et al.* (2001)) measured by MMSE, self-perceived health, type of accommodation, alcohol drinking (Richardson *et al.* (2011)), other health conditions (arthritis, asthma, bronchitis, epilepsy, Parkinson's disease, pernicious anaemia, stroke and thyroid problems).

The focus of this paper is to investigate the onset of ADLs disability as a predictor of mortality among individuals aged 65 and older living in England and Wales. This study adds to the literature on the relationship between disability, measured by difficulties in ADLs, and mortality.

4.3 Methods

4.3.1 Data

The Medical Research Council (MRC) Cognitive Function and Ageing Studies (CFAS) are longitudinal multicentre studies based on UK sample. There are two CFAS studies: CFAS I baseline took place between 1991/93 with subsequent interviews continues till 2008. The CFAS II baseline took place between 2008/11 with wave 2 interviews being conducted now. This paper focused on CFAS I. The baseline of CFAS I involved the interviews people aged 65 years and older in five geographical areas in England and Wales (Cambridgeshire, Gwynedd, Newcastle, Nottingham, and Oxford). The baseline interviews, took place between 1991 and 1994. They involved a two stage process with screening followed by diagnostic assessment to estimate prevalence of dementia. Two years later, the two stage screening and assessment took place on part of the sample. Those assessed for dementia were followed-up using biennial interviews till 2001. The technical details of the CFAS I study have been discussed in Brayne *et al.* (2006b, 1998) and are also available at the MRC CFAS web site (http://www.cfas.ac.uk/).

Data available are of 13,004 people aged over 65 years from all five centres. The initial sample, with equal number of respondents in age groups 65 to 74 and 75 and older, was biased toward the old. A second wave of screening and assessment, between 1993 and 1996, conducted on all those who were not screened at baseline assessment, was used to estimate incidence of dementia.

Although, MRC CFAS was primarily designed to study dementia, it also collected information on other disorders and ageing factors. This allows the use of CFAS in investigation of disability and other health conditions at older age.

The CFAS I study took the form of two waves (see figure 4.1). Both waves involved screening and assessment of cognitive function. The initial wave consisted of a screening interview ‘S0’, which was attempted on 13,004 individuals, followed by a more detailed assessment interview ‘A0’ on a 20% sub-sample of the respondents, biased towards the cognitively frail. 7,175 of the screened only respondent were interviewed again at wave two using the same two-phase technique, screening ‘S2’ followed by assessment ‘A2’ of a 20% sub-sample.

Subjects assessed on the initial wave were re-interviewed (i.e. gone through a combined screening and assessment ‘C2’) two years later. This was during the same period the second wave was taking place. This means that all subjects screened in wave 1 were seen again two years later. Subjects who have gone through any of the assessments were followed up on biennial basis on 1997/98 and 1999/2000, using a combined screening and assessment interviews ‘C6’ and ‘C8’. At the end of 10 years follow-up of 3,154 survivors, including subjects who were only screened in any of the two waves, were contacted for a final combined screening and assessment interview ‘C10’.

The interviews questions covered demographics including marital status and years in education, social economic group, social support, cognitive impairment (measured using Mini Mental State Examination (MMSE; Cockrell and Folstein (2002)) and AGECAT Copeland and Dewey (1991)), functional ability (ADL and IADL and the Townsend Activities of daily living score), on interview diagnosis of chronic diseases (including heart disease, cerebrovascular disease, Rose angina scale and intermittent claudication), motional problems (self-reported depression and anxiety), and self-perceived health.

The data available were version 9.0 release, and information on deaths, loss to follow-up and emigrations has been censored at 31 December 2008. The technical details of this study and the results of primary analyses have been published elsewhere (Brayne *et al.* (1998, 2006b,a)) and are also available at the MRC CFAS web site (http://www.cfas.ac.uk/)

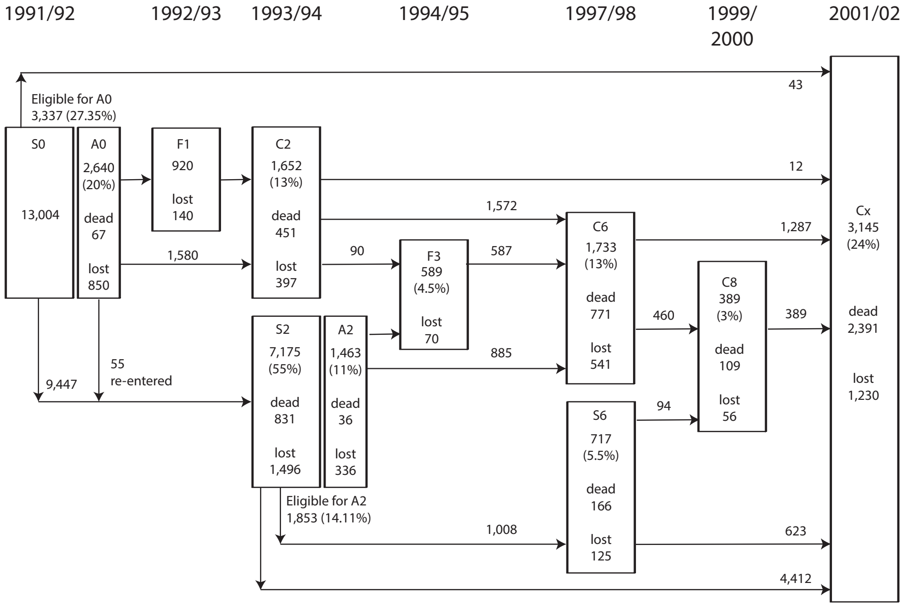


Figure 4.1: Timeline of the MRC CFAS interviews

Types of interviews:

Interviews are coded by a letter and a digit. The letter indicates the type of the interview, and the digit next to the letter denotes the number of years since baseline interview.

† S0 and S2 are screening interviews

† A0 and A2 are assessment interviews

† F1, C2, F3, C6, S6, C8 and Cx are combines screening and assessment follow-ups

4.3.2 Disability measures

The CFAS I questionnaires covered questions about difficulties in 10 activities: cutting toe-nails, washing all over or bath, get on bus, go up and downstairs, do heavy housework, shop and carry heavy bags, prepare or cook a hot meal, reach overhead shelf, tie a knot in a string, and put on shoes and socks. Subjects were asked to rate their difficulty in each of the activities based on three levels: no difficulty, some difficulty, and in need of help. Additionally, The interviewer reported the subject mobility (i.e if the subject is ambulant, housebound chairfast or bedfast). There was also a question about difficulties in using toilet. These activities were categorised into three groups: motor skills, activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Motor skills covered the activities of cutting own toenails, getting on a bus, going up/down stairs, reaching overhead shelf, and tying a knot in string. ADLs are washing and bathing, putting on shoes or socks, using the toilet and reported mobility (i.e ambulant, housebound chairfast or bedfast). IADLs are preparing a hot meal, shopping for groceries (carrying heavy bags), and doing housework.

The ADLs, are the activities essential for an independent life, while carrying out the IADL is more complex, requires a higher level of personal autonomy. These IADLs refer to tasks implying enough capacity as to make decisions as well as a greater interaction with the environment. Studies have shown that loss of independence or the difficulty in the IADL normally precede difficulties in the ADL (Judge *et al.* (1996)). Moreover, the definition of IADL impairment only group is subject to the gender bias (e.g. using a map Chang and Antes (1987); Brown *et al.* (1998)). Also, some IADL disabilities could be argued to be a result of not only by physical or mental limitation, but also by cultural expectations, environmental obstacles, or lack of motivation and training. For example, disability in cooking can be caused by a combination of weakness (e.g. after a stroke) and past experiences, e.g. a widower whose wife used to do the cooking (Boult *et al.* (1994)). Also, motors skills are difficulties that do not necessarily indicate a need for care. For example difficulties in getting on a bus, climbing stairs, reaching a shelf or tying a knot are indicators of weakening in limbs. The weakening might prevent the subject from performing those activities, but the subject might still be able to wash, dress and use the toilet.

4.3.3 Disability definitions

All 13,004 subjects screened at 'S0' were eligible to interview in 2 years time either in the second wave screening 'S2' or the 2 years follow-up at 'C2'. These three interviews were used to form the data used in the analysis presented in this paper. From the baseline sample, there were 1,349 deaths (10.37%) and 2,828 lost to follow-up (21.75%) before the interviews S2 and C2. The number of subjects interviewed in 2 years time was 8,827 (7,175 interviews in S2 and 1,652 in C2).

The analysis sample was restricted to disability free subjects at baseline. Moreover, the sample was based on the definition of disability used. Three definitions of physical disability were used based on the severity of the reported disability. The three definitions are:

Mild disability	at least difficulty in one of the 3 ADLs, or being housebound/ chairfast, or bedfast
Moderate disability	at least a need for help with one of the 3 ADLs, or being housebound/ chairfast, or bedfast
Sever disability	at least a need for help in one of the 3 ADLs and a difficulty in another ADL, or being housebound/ chairfast, or bedfast

4.3.4 Statistical analysis

The analysis focuses on the onset of disability reported 2 years after the baseline during the second wave interviews S2 and C2. The goal of the analysis is to demonstrated statistical evidence of the onset of disability as a predictor of mortality at old age. Cox proportional hazard model with age as the time scale, and using follow up death data of over 15 years from 1993 to 2008 is used. As previous longitudinal studies suggest that disability tends to be affected by factors that increase the vulnerability of older person, and events that could contribute to the onset of disability. Those factors and events are sought to act as control predictors of mortality.

The models estimated proportional hazard ratios, that tell how much the mortality hazard for a given respondent decrease or increase with a particular predictor. STATA 12 SE edition was used to estimate the proportional hazard model of risk of mortality due to disability status, controlling for the confounding variables. The dependent variable in the proportional hazards model is survival time; therefore, for the 6,294 subjects that died by December 2008, survival time was defined as the difference between age at death and age at first interview. Survival time for the remaining 2,533 was defined as the difference between age on 31 December 2008 and age at first interview. Results from these models are presented in terms of the hazard ratios along with their p-value and 95% confidence intervals.

Three definitions of disability were tested; mild, moderate and severe, as defined above. The models investigated age, sex, marital status, years in full-time education, occupational class, and whether respondent is living alone or with others, self-rated health, health risk diseases, and miscellaneous medical conditions, neuro-psychiatric diseases, recent major surgical operations, health behaviour (smoking and alcohol drinking) as predictors of mortality. All variables chosen a priori for investigation were included in the models. Stability of model parameter estimates and associated variances were investigated by re-fitting our final model each time removing a single covariate from all variables contained in the final model. Statistical significance was determined at $p<.05$ to maintain variables in the model.

Independent variables

Factors that are sought to influence mortality include demographic and socioeconomic information; age, sex, marital status, years in full-time education, occupational class, and whether respondent is living alone or with others, self-rated health, health risk diseases, and miscellaneous medical conditions, neuro-psychiatric diseases, recent major surgical operations, health behaviour (smoking and alcohol drinking).

Demographics were reported at initial screening. Marital status is split into married/cohabit or single/widowed. Occupational class is grouped into three categories: professional/ managerial, skilled non-manual/manual, and partly skilled/non-skilled with armed forces added to the professional category.

The subjects were asked if they have ever or recently been diagnosed with any of the health threatening diseases particularly stroke, heart attack, high blood pressure and diabetes. Other conditions; angina, intermittent claudication (peripheral vascular disease), and Parkinson's disease were diagnosed during the interview (following Rose (1962) diagnosis). Reported miscellaneous medical conditions included peptic ulcer disease, pernicious anaemia, thyroid disease, shingles and arthritis. Neuro-psychiatric diseases include epilepsy, head injury, Parkinson's disease (PD), regular headache, and meningitis/encephalitis. Subjects were asked whether they had any recent surgical operation. A dichotomous variable was created to reflect the presence or absence or the history (i.e. report at baseline) of each conditions. Total number of comorbidities was constructed to reflect the presence of multiple conditions together.

Questions about smoking history, current smoking habits and current alcohol drinking were reported only at initial interview, with no follow-up questions about change in smoking behaviour.

4.4 Results

MRC CFAS I initial wave had 13,004 successful interviews at the initial screening S0. Between the initial screening and the second wave of interviews there were 1,349 deaths and 2,828 lost to follow-up (refused interviews, changed address or lost contact). Total number of people interviewed in wave 2 was 8,827 (7,175 from S2 and 1,652 from C2).

Analysis of mortality after the onset of disability was carried out on three supsamples 6,587 , 7,531 and 7,984 dependent on definitions disability mild, moderate and sever consecutively. Those three samples consist of subjects who were not disabled at baseline S0. As shown in table 4.1, higher severity definition of disability, means less subjects are considered disabled. The three models carried out give an indication of at which severity of disability, ADL becomes a strong independent predictor of mortality.

Table 4.1 shows the sample characteristics of the three analysis sub-samples. The number and relative frequency (i.e. percentage) of subjects reporting onset of disability is smaller with tighter disability definition 18.40% reported disability using the mild definition, 10.26% reported under the moderate definition, and 6.30% reported under the sever definition. Women are as twice likely as men to report onset of disability. Furthermore, the gender differences are more persistent at older ages with more older women reporting onset of disability (see tables and figures in 4.A).

About 32% of the samples are married males, and 34% of the sample are single/widowed or divorced females. There are more than 22% of the sample who are married females, leaving slightly more than 11% of the sample single/widowed or divorced males. The gender differences is not observed in both education and social class. More than 60% of the sample have completed statutory education only (i.e. less than 9 years in full time education), and slightly more than 52% of sample retired from semi-skilled, non-skilled or manual jobs.

As the sample is restricted to subjects with no disability at the initial interview, as well as the exclusion of the subject living in nursing home, the analysis sample should be healthier than their peers. This is seen in the self-rated health, almost about 75% of the sample had reported a good or excellent health, leaving only 25% of the subjects rating their health as fair or bad.

