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Quantifying the prevalence of frailty in English Hospitals

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Title: Quantifying the prevalence of frailty in English Hospitals

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Abstract

Title: Quantifying the prevalence of frailty in English Hospitals

Objectives: Population ageing has been associated with an increase in co-morbid chronic disease, functional dependence, disability and associated higher health care costs. Frailty Syndromes have been proposed as a way to define this group within older persons. We explore whether frailty syndromes are a reliable methodology to quantify clinically significant frailty within hospital settings, and measure trends and geospatial variation using English secondary care dataset Hospital Episode Statistics (HES).

Setting: National English Secondary Care Administrative Data HES

Participants: All 50,540,141 patient spells for patients over 65 years admitted to acute provider hospitals in England (January 2005 - March 2013) within HES

Primary and secondary outcome measures: We explore the prevalence of Frailty Syndromes as coded by International Statistical Classification of Diseases, Injuries and Causes of Death (ICD-10) over time, and their geographic distribution across England. We examine national trends for admission spells, inpatient mortality and 30-Day readmission.

Results: A rising trend of admission spells was noted from January 2005 – March 2013(daily average admissions for month rising from over 2000 to over 4000). The overall prevalence of coded frailty is increasing (64559 spells in January 2005 to 150085 spells by Jan 2013). The majority of patients had a single frailty syndrome coded (10.2% vs total burden of 13.9%). Cognitive impairment and Falls (including significant fracture) are the most common frailty syndromes coded within HES. Geographic variation in frailty burden was in keeping with known distribution of prevalence of the English elderly population and location of NHS acute provider sites. Overtime, in-hospital mortality has decreased (>65yrs) whereas readmission rates have increased (esp.>85yrs)

Conclusions: This study provides a novel methodology to reliably quantify clinically significant frailty. Applications include evaluation of health service improvement over time, risk stratification and optimisation of services

Keywords: frailty, ageing, HES, Acute, England, Prevalence, Trends

Article Summary:

1. The number of admissions to acute providers in those >65 years is rising, particularly in the very elderly (>85 years). Inpatient mortality is decreasing, but 30-Day non-elective readmission is increasing. The very elderly (>85 years) are more likely to be readmitted.
2. We defined frailty as the presence of at least one frailty syndrome: The overall prevalence of frailty for those over 65 years admitted to acute provider units is 13.9% as coded within HES
3. Cognitive impairment and Falls (including significant fracture) are the most common frailty syndromes coded within HES.
4. There is an increase in coded admissions with anxiety and/or depression, especially from 2010. The 65-74 age-band exhibits a rising trend. Correlation with clinical datasets is warranted

Strengths and limitations of this study

1. This study is the first to attempt to use frailty syndromes as an operational definition within an English secondary care dataset.
2. The methodology uses whole population routinely collected data, with robust trend analysis examining coding reliability
3. This study is a retrospective analysis reliant on the accuracy, reliability and retrospective nature of coding within HES

Introduction:

People are living longer. At present, it is estimated that 16.1% of the European population is over the age of 65 years(>65y) , and this number is expected to rise to 22% by 2031 (1). In the developed world, the increase is greatest in those over 80 years, and this equates to approximately 3 million people in the UK(2). In health terms patients >65y now constitute two thirds of the general hospital population, account for 40% of all hospital bed days and 65% of NHS spend (3). Recent analysis suggests population ageing contributes directly to the increase in emergency admissions to hospitals(4).

Associated with this demographic shift there has been an increase in co-morbid chronic disease, functional dependence, disability, poorer quality of life and higher health care costs (5, 6). Patients in this category are often considered frail. Currently, there is no universally agreed operational definition for frailty (7). Frailty has been described as a clinical phenotype or a biophysical syndrome of accumulated deficit (frailty index). Phenotypic models describe frailty as specific clinical syndrome encompassing a cluster of characteristics, namely unintentional weight loss, exhaustion, weakness, slowness, and low physical activity (8). The frailty index is characterized by decreased resistance to stressors resulting from the accumulation of deficit across multiple physiological systems, culminating in an increased risk of adverse outcomes (9, 10). Methodologies to reliably identify the "frail" at-risk cohort within secondary care, both at patient and population level, are a current research priority (11-13).

In clinical practice the terms Geriatric Giants (14), Geriatric Syndromes (15, 16) or Frailty Syndromes (17) are often used to describe clinically vulnerable group within the elderly. They likely represent high order clinical manifestations of multi-factorial processes resultant from the accumulation and interaction of deficits and environmental factors. They include cognitive impairment, falls, mobility problems, pressure ulcers and incontinence. These syndromes, more prevalent in the elderly, confer a higher risk of death(8), institutionalization (18), disability and poor quality of life(15). They are arguably the consequences of frailty, or the manifestation of clinically significant frailty(19). Current National guidelines for the care of the older person in acute care recommend using frailty syndromes as a possible methodology to assess for frailty(17, 20).