Table 4.1: Analysis samples characteristics

Mild disability : 1 difficulty in ADLs, or being housebound/ chairfast, or bedfast

Moderate disability: 1 need for help in ADLs, or being housebound/ chairfast, or bedfast

Severe disability: 1 need for help + 1 difficulty in another ADL, or being housebound/ chairfast, or bedfast

	Mild				Moderate				Severe			
	Males		Females		Males		Females		Males		Females	
	2,944		3,643		3,216		4,315		3,364		4,620	
Disability												
ADLs												
No failures	2,442	82.95%	2,776	76.20%	2,893	89.96%	3,647	84.52%	3,116	92.63%	4,107	88.90%
1 or more	438	14.88%	774	21.25%	242	7.52%	531	12.31%	156	4.64%	347	7.51%
missing	64	2.17%	93	2.55%	81	2.52%	137	3.17%	92	2.73%	166	3.59%
Socio-demographics												
Marital Status												
Married/cohabit	2,192	74.46%	1,516	41.61%	2,363	73.48%	1,708	39.58%	2,473	73.51%	1785	38.64%
Single/widow/divorced	752	25.54%	2,127	58.39%	853	26.52%	2,607	60.42%	891	26.49%	2835	61.36%
Years in Education												
Statutory (less than 9 years)	1,792	60.87%	2,084	57.21%	1,974	61.38%	2,508	58.12%	2,075	61.68%	2,700	58.44%
10 years and more	1,145	38.89%	1,548	42.49%	1,235	38.40%	1,791	41.51%	1,280	38.05%	1,903	41.19%
missing	7	0.24%	11	0.30%	7	0.22%	16	0.37%	9	0.27%	17	0.37%
Occupational social class												
Professional/managerial/skilled	1,329	45.14%	1,756	48.20%	1,434	44.59%	2,028	47.00%	1,498	44.53%	2,152	46.58%
Semi-skilled/non-skilled/manual	1,604	54.48%	1,830	50.23%	1,770	55.04%	2,221	51.47%	1,853	55.08%	2,395	51.84%
missing	11	0.37%	57	1.56%	12	0.37%	66	1.53%	13	0.39%	73	1.58%
Health												
Self-rated health												
Excellent	729	24.76%	792	21.74%	756	23.51%	851	19.72%	773	22.98%	871	18.85%
Good	1,455	49.42%	1,927	52.90%	1,557	48.41%	2,228	51.63%	1,610	47.86%	2,343	50.71%
Fair	587	19.94%	738	20.26%	685	21.30%	961	22.27%	735	21.85%	1,068	23.12%

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	Mild				Moderate				Severe			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
Poor	111	3.77%	97	2.66%	138	4.29%	147	3.41%	155	4.61%	177	3.83%
missing	62	2.11%	89	2.44%	80	2.49%	128	2.97%	91	2.71%	161	3.48%
Life-threatening conditions												
Cardiac diseases												
Non	1,720	58.42%	2,095	57.51%	1,856	57.71%	2,412	55.90%	1,934	57.49%	2,547	55.13%
reported at wave 2	269	9.14%	393	10.79%	302	9.39%	468	10.85%	318	9.45%	506	10.95%
older than 2 years	911	30.94%	1,088	29.87%	1,003	31.19%	1,346	31.19%	1,050	31.21%	1,462	31.65%
missing	44	1.49%	67	1.84%	55	1.71%	89	2.06%	62	1.84%	105	2.27%
Diabetes												
Non	2,701	91.75%	3,374	92.62%	2,919	90.76%	3,958	91.73%	3,045	90.52%	4,209	91.10%
reported at wave 2	53	1.80%	46	1.26%	66	2.05%	61	1.41%	70	2.08%	68	1.47%
older than 2 years	131	4.45%	135	3.71%	159	4.94%	169	3.92%	168	4.99%	194	4.20%
missing	59	2.00%	88	2.42%	72	2.24%	127	2.94%	81	2.41%	149	3.23%
Angina												
Non	2,240	76.09%	2,941	80.73%	2,414	75.06%	3,389	78.54%	2,511	74.64%	3,563	77.12%
reported at wave 2	120	4.08%	148	4.06%	134	4.17%	187	4.33%	141	4.19%	202	4.37%
older than 2 years	521	17.70%	458	12.57%	587	18.25%	597	13.84%	622	18.49%	674	14.59%
missing	63	2.14%	96	2.64%	81	2.52%	142	3.29%	90	2.68%	181	3.92%
Intermittent Claudication												
Non	2,650	90.01%	3,330	91.41%	2,875	89.40%	3,895	90.27%	2,992	88.94%	4,124	89.26%
reported at wave 2	78	2.65%	100	2.74%	87	2.71%	112	2.60%	94	2.79%	130	2.81%
older than 2 years	139	4.72%	99	2.72%	157	4.88%	130	3.01%	164	4.88%	143	3.10%
missing	77	2.62%	114	3.13%	97	3.02%	178	4.13%	114	3.39%	223	4.83%
Arthritis												
Non	1,573	53.43%	1,479	40.60%	1,666	51.80%	1,634	37.87%	3,300	98.10%	1,718	37.19%
reported at wave 2	392	13.32%	563	15.45%	430	13.37%	658	15.25%	1,088	32.34%	448	9.70%
older than 2 years	937	31.83%	1,556	42.71%	1,068	33.21%	1,961	45.45%	3,029	90.04%	1,141	24.70%
missing	42	1.43%	45	1.24%	52	1.62%	62	1.44%	114	3.39%	57	1.23%
Miscellaneous medical conditions												

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	Mild				Moderate				Severe			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
Non	1,602	54.42%	1,701	46.69%	1,733	53.89%	1,983	45.96%	3,716	110.46%	1,793	38.81%
reported at wave 2	490	16.64%	772	21.19%	558	17.35%	952	22.06%	1,510	44.89%	599	12.97%
older than 2 years	837	28.43%	1,152	31.62%	907	28.20%	1,357	31.45%	2,264	67.30%	953	20.63%
missing	15	0.51%	18	0.49%	18	0.56%	23	0.53%	41	1.22%	19	0.41%
Neuro-psychiatric diseases												
Non	1,886	64.06%	2,373	65.14%	2,023	62.90%	2,737	63.43%	4,760	141.50%	2,096	45.37%
reported at wave 2	485	16.47%	787	21.60%	551	17.13%	988	22.90%	1,539	45.75%	589	12.75%
older than 2 years	536	18.21%	429	11.78%	597	18.56%	515	11.94%	1,112	33.06%	630	13.64%
missing	37	1.26%	54	1.48%	45	1.40%	75	1.74%	120	3.57%	49	1.06%
Number of comorbidities												
Non	1,611	54.72%	1,782	48.92%	1,728	53.73%	2,054	47.60%	3,782	112.43%	1,789	38.72%
1	658	22.35%	914	25.09%	709	22.05%	1,079	25.01%	1,788	53.15%	746	16.15%
2	366	12.43%	505	13.86%	407	12.66%	609	14.11%	1,016	30.20%	429	9.29%
3 or more	92	3.13%	204	5.60%	109	3.39%	255	5.91%	364	10.82%	117	2.53%
missing	217	7.37%	238	6.53%	263	8.18%	318	7.37%	581	17.27%	283	6.13%
Recent Surgery												
No	2,457	83.46%	3,122	85.70%	2,671	83.05%	3,668	85.01%	6,339	188.44%	2,784	60.26%
Yes	426	14.47%	430	11.80%	467	14.52%	516	11.96%	983	29.22%	492	10.65%
missing	61	2.07%	91	2.50%	78	2.43%	131	3.04%	209	6.21%	88	1.90%
Health related behaviour												
Smoking												
Never	415	14.10%	1,726	47.38%	446	13.87%	2,066	47.88%	2,512	74.67%	459	9.94%
Ex-smoker	1,826	62.02%	1,379	37.85%	2,001	62.22%	1,623	37.61%	3,624	107.73%	2,098	45.41%
Current smoker	702	23.85%	536	14.71%	768	23.88%	624	14.46%	1,392	41.38%	805	17.42%
missing	1	0.03%	2	0.05%	1	0.03%	2	0.05%	3	0.09%	2	0.04%
Alcohol drinking												
Abstinence	126	4.28%	476	13.07%	136	4.23%	574	13.30%	710	21.11%	143	3.10%
Drinking	2,817	95.69%	3,166	86.91%	3,079	95.74%	3,740	86.67%	6,819	202.71%	3,219	69.68%
missing	1	0.03%	1	0.03%	1	0.03%	1	0.02%	2	0.06%	2	0.04%

Life threatening conditions are reported at baseline and at second wave of interviews. Subjects were asked if they have ever been diagnosed at baseline and if they have been diagnosed recently (within last two years) at the second wave interviews. This allows the analysis to control for history of chronic conditions and the recent development of these condition. As the subjects of the CFAS were chosen to represent the frail old people, it is anticipated that the subjects would have high prevalence of chronic diseases associated with living with disability. The subjects have high prevalence of cardiac diseases 30% prevalence, Arthritis 40% and neuro-psychiatric 15% of the subjects. The sample had high onset of cardiac diseases 10%, Arthritis 15% and neuro-psychiatric 20%. This matches with the findings of Kattainen *et al.* (2004), that deaths form cardiac diseases are decreasing and life expectancy with cardiac disease is increasing. Moreover, Arthritis has been seen in other studies (Verbrugge (1992)) to have protective effect. This reflects the medical nature of arthritis being with moderate impact. Finally, the CFAS is aimed at frail old individuals, hence the subjects have high prevalence and onset of neuro-psychiatric conditions.

Diabetes is not very common among the subjects who responded to the CFAS interviews. It was prevalent in only 4% of the sample and only less than 1.5% were diagnosed with diabetes by wave 2. History of angina was reported in 14% of the subjects, and new cases were 4%. Subjects reported an onset of about 2.70% of intermittent claudication.

Miscellaneous medical conditions (include peptic ulcers, pernicious anaemia, thyroid and shingles) were common among the subjects (30% of the sample reported at baseline, and 20% reported at the second wave).

Slightly less than half of the females never smoked and about 37% had stopped smoking. On the other hand, more than 80% males were smoker, with about 23% still current smokers.

4.4.1 Proportional hazard model

Data for sub-samples of subjects with no disability at initial screening, who responded to wave 2 interviews of the MRC CFAS were used in the analysis. The sample sizes for the three divisions of disability were consecutively 6,291, 7,133 and 7,557. Mortality data for those subjects was available till December 31, 2008. The number of deaths from each sub-sample are 4,089 (65%), 4,772 (67%) and 5,127 (68%). There relative percentage of males deaths (slightly over 70%) is higher than females deaths (slightly over 60%) indicates that females live longer.

Disability in ADLs, IADLs and motor skills were strongly associated with mortality. When stricter definition of disability was used, the increase in mortality due to disability in ADLs, IADLs or motor skills was more statistically significant. Because of the hierarchical nature of the activities, motor skills and IADLs would usually be expected to influence ADL disability. Table 4.2 shows the results of the cox proportional hazard models fitted on the three sub-samples of the MRC CFAS. The results show strong significant association of the onset of disability and mortality. Mortality increased after the onset of disability controlling for socio-economics, old age health factors and health behaviours. The increase in mortality after onset of disability was higher in the sample using the sever disability definition, which agrees with the hypothesis that health deterioration accelerates death. The increase in mortality due to severe disability increased mortality by more than double the increase when using more relaxed disability definition (mild and moderate disability levels).

Gender is a strong independent predictor of mortality at old age, but this can be a result of the differentials in exposure to factors and events in old age between men and women. In the models, it is shown that women have between 40% lower mortality compared to men. On the other hand, marital status did not show any statistical significance in any of the three models.

Lower social class and being in education for less than the statutory years increased mortality very little. Although, both education and social class were statistically significant but the change in mortality is shown to be very low.

Both recent diagnosis of cardiac diseases (within last two years before interview) and history of cardiac diseases increased mortality significantly. Arthritis had the opposite effect on mortality. Recent diagnosis of arthritis reduced mortality by about 13%. These results blend well with the studies that suggest that heart problems usually speed up mortality and arthritis has a protective side.

Quitters had higher mortality compared to non-smokers (27% or 23% increase in mortality). Moreover, current smoking increase in mortality (80% and 76% increase in mortality) was notably high compared with ex-smokers.

Table 4.2: Estimated of mortality after the onse of disability

Mild disability : 1 difficulty in ADLs, or being housebound/ chairfast, or bedfast

Moderate disability: 1 need for help in ADLs, or being housebound/ chairfast, or bedfast

Severe disability: 1 need for help + 1 difficulty in another ADL, or being housebound/ chairfast, or bedfast

	Model 1			**Model 2**			**Model 3**		
	Mild disability			**Moderate disability**			**Severe disability**		
Nu. of subjects	6,291			7,133			7,557		
Nu. of deaths	4,089			4,772			5,127		
LR chi2	766			915			1,023		
L-likelihood	-30,422			-35,966			-38,800		
AIC	60,918			71,966			77,634		
BIC	61,033			72,083			77,752		
	HR	**p-value**	**95% CI**	**HR**	**p-value**	**95% CI**	**HR**	**p-value**	**95% CI**
ADLs									
No disability									
Disabled	1.123*	0.012	[1.026,1.229]	1.120*	0.028	[1.012,1.240]	1.431***	4E-10	[1.279,1.600]
IADLs									
No disability									
1 IADL difficulty	1.207***	0.00000324	[1.115,1.306]	1.223***	0.0000002	[1.134,1.319]	1.221***	0.0000002	[1.133,1.316]
need for help	1.449***	2E-11	[1.300,1.614]	1.464***	4E-14	[1.327,1.617]	1.440***	1E-13	[1.308,1.585]
Motor skills									

95% confidence intervals in brackets []

* p<0.05, ** p<0.01, *** p<0.001

d.f. = degrees of freedom

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	Model 1			**Model 2**			**Model 3**		
	Mild disability			**Moderate disability**			**Severe disability**		
No disability									
1 IADL difficulty	1.160***	0.0002	[1.072,1.256]	1.179***	0.00002	[1.093,1.272]	1.192***	0.000004	[1.106,1.285]
need for help	1.415***	0.000000001	[1.265,1.583]	1.439***	1E-12	[1.302,1.590]	1.426***	4E-13	[1.296,1.570]
Sex									
Male									
Female	0.600***	0	[0.558,0.645]	0.592***	0	[0.553,0.633]	0.593***	0	[0.556,0.633]
Marital status									
Married									
Single	1.038	0.28	[0.970,1.111]	1.04	0.221	[0.977,1.108]	1.048	0.135	[0.985,1.114]
Social class									
Professional/Managerial									
Semi-skilled/non-skilled	1.087*	0.015	[1.016,1.163]	1.118***	0.0004	[1.051,1.190]	1.119***	0.0003	[1.053,1.188]
Education									
Statutory									
10 years or more	0.926*	0.028	[0.864,0.992]	0.942	0.068	[0.884,1.004]	0.935*	0.032	[0.879,0.994]
Smoking									
Never									
Ex-smoker	1.274***	6E-10	[1.180,1.375]	1.237***	0.000000003	[1.153,1.328]	1.226***	0.000000004	[1.145,1.312]
Current smoker	1.806***	0	[1.644,1.983]	1.764***	0	[1.617,1.924]	1.760***	0	[1.618,1.915]
Cardiac disease									
No diagnosis									

95% confidence intervals in brackets []

* p<0.05, ** p<0.01, *** p<0.001

d.f. = degrees of freedom

Continued on next page

	Model 1			**Model 2**			**Model 3**		
	Mild disability			**Moderate disability**			**Severe disability**		
Recent diagnosis	1.218***	0.0002	[1.099,1.350]	1.192***	0.0003	[1.084,1.310]	1.181***	0.0004	[1.077,1.294]
History of disease	1.204***	0.0000001	[1.124,1.289]	1.214***	0.000000002	[1.140,1.293]	1.203***	0.000000003	[1.132,1.278]
Arthritis									
No diagnosis									
Recent diagnosis	0.862**	0.002	[0.786,0.945]	0.845***	0.0001	[0.775,0.921]	0.845***	0.00008	[0.777,0.918]
History of disease	0.935	0.058	[0.872,1.002]	0.923*	0.015	[0.866,0.985]	0.903**	0.001	[0.849,0.961]
Intermittent Claudication									
No diagnosis									
Recent diagnosis	1.207*	0.032	[1.016,1.433]	1.16	0.071	[0.987,1.363]	1.09	0.262	[0.937,1.269]
History of disease	1.175*	0.04	[1.008,1.370]	1.235**	0.003	[1.076,1.418]	1.174*	0.019	[1.027,1.341]

95% confidence intervals in brackets []

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

d.f. = degrees of freedom

4.5 Discussion

Physical disability is a state of restriction or incapacity in performing activities that are essential to daily living, such as bathing, dressing, and preparing food. It is usually the result of several factors acting over many years. The extent of a person's physical disability is determined both by the abilities that are compromised and by the degree to which they are compromised. Physical disability influences survival (Manton (1988)). It is also a major determinant of the need for supportive services, such as home care (Evashwick *et al.* (1984); Soldo and Manton (1985); Garber (1989)) and nursing home care (Branch and Jette (1982)). Mild limitation may require only occasional supportive services, e.g., weekly maid service for a person who is unable to do heavy housework. More severe limitation may require more intensive care, e.g., daily personal help for a person who is unable to prepare food or transfer from bed to chair.

This study attempts to identify the increase in the risk of death as result of the onset of disability controlling for the ageing process, and other confounders. The aim of the study was to assess the relationship between functional capacity measured by disability in the ADLs with subsequent mortality. Using age as the time scale provides the median age at death that was computed as a function of time since the onset of the elderly process (65 years). The analysis in this paper have a straightforward interpretation for a fixed covariate (e.g., gender), and time-varying covariate (e.g., disability). This is because the analysis avoids assumptions restricting linear hazard functions on age.

Previous studies have shown disability to predict mortality in short follow-ups (5 years in Majer *et al.* (2011), 3 years in Ramos *et al.* (2001) and 3 years in Bernard *et al.* (1997)). Our study shows that disability remains a significant predictor of mortality even in long term (15 years between 1993 and 2008).

The strengths of our study lie in the extremely high participation rate and the large number of deaths during the long follow-up. Selection bias of the cognitively impaired older adults, which occur because of the nature of CFAS, was avoided in our study by using second wave of interview where all subjects alive were approached for an interview. However, there were also some limitations. We obtained information on disability status only from one interview. Some longitudinal studies have demonstrated that a notable proportion of disabled persons may improve or recover full independence over time (Manton and Gu (2001); Anderson *et al.* (1998); Beckett *et al.* (1996)). Additionally, typically more diseases and disabilities might emerge over time. Thus, the relationship between disability and mortality could be weak in the long term of follow up as non-disabled subjects at the baseline become disabled later without being observed.

In the analysis, motor skills and IADLs remained significant even in the presence of ADLs disabilities. Bernard *et al.* (1997) investigated the three (motor skills, IADLs and ADLs) separate from each other and found an association between disability and mortality only for the IADLs and ADLs. Khokhar *et al.* (2001) showed that men with disabilities in ADLs and motor skills had a higher risk of mortality than men with disabilities in motor skills only.

Gender is an independent predictor of mortality. It is noted in several studies, that women live longer and retain moderate levels of disability for longer times. On the contrary men tend to develop episodes of severe disability, which lead to death at younger old ages. This has been seen in Manton (1988); Scott *et al.* (1997). Moreover, Scott *et al.* (1997) showed that marital status has been seen to increase mortality among men.

In the analysis presented here, it was shown that being female single/ widowed or divorced was associated with lower mortality. This to a limit matched with Scott *et al.* (1997) results. This suggest that women live longer, even while being disabled.

Self-rated health seem to be an independent predictor of mortality. Rating health as fair or poor increased mortality rate by 30% compared with rating health as excellent or good. This effect was prominent for all disability definitions and persisted in the separate gender models.

Although disability is assumed to reflect the impact of medical chronic conditions, these conditions might also act as a confounding factor in the association between disability and mortality. We therefore adjusted for the presence of chronic diseases in some analyses. Furthermore, all analyses were adjusted for age as the time scale. Cardiac diseases including coronary heart disease, stroke, or angina; and arthritis are the main categories of most common morbidities at old age (Manton (1989)). These disease groups have a high prevalence among older adults in general and were shown to impact the on disability in Manton (1989); Verbrugge (1992). Moreover, disability was shown to predict mortality among men with cardiovascular disease group (Kattainen *et al.* (2004)). This was shown in the separate gender models where males models showed higher increase in the risk of mortality from cardiac diseases and angina, and females models showed lower increase in mortality from history of cardiac diseases and not significance of angina as predictor of mortality. Parallel to that, arthritis which is known to produce a relatively slow pace of functional decline (Verbrugge (1992)). This reflects the medical nature of arthritis being with moderate impact. With adjustment for self-rated health and chronic conditions, disability was still a significant predictor of mortality. In accordance with earlier studies, self-rated health and chronic conditions, independent of disability, also were associated with mortality.

Disability, however, had a stronger association with mortality than chronic conditions in the present study. However, it is also possible that our classification of disability, captured the most crucial activities, and was a better predictor of mortality. Several methodological limitations of the present study must be taken into account. First, the fact that the time history of disability was assessed retrospectively may imply recall bias mainly due to erroneous recollection of when transitions between disability status took place. For instance, if most people over-reported the disability, the association between disability and mortality would have been underestimated. If the contrary, it would have been overestimated. Ideally, studies should contain repeated evaluations of ADLs to minimise this type of error.

One major limitation of this study is the use of baseline self-reported disability. Given that disability is a dynamic process at old age, that can deteriorate or improve with time. From a policy perspective, this study implies that the onset of disability accelerate death. Hence, shortens the life expectancy (or the life time) of a dependent person compared to independent peers. This means that the increase in spending on care is for shorter period than if the person stayed independent.

From insurance perspective, as gender pricing is not allowed. While gender is a significantly strong predictor of disability (hence needing care) and mortality at old age, a proxy for gender is needed for the pricing. This study adds to the evidence of identifying potential gender differentials in old age that can be used in the pricing of insurance products that supports long-term care funding.

Appendices

4.A Males mortality after onset of disability

Table 4.A.1: Cox proportional hazard models of mortality after onset of disability: Males

ADLs						
No disability	referent					
Disabled	1.123		1.289**		1.398***	
	[0.991	1.271]	[1.107	1.502]	[1.168	1.675]
IADLs						
No disability	referent					
Disabled	1.102		1.120*		1.123*	
	[0.996	1.219]	[1.020	1.230]	[1.026	1.228]
Social class						
Professional	referent					
Semi-skilled	1.099*		1.109*		1.109*	
	[1.006	1.200]	[1.020	1.207]	[1.021	1.204]
Self-rated						
Excellent/	referent					
Fair/	1.316***		1.268***		1.300***	
	[1.185	1.462]	[1.149	1.400]	[1.182	1.429]
Cardiac diseas						
Never	referent					
recent	1.286**		1.239**		1.251**	
	[1.103	1.499]	[1.073	1.431]	[1.088	1.440]
history	1.235***		1.233***		1.231***	
	[1.119	1.363]	[1.122	1.354]	[1.123	1.350]
Angina						
no	referent					
History	1.171**		1.205***		1.189**	
	[1.044	1.314]	[1.082	1.343]	[1.071	1.321]
Arthritis						
no	referent					
recent	0.892		0.896		0.899	
	[0.786	1.012]	[0.795	1.009]	[0.801	1.010]
Smoking						
Never	referent					
Quitter	1.297***		1.245***		1.222**	
	[1.131	1.488]	[1.093	1.417]	[1.076	1.389]
Current	1.738***		1.684***		1.683***	

Table 4.A.2: Cox proportional hazard models of mortality after onset of disability: Females

ADLs						
No disability	referent					
Disabled	1.152**		1.106		1.302***	
	[1.044	1.273]	[0.994	1.231]	[1.151	1.472]
Marital status						
Married	referent					
Single	0.836***		0.861***		0.855***	
	[0.762	0.918]	[0.791	0.938]	[0.787	0.929]
Education						
Statutory	referent					
10+ years	0.949		0.926		0.937	
	[0.869	1.037]	[0.855	1.003]	[0.867	1.011]
Self-rated health						
Excellent/ good	referent					
Fair/ poor	1.307***		1.304***		1.303***	
	[1.183	1.443]	[1.196	1.422]	[1.201	1.414]
Cardiac disease						
Never	referent					
history	1.112*		1.151***		1.137**	
	[1.014	1.220]	[1.060	1.250]	[1.051	1.231]
Diabetes						
Never	referent					
recent	1.525*		1.649***		1.527**	
	[1.104	2.108]	[1.251	2.174]	[1.176	1.984]
history	1.347**		1.380***		1.380***	
	[1.100	1.650]	[1.152	1.653]	[1.165	1.634]
Arthritis						
Never	referent					
recent	0.864*		0.851**		0.860**	
	[0.769	0.970]	[0.765	0.946]	[0.777	0.951]
Smoking						
Never	referent					
Quitter	1.281***		1.247***		1.241***	
	[1.165	1.410]	[1.145	1.359]	[1.143	1.347]
Current	2.091***		2.074***		2.063***	
	[1.840	2.376]	[1.846	2.331]	[1.842	2.309]

Chapter 5

Admission to care-home and mortality: results from the Medical Research Council Cognitive Functioning and Ageing Study I

Abstract

Long-term care insurance that covers care home costs seems very attractive, but entails uncertainty about the risks involved. Care home residents are vulnerable older people with severe cognitive functioning and/or physical difficulties. The factors that cause the need for care home admission may contribute to higher mortality among care home residents. There is a lack of research on the impact of care home admission on mortality in England and Wales. This chapter uses data from the Cognitive Functioning and Ageing Study I (CFAS I) to inspect the impact of care home admission on mortality. Data from 7,052 subjects who lived in household at baseline, and were followed up two years later, is used to estimate cox-proportional hazard models. The analysis uses care home admission as predictor of mortality, controlling for sex, occupational class, cardiac diseases, stroke, Activities of Daily Living (ADLs), cognitive functioning and smoking. Subject moved to care homes are more likely single or widowed female and with low cognitive score. 1 in 3 of subjects who moved to care homes were diagnosed with dementia in the assessment, and 1 in 6 had a recent stroke. Majority of subjects in care home suffered severe disability in IADL and motor skills, and at

least needed help in 1 ADL. Interaction terms between care home admission and other predictors (stroke, ADLs and cognitive score) were statistically significant. In conclusion, care home admission indicates increase in mortality hazard. Care home admission is reliant on disability, cognitive decline and chronic disease when used to predict mortality. Insurers that may consider offering different benefits according to residence should carry out stringent assessment of the claimant needs to avoid encouraging care home admission.

5.1 Introduction

There are 5,153 nursing homes and 12,525 residential homes in the UK hosting about half million elders aged 65+ (Office of National Statistics (ONS) (2014)). Care home costs form a burden on older persons in times of health deterioration. Insurance product that cover long-term care costs may recognise the costs associated living in care home that are not supported by the government and indemnify them partly or in full. Admission to care home could form an acceleration of death benefits in whole life insurance, or as an increase in annuity payments in disability linked annuity (DLA). Such a product will be based on the hypothesis that the life of older care home residents is shorter than their household peers. Population statistics suggests this theory. More than 20% of the elders aged 85+ live in care homes. Care home residents have a median life of 15 months on admission to care homes, and more than 75% of old people die within 3 years of admission (Oliver (2016)).

On the other hand, there is a lack of research on the mortality of older people in care homes. Although mortality in care homes is a frequent research question in the US, it has been rare in the UK because of data limitations. Health surveys and longitudinal studies either exclude care home residents (e.g. Health Survey of England), or did not follow them till death (e.g. the English Longitudinal Study of Ageing). The Medical Research Council: Cognitive Functioning and Ageing Study I (MRC CFAS I) is a longitudinal survey that interviewed individuals aged 65+ living in household and in care homes in England and Wales, and followed them up with subsequent interviews. CFAS provides the opportunity to examine mortality differences between care homes and household residents. This paper inspects the impact of care home admission on mortality, and adds to the evidence that care home admission is a strong predictor of shortened life. Due to data limitations, the analysis was restricted to subjects who showed no signs of dementia at baseline. The analysis uses data from 7,052 subjects who lived in household at baseline, and followed up two years later. Cox-proportional hazard models of mortality using care home admission as the main predictor controlling for sex, occupational class, cardiac diseases, stroke, Activities of Daily Living (ADLs), cognitive functioning and smoking was estimated.

This paper is organised as follows: section 5.2 discusses current literature on mortality among care home residents, mortality on admission to care home both in the UK and overseas (particularly the US). Followed by discussion of the data, sample and the models used in the analysis in section 5.3. Section 5.4 presents the descriptive statistics of the sample and results of the models. Finally discussion of the implication of the results on the design of insurance products is in section 5.5.

5.2 Mortality in care homes

The literature on mortality in the UK care homes is scarce. This was acknowledged by recent publications Shah *et al.* (2013); McCann *et al.* (2009) stating "Mortality in UK care homes is not well described.". The main reason for scarcity of literature on the mortality in care home is the difficulty of finding appropriate data. There is not any national data collection specific to care home residents in the UK (Moore and Hanratty (2013)). This is mainly because most of longitudinal studies that follow-up cohorts of older people but exclude care home residents at baseline or censor their data by not following subjects who moved into institutions, e.g. the first two waves of English Longitudinal Study of Ageing (ELSA, Steptoe *et al.* (2012)). Moreover, data collected from care homes resident are often collected through a proxy, e.g. the third and subsequent waves of ELSA. The literature presented in this section first discusses the available studies on mortality in UK care homes and then discusses international studies on care homes mortality.

Shah *et al.* (2013) identified care home subjects (residential and/or nursing) in The Health Improvement Network (THIN), a primary care medical records of general practices database in England and Wales, documents information on diagnosis, consultation and prescribing. The study compared mortality experience between care home and household residents; aged 65 and older registered in general practices on February 2009 with a 12 months follow-up period. The authors identified 9,772 care home residents and 354,306 household residents. The analysis estimated separated cox proportional hazard models to compare the mortality of care home and household resident adjusting for demographics, diagnosis and recent health care utilisation. The proportion of deaths among care home residents was much higher than among household residents. Nursing home residents had the higher 1 year mortality than residential care homes. The difference in mortality experience between care home and household residents and between nursing and residential care was persistent across age and gender. Diagnosis with dementia predicted high mortality rate, and its effect was higher among household residents than among care home residents. This was true for all other diagnoses (stroke, heart failure, asthma, and Parkinson's disease), except for cancer which had similar effect in both care home and household residents. Coronary heart disease (CHD) and diabetes were not significant predictors of mortality. High number of consultations and prescribed medications predicted higher mortality in both care home and household. Moreover, new general practice registrations in care homes had high mortality, which might indicate high mortality on admission. Overall, the study provides an evidence of high mortality in care homes compared with households. The mortality in care homes is not explained by age or diagnosis. Finally, primary care utilisation predicted mortality in both care home and household. Although this was the first England and Wales based study of mortality in care home, it did not identify dates of entry to care home. The cohort was identified cross-sectionally, and the follow-up was limited to 1 year. Moreover, THIN dataset does not include records of disability, e.g. Activities of Daily Living (ADLs).