In this study, we measure the trends for all hospital admissions, in-hospital death and re-admissions for those over 65 years. We describe Frailty Syndromes(17, 20) as an operational definition within the English secondary care dataset Hospital Episode Statistics (HES) in order to examine the frailty burden between 2005 and 2012. In addition we describe the geospatial variation of frailty in English secondary health care settings. We compare our results with the existing literature on frailty prevalence and discuss possible applications of this methodology.

Methods:

Data sources

HES is a national administrative database containing patient-level records of all admissions to NHS hospitals in England(21). It has high levels of data completeness and rigorous data cleaning processes to ensure data quality. Each record in HES corresponds to a finished consultant episode, during which a patient is under the care of an individual consultant. These episodes were aggregated into hospital spells covering a patient's total length of stay in a hospital (ie a hospital admission) using established methodology(22).

HES contains 20 fields per record for diagnoses codes that are defined using the tenth revision of the International Statistical Classification of Diseases, Injuries and Causes of Death (ICD-10). The first of these is the primary diagnosis, with the rest available for coding of comorbidities or complications. HES does not contain present-on-admission flags. We reviewed HES for ICD-10 diagnostic codes that could be grouped for frailty syndromes (Appendix 1) in all 20 fields. We included only inpatients at acute non specialist hospital trusts, with elective and non-elective admissions for those 65 years and over>65yo. We excluded hyper-specialist hospitals and mental health units as they have a very different case-mix and data quality(23). Thus, we defined frailty as the presence of at least one frailty syndrome and within the cohort of patients greater than 65 years old.

Annual trend profiles were created for the grouped ICD-10 diagnostic codes from January 2005 to March 2013 to determine coding reliability and shifts (Appendix 2). The spells were aggregated both by age-band (65-74 years; 75-84 years; >85 years) and monthly. Monthly data are visualised as simple line plots in the first instance. Office of National Statistics (ONS) databases were queried for population size estimates or census data where available.

Study population

All hospital admissions for >65y to English acute trusts between January 2005 and March 2013 (N=50,540,141 patient spells) were available for analysis.

Temporal analysis:

To analyse the variation present in these time-series data, Statistical Process Control (SPC) is used to separate special cause variation (signal) from common cause variation, an inherent property of all systems. The XmR chart is used as it is a method that is not dependent on data distributions or underlying assumptions(24). When analysing count data, daily averages for months were calculated to correct for unequal “areas of opportunity”; for example, a count of February admissions will be lower by virtue of fewer days in February, and daily averages account for the difference in available days. For percentage data, such a correction is attained through division by the denominator – all spells and all spells with frailty. Adjustments for seasonal variation are made, and seasonalised reference lines are plotted, for more natural interpretation of the charts. In this work, a standard rule set for detection of signal is adopted, using Microsoft Excel to construct the charts(24).

Spatial Analysis:

Geo-location is the identification of real-world geographic location of an object. Postcodes of provider sites were used to geo-locate sites, and map elements were derived from open source data provided by Office for National Statistics. Geo-locations aggregated to Primary Care Trust (PCT) level were attached to counts of frailty syndromes for patients >65y admitted to NHS acute providers in 2012 as this is the applicable unit for these data. Choropleths are thematic maps that shade or colour areas to represent classified values of specific phenomena. ESRI ArcMap 10.2 software was used to create a choropleth map. Annual trend profiles for inpatient mortality and non-elective readmission within 30 days were plotted. This temporal range of April 2006 to December 2012 was selected due to changes in structure of health geographies within England in 2006 (26), and to allow a sufficient follow up period to more accurately reflect the clinical outcomes listed above.

Results

Between January 2005 and March 2013, there was a rising trend with daily average admissions for month increasing from over 2000 to over 4000(Fig 1a). There has been an increase in all age bands over this period, 65-74 increasing from 161641 to 235756, 75-84 increasing from 162817 to 233870

and >85 increasing from 71396-137991(Fig 1b). The relative proportion of total admissions has remained constant each age band at 40%, 40% and 20% respectively. Examination of ONS data, (Appendix 4) finds that in the general UK population the number of >64 years old in the population increased from 8031000 in 2005, to 905179 in 2013. In 2005, the 65-74s represented 52% of those >65yr; in 2013 it was 54%; 75-84s were 36% and 33% 2005-2013; and >85s were 12% and 13%.