McCann *et al.* (2009) but used The Northern Ireland Mortality Study (NIMS), a census-based longitudinal study of residents of nursing and residential homes in Northern Ireland in 2001 with six years follow-up. The analysis sample consisted of 9,072 residents of care homes in Northern Ireland at the time of the 2001 census, emphasising new admissions (i.e. all individuals with admission date within the 1 year preceding the census date). Characteristics collected during the census were age, sex, marital status and self-reported morbidity, limiting long-term illness and general health, living alone, relationship to co-residents if not alone and marital status. The analysis estimated cox proportional hazard models to examine admission to care home as a predictor of mortality, controlling for age, sex, marital status, general health and mental infirmity. Majority of care home residents were females, most of them had poorer health and diagnosed with a limiting long-term illness (LLTI). The 5 years mortality among care home residents was more than three times the mortality among household residents. Moreover, when adjusted for age and chronic conditions mortality in care homes was twice mortality in household. Experience differed by the type of care home.

Almost all nursing care residents had LLTI, but less proportion of people in residential care had LLTI. Residents of nursing care homes had the highest rate of mortality, followed by dual registration and residential care home residents had the lowest mortality. The median time-to-death among nursing care residents (admitted to in the previous year) was 2.33 years, compared to 2.75 years for dual registered care homes and 4.51 years for residential care home residents. Age and sex predicted higher mortality among care home residents. Their effect was more prominent among residential care homes than dual registration and nursing care. Self-rated health predicted higher mortality among household residents, but not in care homes. Being married had a protective effect for persons living in household. The analysis was limited to the demographics of the subjects, as data on diagnoses or disability were not available. Although the study is the first and the largest UK based study of mortality in care home, but it did not identify the date of entry to care home as the sample was extracted from census data. New entrants were identified using the question on address 1 year before the census day. Acute health conditions that precipitate care home admission are usually associated with very high mortality within the first few months. Hence, it is possible mortality was underestimated for new entrants if a big proportion of new admission died before the census date.

Raines and Wight (2002) compared the mortality experience of 841 individuals admitted to care homes between April 1993 and December 1997 from hospital (535 individuals) and from household (306 individuals) in Wakefield, England. The study focused on local authorities care homes and excluded private care homes for lack of data. Survival curves and standardised mortality ratios were used to compare between the sources of admission to care homes (hospital vs community). Results showed that the increased mortality in care homes was independent of the source of admission (hospital vs household). The main shortfall of this study is the lack of information about any health conditions that can predict earlier mortality.

Forder and Fernandez (2011) conducted a retrospective study of mortality in care homes. The study examined the length of staying in care homes run by

Bupa (one of the largest care home providers in England). The data used for this study were based on death record of 11,565 individuals who died between November 2008 and May 2010. The length of stay was measured as the time from admission until death. The sample was selected to represent the cognitively frail, demented, and self-funded elders living in Bupa's residential or nursing care homes. Estimated cox regression was used to model the length of stay in care homes (i.e. time-to-death) adjusting for age, sex, type of care home (residential/nursing), source of funding at death, physical impairment at death, frailty or dementia at death, and the geographical area of the care home. The results show that 1 in 4 individuals might live longer than 3 years in care home, and 1 in 10 might live longer than 6 years. The time-to-death from admission to care home is lower for older age and for men. Sex, age and type of care (residential vs nursing) are shown to be significant predictors of mortality in care homes. Persons in nursing care are likely to be more vulnerable than their peers in residential care. People in poorer areas had higher mortality than people in affluent areas. Living in nursing care was an indicator of more deterioration in health and earlier death compared to living in residential home. Non-ambulant individuals were more likely to die more than 18 months earlier than their ambulant peers were. Although this study takes account of several predictors of mortality in care homes, the predictors were all measured at the time death. While age on admission can be easily calculated, and sex would remain the same between admission and death, other factors will not. At the time of death, health might have worsened; individuals might have developed new chronic conditions, and higher levels disabilities, or moved to nursing care from residential care home. The predictors power are likely underestimated particularly for conditions that developed soon before death.

Dale *et al.* (2001) examined the admission characteristics as predictors of mortality in care homes (shortly after admission and in the long term). The study conducted retrospective mortality analysis on individuals who died in 59 care homes registered with Manchester Health Authority between 1 September 1994 and 31 August 1995. The study is retrospective as the characteristics on admission were collected at the time of death. The data covered date of birth, date of admission, date of death, gender, cause of death, marital status, placement immediately prior to admission, reason for admission, 12 ADLs (getting up or going to bed, washing, dressing, eating, household tasks, stairs, mobility, risk of falling, ability to transfer, administration of medication, urinary incontinence and faecal incontinence), and cognitive impairment. The study used cox proportional hazard model to examine the factors predicting the time between admission and death. One in five residents died in the first year after admission. Age on admission, gender, ADLs, cognitive function, number of drugs, appetite, placement before admission were all significant predictors of mortality. Poor cognitive function increased mortality hazard ten times. Admittance form hospice care increased mortality hazard nine times. Fluids only appetite was associated with four times higher mortality. To examine the factors affecting death in short periods after admission (one, two and four weeks, and three, six and twelve months) logistic regression analysis was estimated. Results of the logistic regression showed that cancer, pressure sores, number of drugs prescribed and appetite were strong predictors of death in the first four weeks. ADLs were more significant on longer periods (three, six and 12 months) than short periods. The analysis was based on information that were collected by a retrospective casenote with no contact with patients or their relatives.

Contrarily to the UK, The literature on mortality in the U.S. care homes is more diverse, thanks to the Minimum Data Set (MDS). The MDS is a 400 item standardised assessment for all residents in Medicare or Medicaid certified nursing homes. The MDS aimed to help nursing home staff identify health problems. The assessments are required within 14 days of admission to the care home, annually, and after a significant change in the resident status.

Several US based studies aimed at finding the predictors of mortality in care homes during the last 1-year or six months before death. While these studies look at mortality in care homes, they do not study the length of stay in care homes. For example, Porock *et al.* (2005) used MDS data from the State of Missouri to identify predictors of mortality in the 6 months before deaths in care homes. The study used a cohort of 43,510 individuals living in care homes in Missouri, the U.S. The data was retrieved from the MDS assessment on 1999. Data from MDS consisted of demographics (e.g., age, sex), diseases (e.g., cancer, chronic obstructive pulmonary disease, congestive heart failure), clinical signs and symptoms (pain, shortness of breath, weight loss, ADLs, cognitive function), and adverse events (e.g., falls, infections, hospitalizations, loss of a spouse). Disability was measured using seven ADLs; bed mobility, transfer between surfaces (e.g., bed to chair), locomotion on unit, dressing, eating, personal hygiene, and toilet use. The study used the 6-month MDS Mortality Risk Index (MMRI) algorithm to determine a resident's risk of dying within the next 6 months. Logistic regression analysis results were used as guidance in creating the 6-month MMRI an additive scale with weights. Logistic regression models were used to identify factors that predicted six months mortality from the assessment on 1999. The models were fit iteratively on 20 sub-samples and the results were used to rank predictors from demographics, diseases, clinical signs and symptoms and adverse events. One out of four residents died in the 6 months following their first full assessment on 1999. Being male, older age, recent admission to nursing home, ADLs dependence, short breath, cancer diagnosis, poor appetite, deteriorating conditions, weight loss, chronic heart failure, renal failure, low cognitive performance, Alzheimer's disease or dementia and dehydration were all found to be strong predictors of high mortality within six month. Moreover, two interactions between deteriorating condition and recent admission to nursing home, and cancer and younger age at admission were shown to be strong predictors of mortality.

Van Dijk *et al.* (2005) used data from the MDS assessment on 1999 to studied causes of 1-year mortality of a cohort of 43,510 individuals living care homes in Missouri, the U.S. A follow up of one year was used to determine the short-term predictors of mortality in care homes. The analysis followed similar procedures as described above. One out of three residents died in the year following the assessment on 1999. Two separate models for males and females were estimated, as males had higher mortality than females. The results showed that the top diseases associated with death for both males and females were renal failure, cancer, emphysema/chronic obstructive pulmonary disease (COPD), congestive heart failure, dysrhythmias, peripheral vascular disease, anaemia, and other cardiovascular diseases. The final logistic model controlled for male, age, cancer, cancer/age interaction, renal failure, heart failure, emphysema/chronic obstructive pulmonary disease, dementia, diabetes mellitus, anaemia and ADLs. All predictors in the logistic model predicted higher mortality significantly. Although the results from the MDS based studies are useful to identify predictors of mortality risk, the design and short follow-up are not relevant for the question presented here. Therefore, no further discussion of the MDS based studies.

Wolinsky *et al.* (1992) examined nursing home admission and subsequent mortality within 4 years of follow-up using data from the Longitudinal Study on Ageing (LSOA), a longitudinal survey of 5,151 Americans aged 70 and older living in household on 1984, who were followed up by phone or mail in 1986, 1988 and 1990. The baseline collected data on age, gender, race, living alone, owning a telephone, education, kin supports, non-kin supports, worrying about health, feeling control over health, private insurance, Medicaid card, residentially stable, Social Security dependence, self-perceived health, 4 ADLs (bathing, dressing, getting out of bed, and toileting), IADLs (managing money, in using the telephone, and in eating), motor skills, diagnosis with atherosclerosis, valvular heart disease, osteoporosis, fractured a hip, cerebrovascular disease, cancer, Alzheimer's disease, and Health Services Utilization. Two separate logistic regression models for admission to nursing care home, and subsequent mortality were estimated. Identification of care home admission happened at the time of follow-up interview, and there was no recording of date of admission to care home or date of death in care homes. The care home admission model results showed that older age, being White, living alone, owning a telephone, having less access to non-kin social supports, not feeling control over own future health, ADLs dependency, and hospital (or nursing home) placement during the year prior to baseline were associated with greater odds of admission to care homes in the follow-up. This analysis of mortality from care home was limited to 549 subject who moved to care home after the baseline interview. Predictors of mortality in care homes were older age, gender, not living in a multigenerational households, not worrying about own health, dependence in upper body limitations, history of valvular heart disease or cancer. Moreover, a logistic model that compares between mortality in hospitals after placement in care home and mortality in care homes was estimated. This model showed that younger individuals living in care home were more likely to be hospitalised before death if they did not live in multigenerational household before admission, and had more upper body limitations. Finally, comparison of mortality of household and nursing care subjects showed that admission to nursing care increased mortality more than double, which reflects the worsening of the health condition of the individuals placed in nursing care homes. The study captures the mortality after admission to care home, but the main limitation is that the date of admission is not known. Subjects who died in care home before follow-up were not identified. Although, results should not be generalised, but they can be used to support the analysis on possible causes of excess mortality in the UK care homes.

It could be argued that the factors that prompt entry to care home cause increase in mortality. The studies that investigated care home admission in the UK examined demographics (age, sex living alone), socioeconomic characteristics (social class, home ownership, access to kin and non-kin support, income, receiving benefits), ADLs, IADLs, motor skills, cognitive impairment, and health service utilisation. For example Hancock *et al.* (2002) studied the effect of the economic resources on the decision of admission to care home under the Long-Term Care financing system at the time of the study in 2002. The study used sample data extracted from general practice register in Melton Mowbray, Leicestershire. The sample was of individual aged 75 years and older on 31 December 1987. The survey took place in 1988 and follow-up assessment took place five years later. The study showed that older age, living alone, having difficulty in moving from chair, having cognitive impairment and reporting poor self-perceived health increased the risk of moving to care home. The main outcome of the study showed that ownership of the occupied house reduced the chances of taking the decision to move to care home.

O'Reilly and Connolly (2009) is another UK based study that examined the causes of admission to care homes in Northern Ireland. The study used data from the Data Retrieval in General Practice (DRGP) project in Northern Ireland, for a cohort of persons aged 65 and over living in household at baseline in 2000, and followed up for 5 years to identify entry to nursing or residential care home. The analysis controlled for the demographic, household composition and health characteristics of individuals. Factors associated with increase in risk of moving to care home were older age, being female, diagnosis with dementia and stroke. Living with others in the household reduced the risk significantly.

5.2.1 Mortality in MRC CFAS

The Medical Research Council Cognitive Functioning and Ageing Study I (MRC CFAS I) has been designed to follow subjects with dementia. The set-up of CFAS I design allowed interviews with subjects in care homes, and subjects who moved to care home during the follow-up. The main shortfall in CFAS is the lack of an indicator variable to identify care home admission at follow-ups. Predictors of mortality among CFAS subjects has received research attention. For example, self-rated health (Bond *et al.* (2006)), cognitive capacity (Neale *et al.* (2001)), and the use of medication (Richardson *et al.* (2011)). Moreover, some studies focused on mortality of a sub-sample of CFAS, e.g. the oldest old (Xie *et al.* (2008b)), and survival after onset of dementia (Xie *et al.* (2008a); Valenzuela *et al.* (2011)). The information collected in CFAS I interviews on demographics, socioeconomic characteristics, ADLs, multi-morbidities, and health behaviour have been used by studies of the predictors of mortality. Other studies also controlled for factors like level of cognitive impairment (Neale *et al.* (2001)) measured by MMSE, self-perceived health, type of accommodation, alcohol drinking (Richardson *et al.* (2011)), other health conditions (arthritis, asthma, bronchitis, epilepsy, Parkinson's disease, pernicious anaemia, stroke and thyroid problems) reported in CFAS I.

The focus of this paper is to contrast the mortality of subjects admitted to care homes and their peers who stayed in household among individuals aged 65 and older living in England and Wales. This study adds to the literature on the relationship between admission to care homes and mortality in the UK, particularly in England and Wales. This is the first longitudinal cohort study of the effect of admission to care home as independent predictor of mortality.

5.3 Methods

5.3.1 Data

The Cognitive Function and Ageing Studies I (CFAS I), discussed in chapter 6 section 6, is longitudinal multicentre study based on five centres in England and Wales. CFAS I baseline involved interviewing people aged 65 years and older between 1991 and 1994, and involved a two stage process with screening followed by diagnostic assessment to estimate prevalence of dementia. Two years later, the two stage screening and assessment took place on part of the sample. Those assessed for dementia were followed-up using biennial interviews till 2001.

Data available are of 13,004 people aged over 65 years from all five centres. The initial sample, with equal number of respondents in age groups '65 to 74' and '75 and older', was biased toward the old. Care home admission was identified using the second wave of screening between 1993 and 1996, which was conducted on all those who were not screened at baseline assessment.

CFAS I collected information on dementia and other disorders and ageing factors. The design of the CFAS data allowed the interview of subjects living in care homes. This supports the use of CFAS in the investigation of the effect of admission to care home on mortality at old ages subject to some data limitations which are discussed later.

13,004 subjects were interviewed in the initial screening (S0), leading to 3,557 subjects (27.35% of initial sample) identified as potential cases of dementia, hence qualifying them for an assessment interview. The remaining 9,447 healthier subjects (72.65% of the initial sample) were eligible for a second screening (S2) two years into the study, together with 55 who re-entered the study after being lost to follow-up in the initial assessment. The second screening resulted in 1,835 subjects (14.11% of the double screened sample) identified with cognitive deterioration, hence eligible for the second assessment interview.

Data from the study have been released in stages. Version 9.0 of the data has been used for this analysis and information from ONS for deaths, loss to follow-up and emigrations has been censored at 31 December 2008.

The screening interviews, considered for the analysis in this paper, included questions about demographics (e.g. age, sex, marital status and type of accommodation), socio-economic status (e.g. years in full-time education and social economic group), social support, cognitive impairment (measured using Mini Mental State Examination (MMSE; Cockrell and Folstein (2002)) and AGECAT Copeland and Dewey (1991)), functional ability (ADL and IADL and the Townsend Activities of daily living score), chronic diseases (including heart disease, cerebrovascular disease, Rose angina, stroke, diabetes, arthritis scale and intermittent claudication), miscellaneous medical problems, emotional problems (self-reported depression and anxiety), health related habits (smoking and drinking) and self-perceived health.

Identifying care-home admission

The CFAS I interviews included several variables indicating whether a subject lived in care home or in household. This section discusses the approach taken to identify subjects not in care homes at the baseline who had entered a care home by two year follow-up.

First, identifying subjects not in care home at baseline. This was straight forward as the baseline screening interview included a question on the type of accommodation. The question about the type of accommodation listed 6 categories house, flat, granny flat; warden controlled flat; council residential home; private residential home; private nursing home; and long stay hospital. These six categories were split into three major categories: subjects living in care-home (i.e. in any of the council residential home; private residential home; private nursing home), subjects living in household (house, flat, granny flat; warden controlled flat) or other (long stay hospital, other or missing). At baseline the sample was narrowed down to subjects who reported being in household (i.e. house, flat, granny flat; warden controlled flat).

Second, identifying admission to care home in subsequent interviews. There are three types of interviews; assessments, second screening, and follow-up interviews. In assessment and follow-up interviews an interviewer was asked to report whether the subject is in institution or not. Residential home, nursing home and long stay hospitals were all counted as institutions. The interviewer question was an administrative variable which was followed by a question about the subjects home address, or the address of institution where they lived. Cross tabulation of the interviewer report and the address variables showed inconsistency in the number of subjects in care home. Moreover, there is not enough information on the questionnaire documents or the MRC CFAS website to identify the reason for these differences. Follow-up interviews included a question about the date of admission to nursing home. Based on the questionnaire, the date of admission question was asked to all subjects who completed the given interview and lived in nursing care home at the time. It was not clear who responded to this question, and it had too many missing values. There was too much vagueness in these questions, and it was decided to discard them.

The last choice was to used the self-report type of accommodation which was reported in assessment interviews and the second screening. This question indicated clearly the type of accommodation and was asked to all subjects at a given interview. This suggests the reliability of the self-reported question.

It is not possible to identify entry to care home among subjects who responded to the first assessment interview. Those subjects were never screened again. Hence, there is no reliable variable to indicate if they were admitted to care home. The analysis in this paper is restricted to double screened subjects. The double screened subjects are those who were healthier at baseline. The second screening was only two years after the baseline screening. Hence, the number of subjects admitted from the double screened was small.

Sample

The analysis sample included all double screened subjects (i.e. subjects responded to S0 and were eligible to S2), who have self reported to be living in household at the initial screening ‘S0’. Total number of double screened subjects living in household at S0 is 9,276. Between the initial screening and the second screening there were 753 (8.12%) deaths. 1,471 (15.86%) were lost to follow up, i.e. refused to respond or left without way to contact them. The analysis sample used in this paper is restricted the 7,052 double screened subjects. Moreover, we compared the experience of the double screened subject and the 1,471 lost to follow-up who were eligible for a second screen.

5.3.2 Statistical Analysis

The analysis contrasts the mortality of subjects moved to care homes, household subjects. The preliminary analysis investigates the differences in survival between three categories of subjects; household, care home and lost to follow-up. This was achieved using Kaplan-Meier's. Then characteristics (demographics, socioeconomic status, medical conditions, impairment and physical disability) of the three subject categories are compared. The main analysis investigates the relationship between admission to care home and mortality at old age for over 17 years from 1991 to 2008.

Care home admission as an independent predictor of mortality was addressed controlling for other predictors. Admission to care home was identified using subject self-report of living in care home (residential or nursing) at the second screening. The analysis was restricted to subjects living in household at the initial screening. The models investigated second screening status (i.e. household, care home or lost to follow-up), age, sex, marital status, years in full-time education, occupational class, impairment (cognitive and physical), self-rated health, health risk diseases, and miscellaneous medical conditions, neuro-psychiatric diseases, recent major surgical operations, health behaviour (smoking and alcohol drinking) as predictors of mortality.

Three proportional hazard models were used to study the effect of admission to care home on mortality controlling for medical conditions and impairments measured at baseline. First model (model 1) used data from all subjects (household, care home and lost to follow-up), and controlled for medical conditions and physical conditions measured at initial screening. Second model (model 2) used data from double screened subjects (i.e. excludes lost to follow-up subjects), and controlled for medical conditions and impairment measured at first screening. The third model (model 3) uses the same sample as model 2, the difference is the use of the AGECAT score from second screening. Model 1 and 2 compare between the inclusion of subjects who are lost to follow up and excluding them. Models 2 and 3 compare between controlling for the AGECAT score measured at S2 and not.

All variables chosen at the beginning of investigation were included in the models. Model parameter estimates and associated variances were investigated by re-fitting our final model containing all covariates multiple times, each time removing a single covariate from all variables contained in the final model. Statistical significance was determined at $P < .05$ to maintain variables in the model. This was accomplished by using a Cox-proportional hazard models, with age as the underlying time scale. The models estimated proportional hazard ratios, that tell how much the mortality hazard for a given respondent decrease or increase with a particular predictor. STATA 12 SE edition was used to generate proportional hazards model estimates of risk of mortality due to admission to care home, controlling confounding variables. The dependent variable in the proportional hazards model is time to death. Time to death was measured from age at the initial screening to age at death or to 31 December 2008 whichever comes first. Results from these models are presented in terms of the hazard ratios along with their p-value and 95% confidence intervals.

A substantial number of care home subjects (31 out of 118, 26.27%) had missing data on physical disability and medical conditions through entering priority mode (i.e. shorter questionnaire that focused on cognitive impairment) in the second screening. When the models controlled for variabels measured in second screening the missing values are being removed from the analysis in the listwise deletion process. Hence, a fourth proportional hazard model was used to study the impact of using medical conditions and impairments measured at the second screening. It is important to appriciate that the number of subjects in care home included in the fourth model is reduced significanlty.

Independent variables

Factors that are sought to influence mortality include demographic and socioeconomic status; age, sex, marital status, years in full-time education, occupational class, and whether respondent is living alone or with others, self-rated health, health risk diseases, and miscellaneous medical conditions, neuro-psychiatric diseases, recent major surgical operations, health behaviour (smoking and alcohol drinking).

Demographics were reported at initial screening. Marital status is split into married/cohabit or single/widowed. Occupational class is grouped into three categories: professional/ managerial, skilled non-manual/manual, and partly skilled/non-skilled with armed forces added to the professional category.

The subjects were asked if they have ever or recently been diagnosed with any of the health threatening diseases particularly stroke, heart attack, high blood pressure and diabetes. Other conditions; angina, intermittent claudication (peripheral vascular disease), and Parkinson's disease were diagnosed during the interview (following Rose (1962) diagnosis). Reported miscellaneous medical conditions included peptic ulcer disease, pernicious anaemia, thyroid disease, shingles and arthritis. Neuro-psychiatric diseases include epilepsy, head injury, Parkinsons disease (PD), regular headache, and meningitis/encephalitis. Subjects were asked whether they had any recent surgical operation. A dichotomous variable was created to reflect the presence or absence of each conditions both at the initial and second screening to establish the influence of recent deterioration in health on mortality. A variable for the number of comorbidities was constructed to reflect the presence of multiple conditions together.

The development of disability (cognitive impairment or physical disability) precedes the admission to care home. Both screening interviews included cognitive functioning measures (MMSE and AGECAT), dementia diagnosis, and any difficulties in 11 activities with three levels of difficulty (no difficulty, some difficulty, and needs help) for each activity. The activities include: cutting toe-nails, washing all over or bath, get on bus, go up and downstairs, do heavy housework, shop and carry heavy bags, prepare or cook a hot meal, reach overhead shelf, tie a knot in a string, using the toilet and put on shoes and socks. Additionally, there is a question about mobility (i.e ambulant, housebound chairfast or bedfast).

For the purpose of the analysis the activities were classified into three groups motor skills, activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Motor skills activities are cutting own toenails, getting on a bus, going up/down stairs, reaching overhead shelf, and tying a knot in string. The ADLs include washing and bathing, putting on shoes or socks, using the toilet and reported mobility (i.e ambulant, housebound chairfast or bedfast). IADLs include preparing a hot meal, shopping for groceries (carrying heavy bags), and doing housework.

Questions about smoking history and current smoking habits were asked only at initial interview, with no follow-up questions about change in smoking behaviour. On the other hand, change alcohol drinking was reported at each interview.

Age as the timescale

The use of age as the time scale in time-to-death analysis is becoming a popular practice in modelling of the ageing process. As shown in Kom *et al.* (1997) proportional hazards regression models using age as the time-scale is an appropriate model of time to death in old age.

Age was used as the time variable, with age at the interview as the point of entry to observation and age at death or 31 December 2008, whichever comes first, as the point of exit from the study. In other words age was used to measure the time-to-death with the purpose of studying the association of care home admission with ageing, following Lamarca *et al.* (1998, 2003) methodology. Using this approach doesn't require adjustment for the confounding effect of age on mortality as it is directly accounted for. This allows conjecture about specific ages (e.g., the mortality will be based on an individual aged 70 years, and not of an individual who has spent 2 years in the study).

Finally, the left truncation resulting from late entries (i.e. subjects entering the study at age later than 65) and from those who died after age 65 and before the study started, is dealt by incorporating delayed entry in the proportional hazard model.

5.4 Results

The total double screen eligible subjects who lived in household at S0 was 9,250. Within two years 753 (8.14%) died and 1,471 (15.86%) were lost to follow up, i.e. refused to respond or moved from address. The remaining 7,000 (75.67%) have completed the second screening together with 52 household subject who re-entered after being lost from the initial assessment.

The total number of subjects eligible foe the analysis is 8,523 (6,934 (81.36%) household subjects, 118 (1.38%) care home subjects and 1,471 (17.26%) lost to follow-up subjects). Total number of deaths, in 17 years follow-up period up to 31 December 2008, was 5,912 (69.37% of the samples). Most of the subjects who moved to care home had died within the follow-up period (115 deaths, 97.46% of the care home subjects).

5.4.1 Diffences in mortality within the sample

The total number of subjects living in household at S0, who were eligible to a second screening is 9,276. Their death data were updated with the ONS and death dates available up to 31 December 2008. The total number of deaths observed is 5,912 (69.37%). The ratio of subjects died vary by the follow-up status at S2. The mortality differences between the three categories of follow-up status: household, lost to follow-up and moved to care home was investigated by conducting a survival analysis using Kaplan Meier's survival estimates with age as the time scale.

Table 5.1: Median age at death of subjects living in household at baseline, categorised by status at the second screening.

Second screening status	Number of subjects	% of total sample	Median age at death	IQ range of age at death	
MALES					
Household	2,963	31.94%	77.31	83.79	89.08
Care home	32	0.34%	69.60	72.01	74.49
Lost to follow-up	519	5.60%	75.93	81.74	87.26
Death before S2	400	4.31%	67.13	67.63	68.50
FEMALES					
Household	3,971	42.81%	81.77	87.78	92.82
Care home	86	0.93%	75.33	79.95	85.95
Lost to follow-up	952	10.26%	81.02	87.20	93.01
Death before S2	353	3.81%	65.83	65.83	67.53
ALL					
Household	6,934	74.75%	85.95	79.68	91.39
Care home	118	1.27%	74.49	70.64	81.86
Lost to follow-up	1,471	15.86%	85.04	78.54	90.92
Death before S2	753	8.12%	67.38	66.21	67.98
Total	9,276		83.86	76.77	89.96

Women are 57.81% of the sample and are more likely than men to report moving into care home. There are 86 females who reported admission to care home compared only 32 male subjects. The gender differences is persistent across all ages, which could be interpreted as a result of women living with disabilities longer than men. 25% of males who moved to care homes died within 1 year of the second screening interview, 50% died within 1 year and 4 months, and 75% died within 3 years and 5 months of the second screening. On the other hand, 25% of the females who moved to care homes died within 1 year and 4 months of the second sceeening, 50% within 2 years and 8 months 75% died within 6 years of the second screening interview. Gender differences were seen among subjects who were in household, but the difference decreased with age.

Table 5.1 shows the median ages at death and the interquartile range of age at death for the four subject categories. The median age did not change much between the household and the lost to follow-up subjects. There was a slight change in the interquartile change between the two categories. Males who have moved to care home had a reduced median age by 8 years (77 years for household vs 69 years for moved to care home subjects). Females lived longer than males, and the difference between care home and household was 7 years (82 for females in household vs 75 for females moved to care homes).

Figure 5.1 shows the Kaplan-Meier's survival curves for household against lost to follow-up (LTF) subjects. The survival curves show that mortality of those subjects who were lost to follow-up is not different from the mortality of the subjects stayed in household.

Figure 5.2 shows the survival curves for household against moved to care home subjects. Due to small number of care home subjects the graph shown is not broken by sex. The survival curve of subjects moved to care home starts at 70 mainly because the youngest subject move to care home aged 69 at the time of the interview. Subjects living in care homes were older at the time of the interview, and lived shorter than subjects stayed in household.

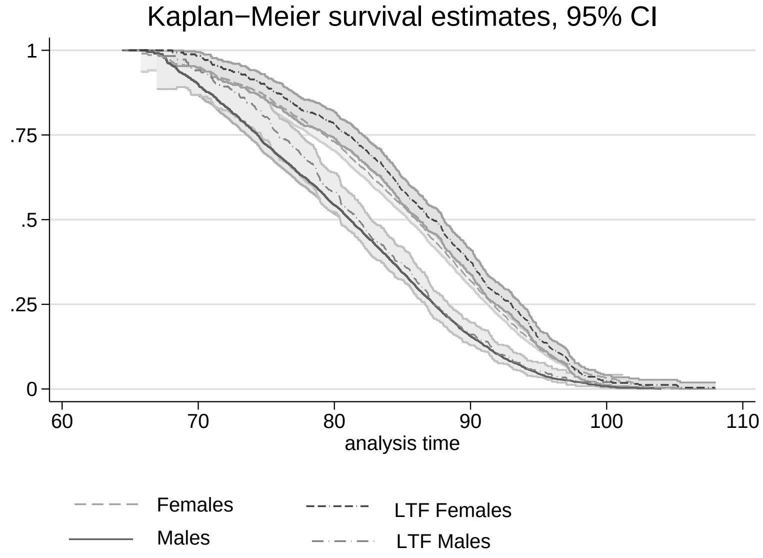

Figure 5.1: Comparison of survival of subjects observed again in CFAS and subjects lost to follow-up

5.4.2 Sample characteristics

The analysis sample consists of 8,523 subjects, of which 5,009 (58.77%) females and 3,514 (41.23%) males. Subjects moved to care home were older and more likely to be females. As shown in table 5.2, more than 35% of the sample are single/widowed or divorced females and more than 30% of the sample are married or cohabiting males. 23% of the sample are married females, and 10% are sinle/widowed or divorced males. Males in care homes are as twice as likely to be single, and females are more than 7 times likely to be single. This is likely because at older ages women seem to live longer than men. Moreover subjects who move to care home are more likely to need care if they live alone.

There is a very little difference between the household subjects, care-home subjects and lost to follow-up subjects in educational qualification and social class. More than 60% of the sample had statutory education, and more than 53% have semi/non-skilled occupations. This reflects the expectation of the diminishing effects of socioeconomics (particularly education and social class) on health. Moreover, the differences between subjects who moved to care home and

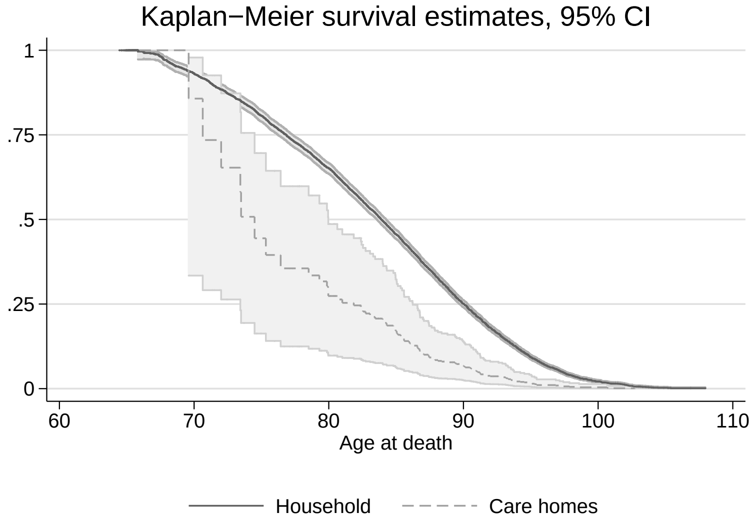

Figure 5.2: Comparison of subjects survival originally in care home, moved to care home and household subjects

subjects who stayed in household are small.

Cognitive functioning is a major factor affecting admission to care home. It is anticipated that low cognitive functioning (measured by MMSE or AGECAT) is more common among the subjects who moved to care home. Majority of the sample have scored well in the cognitive scores measured at S0 (96% of the sample scored well in the MMSE and more than 99% of the sample scored well in AGECAT). This is because the analysis is restricted to the double screened subjects, who were more cognitively sound at S0. When using cognitive measures at S2, the number of subjects showing low cognitive ability doubles (2% at S0 to 5% at S2 in the MMSE scores, 1% at S0 to 2% at S2 in the AGECAT scores). Moreover, two thirds of the subjects moved to care home scored low in MMSE, and one third scored worse on AGECAT. Half of the subjects who moved to care home are diagnosed with dementia.

Table 5.2: Demographics, Socioeconomics, Cognitive measures and Health behaviour characteristics of the sample (% are of the total sample)

	Household				**Nursing**				**Lost to follow-up**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
Married/cohabit	2,205	74.42%	1,553	39.11%	11	34.38%	10	11.63%	398	76.69%	400	42.02%
Single/widowed	758	25.58%	2,418	60.89%	21	65.63%	76	88.37%	121	23.31%	552	57.98%
Socioeconomics												
Education												
Statutory	1,807	60.99%	2,290	57.67%	25	78.13%	60	69.77%	342	65.90%	621	65.23%
10 years+	1,151	38.85%	1,667	41.98%	7	21.88%	26	30.23%	173	33.33%	324	34.03%
missing	5	0.17%	14	0.35%	-	-	-	-	4	0.77%	7	0.74%
Social Class												
Professional/Managerial	1,353	45.66%	1,895	47.72%	10	31.25%	32	37.21%	211	40.66%	427	44.85%
Semi/Non-skilled	1,599	53.97%	2,014	50.72%	22	68.75%	50	58.14%	305	58.77%	506	53.15%
missing	11	0.37%	62	1.56%	-	-	4	4.65%	3	0.58%	19	2.00%
Cognitive measures												
MMSE score at S0												
more than 21	2,909	98.18%	3,838	96.65%	28	87.50%	69	80.23%	500	96.34%	879	92.33%

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	Household				**Nursing**				**Lost to follow-up**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
low cognitive score	41	1.38%	112	2.82%	1	3.13%	14	16.28%	11	2.12%	52	5.46%
missing	13	0.44%	21	0.53%	3	9.38%	3	3.49%	8	1.54%	21	2.21%
MMSE score at S2												
more than 21	2,791	94.20%	3,609	90.88%	16	50.00%	23	26.74%	-	-	-	-
low cognitive score	129	4.35%	295	7.43%	12	37.50%	48	55.81%	-	-	-	-
missing	43	1.45%	67	1.69%	4	12.50%	15	17.44%	519	100.00%	952	100.00%
AGECAT score at S0												
less than 3	2,957	99.80%	3,962	99.77%	31	96.88%	80	93.02%	517	99.61%	947	99.47%
more than 3 (impaired)	6	0.20%	9	0.23%	1	3.13%	6	6.98%	2	0.39%	5	0.53%
AGECAT score at S2												
less than 3	2,896	97.74%	3,876	97.61%	17	53.13%	53	61.63%	-	-	-	-
more than 3 (impaired)	65	2.19%	90	2.27%	14	43.75%	31	36.05%	-	-	-	-
missing	2	0.07%	5	0.13%	1	3.13%	2	2.33%	519	100.00%	952	100.00%
Dementia		0.00%		0.00%		0.00%		0.00%		0.00%		0.00%
No diagnosis	2,911	98.25%	3,889	97.94%	22	68.75%	58	67.44%	-	-	-	-
Diagnosed	52	1.75%	82	2.06%	10	31.25%	28	32.56%	-	-	-	-
missing	-	-	-	-	-	-	-	-	519	100.00%	952	100.00%

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	Household				Nursing				Lost to follow-up			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
Health Behaviours												
Smoking												
Never smoked	413	13.94%	1,901	47.87%	4	12.50%	51	59.30%	74	14.26%	464	48.74%
Ex-smoker	1,864	62.91%	1,519	38.25%	20	62.50%	26	30.23%	297	57.23%	345	36.24%
Current smoker	677	22.85%	547	13.77%	8	25.00%	6	6.98%	143	27.55%	134	14.08%
missing	9	0.30%	4	0.10%	-	-	3	3.49%	5	0.96%	9	0.95%
Drinking												
No drinking	127	4.29%	519	13.07%	-	-	19	22.09%	36	6.94%	164	17.23%
Drinking	2,827	95.41%	3,448	86.83%	32	100.00%	64	74.42%	478	92.10%	778	81.72%
missing	9	0.30%	4	0.10%	-	-	3	3.49%	5	0.96%	10	1.05%

Household and care-home subjects had very little differences in health behaviours (both smoking and drinking habits). Majority of the sample are non-smoker females (28% of the sample), and ex-smokers (males 25% of the smaple, and females 22% of the sample). Females at care home were twice likely non-smokers to ex-smokers. Moreover, females in household or care-homes were more likely than males to be abstinent from alcohol. Most of the subjects drink alcohol (about 95% of males and 86% of females.)

The interviews cover several questions about daily activities whether basic activities of daily living, instrumental activities of daily living or motor skills. This covers 12 activities with three levels of difficulty (no difficulty, some difficulty, and in need for help) for each activity. The basic activities of daily living (ADL) include washing and bathing, putting on shoes or socks, using the toilet and reported mobility (i.e ambulant, housebound chairfast or bedfast). Other activities reported at the interviews, the instrumental activities of daily living (IADL) include preparing a hot meal, shopping for groceries (carrying heavy bags), and doing housework. Other activities reported at interviews were classified as motor skills. These activities are cutting own toenails, getting on a bus, going up/down stairs, reaching overhead shelf, and tying a knot in string.

Table 5.3 shows the disability profile of the sample. ADL disability is defined as having difficulty in at least 1 of the ADL or being chairfast or bedfast. IADL and motor skills disabilities were split into two levels, having difficulties only (at least 1 difficulty), and being in need for help in at least 1 activity. One third of the subjects moved to care home have reported at least a need for help in one ADL at the first screening, and the number increased to half of them in the second screening. This indicated the deterioration of physical abilities overtime. There are about two thirds of the subjects moved to care home reporting need for help in at least 1 IADL and 1 motor skill at the initial screening and the number stays similar for the second screening.

Table 5.3: Disaplity profile of the double screened sample (% of the total sample)

	Household				**Nursing**				**Lost to follow-up**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
At initial screening S0												
ADLs												
No disability	2,852	96.25%	3,729	93.91%	23	71.88%	57	66.28%	498	95.95%	879	92.33%
need for help in 1+	104	3.51%	239	6.02%	9	28.13%	27	31.40%	16	3.08%	65	6.83%
missing	7	0.24%	3	0.08%	-	-	2	2.33%	5	0.96%	8	0.84%
IADLs												
No disability	2,006	67.70%	1,870	47.09%	6	18.75%	10	11.63%	343	66.09%	449	47.16%
1+ difficulties	620	20.92%	1,216	30.62%	8	25.00%	18	20.93%	97	18.69%	279	29.31%
need for help in 1+	330	11.14%	882	22.21%	18	56.25%	56	65.12%	74	14.26%	216	22.69%
missing	7	0.24%	3	0.08%	-	-	2	2.33%	5	0.96%	8	0.84%
Motor skills												
No disability	1,832	61.83%	1,715	43.19%	4	12.50%	5	5.81%	312	60.12%	420	44.12%
1+ difficulties	883	29.80%	1,412	35.56%	10	31.25%	25	29.07%	155	29.87%	318	33.40%
need for help in 1+	241	8.13%	841	21.18%	18	56.25%	54	62.79%	47	9.06%	206	21.64%
missing	7	0.24%	3	0.08%	-	-	2	2.33%	5	0.96%	8	0.84%

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	Household				**Nursing**				**Lost to follow-up**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
At second screening S2												
ADLs												
No disability	2,754	92.95%	3,540	89.15%	8	25.00%	17	19.77%	-	-	-	-
need for help in 1+	186	6.28%	393	9.90%	14	43.75%	48	55.81%	-	-	-	-
missing	23	0.78%	38	0.96%	10	31.25%	21	24.42%	519	100.00%	952	100.00%
IADLs												
No disability	1,682	56.77%	1,301	32.76%	1	3.13%	1	1.16%	-	-	-	-
1+ difficulties	722	24.37%	1,318	33.19%	3	9.38%	5	5.81%	-	-	-	-
need for help in 1+	534	18.02%	1,313	33.06%	18	56.25%	58	67.44%	-	-	-	-
missing	25	0.84%	39	0.98%	10	31.25%	22	25.58%	519	100.00%	952	100.00%
Motor skills												
No disability	1,560	52.65%	1,319	33.22%	1	3.13%	2	2.33%	-	-	-	-
1+ difficulties	799	26.97%	1,143	28.78%	4	12.50%	4	4.65%	-	-	-	-
need for help in 1+	581	19.61%	1,471	37.04%	17	53.13%	59	68.60%	-	-	-	-
missing	23	0.78%	38	0.96%	10	31.25%	21	24.42%	519	100.00%	952	100.00%

ADLs, IADLs, and motor skills reported at second screening by subjects include 92 missing values (61 from households and 31 care home subjects). Those missing values are for subjects who switched to priorty mode interview (a shorter interview that focused on cognitive measures AGECAT and MMSE).

In the CFAS interviews subjects were asked to self-rate their health and if they were diagnosed with several health conditions. Those conditions asked include cardiac diseases (heart attack and high blood pressure), stroke, diabetes, angina, arthritis, miscellaneous conditions (intermittent claudication, peptic ulcers, anaemia, thyroid and shingles), and neurological conditions (including Parkinson's, epilepsy, head injury, headache, and meningitis). Moreover, subjects were asked about any recent surgery.

The subjects from care homes tended to have higher non-response rate. This can be explained by their low cognitive functioning and the use of priority mode in interviews at times where the subject was struggling. This is a result of the main aim of the CFAS is to study cognition and dementia.

There are 21% of the sample who are subjects at household and rated their health as fair or poor at the initial screening. The percentage increased in the second screening to 28% of the sample. Subjects living in care home were equally likely to rate their health as good/excellent or fair/poor in both initial and second screening. Bearing in mind that a big number of the subjects from care-homes (40%) didn't report any ratings, as shown in table 5.5.

Tables 5.4 and 5.5 show the medical characteristics and life threatening conditions reported in the initial screening and the second screening consecutively. Cardiac diseases (i.e. heart attack and high blood pressure) had a prevalence of 30% among the subjects and an onset of 10%. There were few subjects (less than 5% of the sample) reporting prevalence/onset of stroke or diabetes. Angina had a low onset at the second screening of about 4% ,but there are more than 15% of the subject who had been diagnosed Angina at the initial screening. Arthritis had the highest onset (about 15% of the sample), and half of the sample had history of arthritis reported at the initial screening. Arthritis has been seen in other studies (Verbrugge (1992)) to have protective effect. This reflects the moderate impact nature of arthritis as a medical condition.

Miscellaneous medical conditions (peptic ulcers, pernicious anaemia, thyroid and shingles) were prevalent in 41% of the sample at the initial screening. In two years time there were more than 98% of the sample with at least one of the miscellaneous conditions. There is no gender difference in the history or the incidence of those conditions. The same applies to the neuro-psychiatric conditions (Parkinson's, epilepsy, head injury, regular headache, meningitis and encephalitis), men and women were equally likely to have history of these conidtions. Finally, more women have reported comorbidities than men, and men are more likely to have had a surgical operation with the last two years before interview.

Medical conditions reported in the initial screening present the long-term conditions and in order of the highest to lowest prevalence the conditions are arthritis, cardiac diseases, angina, stroke and diabetes. Recent diagnosis (.i.e. diagnosis in the second screening) of medical conditions showed similar pattern of the frequency of medical conditions.

Arthritis and cardiac diseases are the most common long term health condition with 51% and 38% of the sample reported diagnosis on the initial screening. Moreover, 15% and 10% of the sample reported recent diagnosis in the second screening.

There is a very small number of subjects who moved to care home, and a big number of subjects from care-homes has not responded to questions about health conditions (31 out of 118 had missing values in the medical conditions). Acknowleding the given limitation, we could draw a subjective conclusion that the care home subjects were not differnt from the rest of the sample.

Table 5.4: Life threatening conditions and medical disagnosis reported at initial screening (% of the total sample)

	Household				**Nursing**				**Lost to follow-up**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
	Household				**Nursing**				**Lost to follow-up**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
Self-rated Health												
Excellent/Good	2,220	74.92%	2,849	71.75%	17	53.13%	40	46.51%	358	68.98%	658	69.12%
Fair/Poor	740	24.97%	1,119	28.18%	15	46.88%	46	53.49%	160	30.83%	289	30.36%
missing	3	0.10%	3	0.08%	-	-	-	-	1	0.19%	5	0.53%
Cardiac diseases												
No diagnosis	1,866	62.98%	2,417	60.87%	21	65.63%	50	58.14%	322	62.04%	567	59.56%
Diagnosed	1,093	36.89%	1,545	38.91%	11	34.38%	36	41.86%	196	37.76%	379	39.81%
missing	4	0.13%	9	0.23%	-	-	-	-	1	0.19%	6	0.63%
Stroke												
No diagnosis	2,769	93.45%	3,779	95.16%	29	90.63%	75	87.21%	496	95.57%	906	95.17%
Diagnosed	190	6.41%	186	4.68%	2	6.25%	11	12.79%	22	4.24%	40	4.20%
missing	4	0.13%	6	0.15%	1	3.13%	-	-	1	0.19%	6	0.63%

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	Household				**Nursing**				**Lost to follow-up**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
Diabetes												
No diagnosis	2,782	93.89%	3,774	95.04%	27	84.38%	80	93.02%	486	93.64%	911	95.69%
Diagnosed	177	5.97%	190	4.78%	5	15.63%	5	5.81%	31	5.97%	35	3.68%
missing	4	0.13%	7	0.18%	-	-	1	1.16%	2	0.39%	6	0.63%
Angina												
No diagnosis	2,413	81.44%	3,371	84.89%	25	78.13%	69	80.23%	425	81.89%	821	86.24%
Diagnosed	535	18.06%	578	14.56%	7	21.88%	15	17.44%	93	17.92%	124	13.03%
missing	15	0.51%	22	0.55%	-	-	2	2.33%	1	0.19%	7	0.74%
Arthritis												
No diagnosis	1,712	57.78%	1,668	42.00%	17	53.13%	29	33.72%	300	57.80%	416	43.70%
Diagnosed	1,246	42.05%	2,298	57.87%	15	46.88%	56	65.12%	217	41.81%	530	55.67%
missing	5	0.17%	5	0.13%	-	-	1	1.16%	2	0.39%	6	0.63%
Miscellaneous												
No diagnosis	1,819	61.39%	2,226	56.06%	21	65.63%	51	59.30%	323	62.24%	541	56.83%
Diagnosed	1,140	38.47%	1,740	43.82%	11	34.38%	35	40.70%	195	37.57%	405	42.54%
missing	4	0.13%	5	0.13%	-	-	-	-	1	0.19%	6	0.63%
Neurological												

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	Household				Nursing				Lost to follow-up			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	2,963		3,971		32		86		519		952	
No diagnosis	2,220	74.92%	3,145	79.20%	25	78.13%	59	68.60%	386	74.37%	760	79.83%
Diagnosed	739	24.94%	820	20.65%	7	21.88%	26	30.23%	131	25.24%	186	19.54%
missing	4	0.13%	6	0.15%	0	0.00%	1	1.16%	2	0.39%	6	0.63%
Recent surgery												
No	613	20.69%	731	18.41%	7	21.88%	14	16.28%	138	26.59%	232	24.37%
Yes	2,344	79.11%	3,235	81.47%	25	78.13%	71	82.56%	379	73.03%	714	75.00%
missing	6	0.20%	5	0.13%	-	-	1	1.16%	2	0.39%	6	0.63%

Table 5.5: Life threatening conditions and medical diagnosis reported at second screening (% of the total sample)

	Household				**Nursing**			
	Males		**Females**		**Males**		**Females**	
	2,963		3,971		32		86	
Self-rated Health								
Excellent/Good	2,115	71.38%	2,773	69.83%	12	37.50%	33	38.37%
Fair/Poor	831	28.05%	1,167	29.39%	14	43.75%	32	37.21%
missing	17	0.57%	31	0.78%	6	18.75%	21	24.42%
Cardiac diseases								
No diagnosis	2,655	89.61%	3,512	88.44%	22	68.75%	56	65.12%
Diagnosed	285	9.62%	422	10.63%	2	6.25%	13	15.12%
missing	23	0.78%	37	0.93%	8	25.00%	17	19.77%
Stroke								
No diagnosis	2,840	95.85%	3,843	96.78%	22	68.75%	59	68.60%
Diagnosed	103	3.48%	92	2.32%	3	9.38%	10	11.63%
missing	20	0.67%	36	0.91%	7	21.88%	17	19.77%
Diabetes								
No diagnosis	2,888	97.47%	3,883	97.78%	23	71.88%	68	79.07%
Diagnosed	55	1.86%	54	1.36%	2	6.25%	1	1.16%

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	Household				Nursing			
	Males		Females		Males		Females	
	2,963		3,971		32		86	
missing	20	0.67%	34	0.86%	7	21.88%	17	19.77%
Angina								
No diagnosis	2,810	94.84%	3,760	94.69%	23	71.88%	65	75.58%
Diagnosed	127	4.29%	168	4.23%	1	3.13%	5	5.81%
missing	26	0.88%	43	1.08%	8	25.00%	16	18.60%
Arthritis								
No diagnosis	2,540	85.72%	3,313	83.43%	17	53.13%	62	72.09%
Diagnosed	402	13.57%	623	15.69%	6	18.75%	5	5.81%
missing	21	0.71%	35	0.88%	9	28.13%	19	22.09%
Miscellaneous								
No diagnosis	15	0.51%	23	0.58%	2	6.25%	2	2.33%
Diagnosed	2,930	98.89%	3,915	98.59%	23	71.88%	68	79.07%
missing	18	0.61%	33	0.83%	7	21.88%	16	18.60%
Neurological								
No diagnosis	2,724	91.93%	3,473	87.46%	20	62.50%	56	65.12%
Diagnosed	219	7.39%	464	11.68%	4	12.50%	13	15.12%
missing	20	0.67%	34	0.86%	8	25.00%	17	19.77%

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	Household				**Nursing**			
	Males		**Females**		**Males**		**Females**	
	2,963		3,971		32		86	
Recent surgery								
No	2,471	83.40%	3,403	85.70%	19	59.38%	59	68.60%
Yes	472	15.93%	533	13.42%	4	12.50%	10	11.63%
missing	20	0.67%	35	0.88%	9	28.13%	17	19.77%

5.4.3 Proportional hazard models

Data for the analysis sample of subjects living in household at initial screening, who were eligible to the second screen of the MRC CFAS were used in the analysis. The sample size is 8,523 (7,052 double screened subjects and 1,471 were lost to follow-up). Subjects moved to care home between the two screening interviews were 118. Mortality data for all subjects was available till December 31, 2008. The number of deaths 5,912 (4,762 - 68.68% of household subjects, 115 - 97.46% of care home subjects, and 1,035 - 70.36% of lost to follow-up subjects).

Admission to care home is an independent predictor of mortality. In the current sample, the author fitted a single variable cox-proportional hazard model. It showed that mortality for subjects who moved to care home is 65.75% (with confidence interval 37.62% to 99.65% increase in mortality) higher than subject living in household. When controlling for marital status and sex, being in care home showed similar increase in mortality. Moreover, single females living in care home had more than 40% higher mortality married females. The marital status does not have any significant effect on mortality of males living in care home.

Three proportional hazard models were used to investigate the influence of admission to care home on mortality controlling for demographics, socioeconomic factors, cognitive functioning, health conditions, and health related behaviours. Model 1 and model 2 compare between the inclusion of the lost-to-follow (LTF) subjects and excluding them. Model 2 and model 3 compare between the controlling for cognitive impairment measured by AGECAT score at S2, and excluding AGECAT score. Tables 5.6 shows the results of the three models. The results show strong significant association of the admission to care-homes and mortality, which is stronger when controlling for AGECAT score in model 3. Care home subjects had a statistically significant increase of 58.9% in mortality rate compared to household subjects. This increase changed slightly to 58% when lost-to-follow up subjects were excluded in model 2. In model 3 controlling for AGECAT score showed increase in care home mortality to 80.5% higher than mortality of household subjects.

In models 1 and 2, the only interaction that was significant was the care home admission with being diagnosed with stroke at baseline. Subjects diagnosed with stroke had about 25% higher mortality if they were in household in the second screening. In model 3 cognitive impairment and physical disability were the statistically significant interactions with care home admission. Subjects with cognitive impairment (measured by AGECAT score) living in household have increased mortality risk of 50.10% compared to 55.79% for those living in care homes. Physical disability increased mortality risk among the household subjects by 52.10% and among the care home subjects by 94.92%.

As anticipated, the three models showed increase in mortality is strongly predicted by characteristics like being male, being from a semi/non-skilled occupational class, having disability and cognitive impairment, and being a current smoker. Moreover, mortality is increased by events like being diagnosed with cardiac disease or stroke. Subjects who have cardiac disease are more vulnerable to get a stroke, which was reflected in the fact that those with stroke had as twice the increase in mortality as subjects who reported diagnosis of cardiac diseases.

Tables 5.7 shows the results of the fourth cox proportional hazard model using the double screened sample. Although the number of care home subjects remained in the model after the stepwise deletion process is 78 (out of 118 subjects), we can draw an idea of the predictors of mortality in care home. The model controls for onset of cardiac disease, stroke and physical disability reported in the second screening. The results show weak significance of the association of the onset of cardiac disease on mortality. It showed also that mortality is not affected significantly by reported recovery from physical disability. The increase of mortality risk in care home, was slightly increased by adding the new control variables, but with increased width of the 95% confidence interval. This is mainly due to the reduced number of subjects included in the model.

In short, sex is a strong independent predictor of mortality at old age, but this can be a result of the differentials in exposure to factors and events in old age between men and women. In the models, it is shown that women have about 30% lower mortality compared to men. Both recent diagnosis of cardiac diseases (within last two years before interview) and history of cardiac diseases increased mortality significantly. Ex-smokers had higher mortality compared to non-smokers (about 25% or more increase in mortality). Moreover, current smoking increased mortality by about 90%,

Table 5.6: Cox proportional hazard model time to death controlling for variables measured at baseline

	Model 1			**Model 2**			**Model 3**		
	Household, care home and LTF			**Household and care home only**			**Household and care home only**		
Number of subject	8,393			6,954			6,944		
Care-home subjects	110			110			107		
Number of deaths	5,816			4,805			4,795		
LR chi2	822			682			703		
Log likelihood	-45,293			-36,547			-36,456		
AIC	90,609			73,112			72,933		
BIC	90,686			73,173			73,008		
	HR	**p-value**	**95% CI**	**HR**	**p-value**	**95% CI**	**HR**	**p-value**	**95% CI**
Care home status at S2									
In Household		*referrent*			*referrent*			*referrent*	
In care home	1.589***	0.00001	[1.294,1.951]	1.580***	0.00001	[1.286,1.942]	1.805***	0.0001	[1.338,2.434]
Lost to follow-up	1.068	0.0646	[0.996,1.146]	-	-	-	-	-	-
Sex									
Male		*referrent*			*referrent*			*referrent*	
Female	0.687***	0	[0.649,0.727]	0.696***	0	[0.654,0.740]	0.697***	0	[0.655,0.741]
Occupational class									
Professional/ Managerial		*referrent*			*referrent*			*referrent*	
Semi/non-skilled	1.151***	0.0000001	[1.093,1.213]	1.164***	0.0000002	[1.100,1.233]	1.158***	0.0000005	[1.094,1.227]
Life threatening conditions									
Cardiac diseases									

95% confidence intervals in brackets []

* p<0.05, ** p<0.01, *** p<0.001

d.f. = degrees of freedom

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	Model 1			Model 2			Model 3		
	Household, care home and LTF			**Household and care home only**			**Household and care home only**		
No diagnosis	*referrent*			*referrent*			*referrent*		
Diagnosed at S0	1.267***	0	[1.201,1.336]	1.290***	0	[1.217,1.367]	1.291***	0	[1.218,1.369]
Stroke									
No report	*referrent*			*referrent*			*referrent*		
Reported stroke at S0	1.518***	1.33E-12	[1.353,1.704]	1.520***	1.51E-12	[1.353,1.707]	1.483***	1.97E-11	[1.322,1.664]
Interaction with care home status									
reported stroke & in care home	0.520*	0.0437	[0.276,0.982]	0.519*	0.0429	[0.275,0.979]	-	-	-
reported stroke & lTF	0.767	0.0845	[0.567,1.037]	-	-	-	-	-	-
Disabilty									
Physical disability									
No disability	*referrent*			*referrent*			*referrent*		
needs help in 1 ADL +	1.499***	0	[1.364,1.647]	1.478***	3.9E-13	[1.330,1.643]	1.501***	2.16E-13	[1.347,1.673]
Interaction with care home status									
Disabled & in Care home	-	-	-	-	-	-	0.575**	0.008	[0.381,0.867]
AGECAT score									
less than 3	-	-	-	-	-	-	*referrent*		
more than or equal 3 (impaired)	-	-	-	-	-	-	1.521***	0.0000008	[1.288,1.795]
Interaction with care home status									
cognitively impaired & in care home	-	-	-	-	-	-	0.71	0.117	[0.462,1.089]
Smoking									
Non-smoker	*referrent*			*referrent*			*referrent*		
Ex-smoker	1.246***	8.19E-12	[1.170,1.327]	1.244***	7.65E-10	[1.161,1.334]	1.250***	3.69E-10	[1.165,1.340]
Current smoker	1.926***	0	[1.780,2.084]	1.935***	0	[1.773,2.113]	1.943***	0	[1.780,2.122]

95% confidence intervals in brackets []

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

d.f. = degrees of freedom

Table 5.7: Cox proportional hazard models of time to death controlling for variables measured on admission to care home

Number of subject	6,851			**LR chi2**	762		
Care-home subjects	78			**Log likelihood**	-35,733		
Number of deaths	4,709			**AIC**	71,503		
				BIC	71,626		
	HR	**p-value**	**95% CI**		**HR**	**p-value**	**95% CI**
Care home status at S2							
In Household		referrent					
In care home	1.813**	0.00998	[1.153,2.850]				
Sex				**Disabilty**			
Male		referrent		**Physical disability**			
Female	0.688***	0	[0.646,0.732]	No disability		referrent	
Occupational class				Reported disability in S2	1.580***	2.22E-16	[1.416,1.763]
Professional/ Managerial		referrent		Reported recovery in S2	1.264	0.0832	[0.970,1.649]
Semi/non-skilled	1.151***	0.000002	[1.086,1.219]	Reported in S0 and S2	1.673***	0	[1.484,1.887]
Life threatening conditions				**Interaction with care home status**			
Cardiac diseases				Reported disability in S2	0.56	0.0601	[0.306,1.025]

95% confidence intervals in brackets []

* p<0.05, ** p<0.01, *** p<0.001

d.f. = degrees of freedom

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	HR	**p-value**	**95% CI**		**HR**	**p-value**	**95% CI**
No diagnosis		referrent		Reported recovery in S2	0.229	0.155	[0.0298,1.751]
Diagnosed recently	1.095	0.222	[0.947,1.265]	Reported in S0 and S2	0.462*	0.01	[0.256,0.832]
Diagnosed before S0	1.260***	6.05E-13	[1.184,1.342]	**AGECAT score**			
Early diagnosis & recent report	1.402***	2.04E-08	[1.246,1.578]	less than 3		referrent	
Stroke				more than or equal 3 (impaired)	1.327**	0.00142	[1.115,1.578]
No diagnosis		referrent		**Smoking**			
Diagnosed recently	1.280**	0.008	[1.067,1.536]	Non-smoker		referrent	
Diagnosed before S0	1.369***	0.000001	[1.205,1.554]	Ex-smoker	1.254***	-3.03E-10	[1.168,1.345]
Early diagnosis & recent report	1.910***	0.000003	[1.456,2.506]	Current smoker	1.923***	0	[1.760,2.102]

95% confidence intervals in brackets []

* p<0.05, ** p<0.01, *** p<0.001

d.f. = degrees of freedom

5.5 Discussion

Mortality in care homes in the UK has not received enough research attention because of the unavailability of data that follow-up on subjects who live in care homes. There are some published studied that looked at the length of stay in care home retrospectively (Forder and Fernandez (2011)), and the short term mortality in care homes (Shah *et al.* (2013)). Moreover, there is a population census based study, but was outside England (McCann *et al.* (2009)).

Admission to care home in old age is the result of several demographic and socioeconomic factors together with the medical conditions that form part of the ageing process. Those factors and events contribute to the loss of function which lead to the person requiring help in the basic activities of daily living. Cognitive impairment and physical disabilities are among the main reasons individuals decide it is time to move to a care home, plus the loss of partner or the unavailability of close relative carer.

In this paper, we aim to add to the current literature on mortality in care homes. This will form part of the guidance to the insurance firms in their path to emerge a market for funding long-term care. As care homes are the most expensive form of care provided at old age, a key funding driver is the length of stay in care homes. Studies have shown that care home admission is associated with short term increase in mortality (most of the studies showed that more half of the individuals admitted to care home died withing 1 year of admission, and about 25% live as long as 3 years). There has been little attention paid to the full length of stay in care home. In this paper we study care home admission as an independent predictor of long-term mortality controlling for other predictors. Although, life threatening medical conditions are major contributors to accelerated mortality in old age, it has not been possible to include them in the current model presented in this paper. This was due the nature the MRC CFAS, as subjected were entered a priority mode that focused on measuring cognitive functioning. This should not be a problem as other studies (e.g. Porock *et al.* (2005); McCann *et al.* (2009)) have shown that people with dementia are more likely to enter a nursing home because of problems in behavior, wandering, and incontinence rather than through loss of function due to serious medical illness such as cancer or heart disease. Therefore, life threatening conditions might lose their predictability of mortality in care home to cognitive impairment.

Physical disability and cognitive impairment are major contributors to the decision of admission to care homes, and hence they contribute to the mortality in care homes. To understand the interaction between cognitive impairment and care home admission, the median and interquartile range of age at death was computed. Subjects who had cognitive impairment died 10 years younger than people with good cognition, and subjects in care home with cognitive impairment died 17 years younger than subjects in household with good cognition. Half of the subjects in care home with cognitive impairment died at the age of 69, and half of the subjects in care home with good cognition died at the age of 79, and half of the subjects who lived in household and had good cognitive function lived beyond age 86. Physical disability decreased median age at death by 7 years regardless of whether the subject had moved to care home or stayed in household by the time of the second screening.

There are several limitations to the current study. The main one is the inability to identify admissions to care home except for the healthier subjects at baseline who were eligible to a second screening and were admitted between the two screening interviews. Follow-ups in the MRC CFAS study did not include a clear identification of the care home subjects. The available variables contradicted each other and we ended up with small number of subjects in care home which should be acknowledged before any generalising of the results. Moreover, we obtained information on disability status and medical conditions only from one interview. Longitudinal studies have demonstrated that disability is changing over time (Manton and Gu (2001); Anderson *et al.* (1998); Beckett *et al.* (1996)). Additionally, typical more diseases and disabilities might emerge over time. Thus, the relationship between disability, medical conditions, care home admission and mortality could be weak in the long time of follow up as non-disabled subjects at the baseline become disabled later and get admitted to care home without being observed.

From a policy perspective, this study implies that the onset of cognitive impairment accompanied by admission to care home accelerate death significantly. Hence, shortens the life expectancy (or the life time) of a dependent person compared to independent peers. This means that the increase in spending on care is for shorter period than if the person stayed independent.

From insurance perspective, while the market has been struggling to emerge with new products that support the older people at the time of distress when it is difficult to make sound financial decision. The analysis presented here adds to the fertile soil of the discussion and debate on factors and life events at old age that can be used in the pricing of insurance products that supports long-term care funding.

Chapter 6

Care costs in the United Kingdom, development of insurance solution

6.1 Summary of findings

In this thesis, data from two English surveys are used to analyse risks that instigate the need for care in older age. Data from English Longitudinal Study of Ageing (ELSA), were used to answer two fundamental questions on mortality, and disability dynamics at older age. The data were used to estimate Cox proportional hazards models using two alternative approaches. The mortality question focused on whether the prediction of mortality improves with close monitoring of health conditions, and disabilities in ADLs in older age. Initially the baseline values of the predictors were used in the model. This corresponds to the likely situation for insurance companies when they set premiums. Subsequently the value of predictors, such as disability levels, were allowed to change over time in a second model. Death was the primary outcome of interest and institutionalisation was a competing risk. The predictors used in the models were demographics (age, sex and marital status), socioeconomic status (educational qualification and social class), health related behaviour (smoking and alcohol consumption), and self-reported health (motor skills, activities of daily living, and instrumental activities of daily living). The results showed that mortality hazard from life threatening diseases, and disability was significant higher when predictors were allowed to change over time. Moreover, health inequality was more prominent when changes in health conditions and disability levels were observed in the model. In conclusion, taking into account changes in health and disability improves mortality prediction. Therefore, insurers may consider designing a product that encourages policyholders to report health events. For example an annuity provider could set-up a reward system where the insured gets rewarded for updating records of their ADL disabilities, and reporting major health changes. This will enable the insurer to identify individuals who are at higher risk of admission to care home, or death.

ELSA is then used to analyse changes in disability that sample members experienced. Results show that disability is not a static process, improvement and recovery are both possible. The author investigated the factors that predict improvement and deterioration of ADLs at older age. Data from 8,276 subjects aged 60 and over, who responded to at least two waves of ELSA with complete ADL information, was used to estimate pooled panel logistic regression random effects models. Two sets of models were estimated. Initially, models on improvements in ADLs, i.e. reporting less ADLs at follow-up. Subsequently models on deterioration, i.e. reporting more ADLs at follow-up, were estimated for comparison. The predictors used in the models are previous ADLs, age, sex, marital status, education, social class, cardiac diseases, other chronic illnesses, recent joint replacement, smoking and alcohol drinking. The results showed that subjects report improvement twice as likely as they would report deterioration in ADLs. Old age, difficulties in motor skills, neurological diseases and multimorbidity contribute to the vulnerability to disability and reduce the chance of improvement. Arthritis had no association with improvement in ADLs, but had a protective effect against deterioration. Therefore, Insurers may require regular assessment of disability levels of their claimants. Moreover, flexible benefits systems that offer additional services during times of moderate disability could potentially reduce the costs of long-term care.

Subsequently, the thesis addressed two original questions: the impact of onset of disability on mortality, and the impact of entry to care home on mortality. To answer these two questions, data from the Cognitive Functioning and Ageing Study (MRC CFAS I) was used to examine. Both onset of disability and care home entry are found to increase mortality at older age. This offers the possibility of annuities whose payments increase following onset of disability or care home entry. The onset of disability may be used by insurance providers as a trigger for claims from long-term care insurance or as a trigger to increase payments from disability linked annuity. The analysis presented uses number of ADLs to measure onset of disability. The results show that at older ages, single divorced or widowed women have the highest rate of onset of disability. Onset of disability in ADLs, IADLs and motor skills are significantly associated with increased mortality. It was shown that gender differences in mortality may be a result of the differentials in health experiences of old age factors and events between men and women. For example, women are more likely to experience chronic condition like arthritis, and cope with the resulting disability. On ther other hand, men are more likely, to suffer abrupt disability that accelerates their death. Insurers may use the health events that prompted disability onset in the pricing and reserving for a product that covers long-term care costs. Moreover, the results shown here adds to the evidence to support disability linked pension annuity.

Finally, long-term care insurance that covers care home costs seems very attractive, but entails uncertainty about the risks involved. Care home residents are vulnerable older people with severe cognitive functioning and/or physical difficulties. The factors that cause the need for care home admission may contribute to higher mortality among care home residents. The author used data from CFAS I to inspect the impact of care home admission on mortality. The analysis used care home admission as predictor of mortality, controlling for sex, occupational class, cardiac diseases, stroke, Activities of Daily Living (ADLs), cognitive functioning and smoking. The results showed that subject moved to care homes are more likely single or widowed female and with low cognitive score. one in three of those who moved to care homes were diagnosed with dementia, and one in six had a recent stroke. Majority of subjects in care home suffered severe disability in IADL and motor skills, and at least needed help in one ADL. This showed that care home admission indicates increase in mortality hazard. Care home admission is reliant on disability, cognitive decline and chronic disease when used to predict mortality. Insurers that may consider offering different benefits according to residence should carry out stringent assessment of the claimant needs to avoid encouraging care home admission.

This thesis presented four major analyses. The first two were used to add to the evidence of dynamics of ageing, disability and mortality. The second two analyses were original analysis of the impact on onset of disability, and entry to care home on admission to care home. The results from the analyses can form significant input in the modelling of a insurance product that covers older age care costs, and encourages the buyers of such a product to record health events and disability levels. It is important to highlight the limitations in the datasets that have been used in the analyses (these limitations are discussed in each chapter). Additionally, the datasets are collected historically, and therefore might not represent future cohorts of older people. The aim of the analysis is to gain insights from knowledge of observed patterns of ageing.

6.2 Future work: Development of price and reserve of LTC insurance

This chapter presents the methodology for the assessment of premiums, reserves and solvency capital requirements for long-term care insurance (LTC) insurance policies using Activities of Daily Living (ADLs). It also provides the background for the modelling work to compare between stand-alone LTC insurance, and disability linked annuities (life annuities combined with LTC insurance). For future work a comprehensive analysis of LTC insurance, using ELSA, in terms of premium costs, policy designs and solvency capital will be implemented to allow a more in-depth reflection of the role and effectiveness of private LTC insurance.

Local authorities in England use the national threshold for care and support service to assess the care needs of an adult. The threshold sets three conditions for an adult to qualify for care; the needs arise from or related to a physical or mental impairment or illness, as a result of those needs the adult is unable to achieve two or more of the care outcomes (the can be linked to ADL scales), and whether there are consequences on the adult wellbeing. Therefor the count of failure in ADLs will be used as disability benefits trigger in the modelling presented here. Moreover, the model covers fixed benefits. The model can be extended to allow for the valuation of indemnity-based benefits. The LTC insurance policy, which is considered in this chapter, is an insurance policy that pays benefits to the insured when the insured becomes functionally disabled. In other words, the benefits are reliant on the current state of "ADL dependence". A four state continuous time Markov chain is used to describe the ADL dynamics of older people. Although this type of model tend to underestimate short duration disabilities (Wolf and Gill (2009)), but it is suitable to the underlying care as the LTC disabilities tend to be chronic and lasts for long durations (Brown and Warshawsky (2013)).

The states of ADL dependence are categorised based on the number of difficulties in performing Activities of Daily Livings (ADLs). The diagram in Figure 6.1 shows the different states. I indicates full independence, MD indicates mild disability (defined as having 1 - 2 ADL difficulties), SD indicates severe disability (defined as having 3 - 6 ADL difficulties), and D indicates death. As shown in the diagram, recovery from disability is allowed in the model, which is in line with prior studies with the results presented in chapter 3. This is important as the recovery rate is shown to be comparatively high and should be taken into account in the modelling.

The transition rates, shown in figure 6.1 , ν, ρ, σ and δ indicate consecutively deterioration to a higher ADL dependence state, recovery to a lower state (or full recovery), staying in the current state, and death. The subscripts in the transition rates indicate the direction of travel from state i state j, such that i, j $\in \{I, SD, MD, D\}$. The transition rate are age- and sex- dependent. Let $\Omega_x = \{I, SD, MD, D\}$ denote the state space for an individual aged x last birthday, and $\chi(x) \in \Omega_x$ is the ADL dependence state at age x. For $t \geq 0$ and $i, j \in \Omega_x$, the transition probability from state i at age x to state j at age $x + t$ is defined as:

$$P_{ij}(x, x+t) = Pr\{\chi(x+t) = j | \chi(x) = I\} \tag{6.1}$$

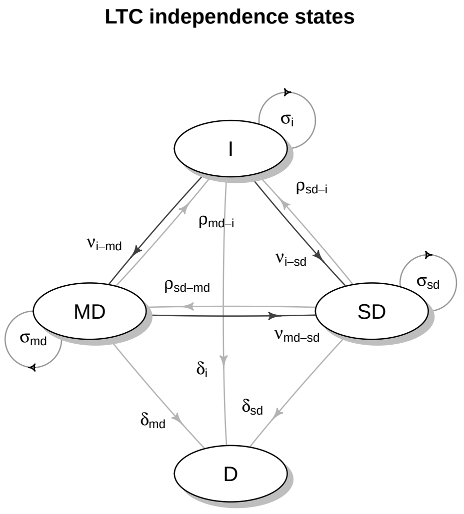
LTC independence states

Figure 6.1: The four-state Markov chain transition diagram for the LTC insurance

and the instantaneous transition intensities for $i \neq j$ are defined as

$$\mu_{ij}(x) = \lim_{dt \to 0^+} \frac{P_{ij}(x, x + dt)}{dt} \tag{6.2}$$

6.3 Estimation of the transition intensities

Estimation of the transition intensities followed Fong *et al.* (2015) approach. The estimation follows these assumptions:

- integrals of the transition intensities ($\mu_{ij}(x)$) are assumed to exist for compact intervals
- recovery from disability is possible, and it is age dependent
- time until transition follows an exponential distribution
- the transitions between states in the model are memoryless

Now let the transition intensities $\mu_{ij}(x)$ be functions of current age x. There is an invertible link function $g(.)$ such that $\eta_{ij}(x) = g(\mu_{ij}(x))$ and $\eta_{ij}(x)$ is a linear function of the regressors (i.e. the explanatory variables). For example, if age is the only variable affecting morbidity- and mortality transitions in this context η is given by the k-degrees polynomial

$$\eta_{ij}(x) = \beta_0 + \beta_1 x + \beta_2 x^2 + \cdots + \beta_k x^k \tag{6.3}$$

Where β's are the polynomial coefficients. Let the number of transitions i_x at age x, is constant in the year of age $[x, x+1)$, and e_x is the central exposed at age x. To estimate values of β's assume that i_x follows a Poisson distribution (i.e. $i_x \sim Poi(e_x \mu_{ij}(x))$)

6.4 Data

The analysis uses data from the English Longitudinal Study for Ageing (ELSA), an ongoing biennial survey of English household residents aged 50 and older. The survey have been conducted biennially since 2002, and data is available up to 2012/13.

6.5 Future research ideas

- use the second CFAS II study to compare between the disability experiences of disabled elders with 20years difference.
- With the complete disability transition probability matrix, we can estimate the average duration of time a person will spend in each disability level, hence understanding the dynamics of disability and possibly building a claims framework to be used by the insurers.

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