Analysis of trends shows that the coded overall frailty burden, based on the coding of at least one frailty syndrome, has increased from 12% to 14% between January 2005 and March 2013. There is evidence of seasonal peaks during winter, partly explained by similar patterns in admission spells (Fig 2)

The coding of the frailty syndromes has increased between 2005 and 2013. Most patients had one frailty syndrome coded (Figure 3) and the most common frailty syndromes described between 2005 and 2013 were cognitive impairment and falls (including significant fracture) with cognitive impairment increasing to the same levels as falls representing approximately 10% of all spells in the those > 65y. Anxiety and/or depression has increased particularly from 2010(2.4%) to 2013(>4%)(Fig 4). There is a persistent and steady rise in coding for mobility problems.

Evaluating the frailty syndromes individually, the very elderly (>85 years) represent between 40-50% of the spells coded for that syndrome, with rising trend. The exception to this was anxiety and/or depression syndrome, which exhibited a rising trend in the 65-74s, and the 75-84s accounted for the largest group.(Appendix 3) Age-band stratification shows that cognitive impairment and falls in age-bands >85 years and 75-84 years account for a large majority of coded frailty syndromes within this cohort. These four groups accounted for 60.2% of frailty syndromes coded over this time period (N= 7399671)

Geographic variation in the frailty burden across admission spells in England was seen based on the 2012 HES data (Fig 5). For patients >65yr admitted to England Acute providers, the highest levels of frailty are seen in the Northeast, Central and South Coast. The top 5 PCTs for highest admissions numbers are Nottingham City, Halton & St Helens, Warrington, Waltham Forrest and Wolverhampton city.

Between April 2006 to December 2012, 1,160,299 (3.4%) spells were associated with inpatient mortality, though a decreasing trend is observed e.g. April 2006 (N=15042) to April 2012(N=14437) (Fig 6a). Non-elective re-admission rates within 30days of discharge have increased for all admissions > 65y from approximately 11% to 12 %. (Fig 6b). The rates of readmission increased across the age bands > 65yrs (10%), 75-84 (12%) and >85 (14%). Though the overall number of very elderly (>85 years) with non-elective 30-Day readmission is lower than the other two age-bands, they have more readmissions (Fig 7).

Discussion:

Frailty is often defined as a clinical state in which there is an increase in an individual's vulnerability for adverse events and harm when exposed to a stressor(25). It is distinct but related to disability and co-morbidity(26, 27). Some approaches to the measurement of frailty have been characteristically biophysical with emphasis on detection of the consequences of sarcopaenia and chronic inflammation-malnutrition(8). Another approach is to measure frailty in relation to the clinical consequences of accumulated loss and insufficiency in ageing individuals(ie the relationship to mortality and adverse outcomes)(28). Both approaches appear complementary(29) and overlap, though not completely(30). Frailty measurement is problematic in the acute care setting. High levels

of disease acuity on top of chronic multi-morbidity, multidimensional complexity and diagnostic uncertainty are challenging for healthcare systems, with increasing evidence and concern for compromised patient safety, quality of care and experience (31-34).

We have examined the prevalence of frailty syndromes within English HES data from both a temporal and geospatial point of view. Temporal analysis, it allows us to observe shifts in diagnostic coding, and observe trend in signal changes over time. Spatial analysis allows us to explore geographic heterogeneity of frailty syndrome prevalence, with consequent implications for service provision and equity of care.

Comparison with ONS data, the corresponding admissions to English acute providers for patients with frailty syndromes is larger than might be expected by demographic shift associated with ageing. Additionally, 75-84s make up approximately one-third of the population of those over 65 years, but have 40% of the admissions, and >85s are approximately 13% of the population of those over 65 years but have 20% of the admissions

This study has focussed on patients admitted to hospital >65y in England to better understand the impact of frailty syndromes. To the authors knowledge, this is the first study to examine the prevalence of frailty syndromes for patients >65y across England. This study confirms increasing number of > 65y admitted to hospital (elective and non-elective). The relative burden of coded frailty syndromes has increased over this period with cognitive impairment increasing to similar levels to falls. Anxiety and/or depression is also increasing in this group.

When complex systems fail (biological or otherwise), high-order functions can be first disrupted (35). Frailty syndromes represent the clinical manifestation of high-order disruption, providing a useful clinical marker of multi-dimensional deficit accumulation. The overall prevalence rate of frailty syndromes found in this study is 13.9%. Between 2005-2013, though there has been an increase in the numbers of patients admitted >65y, the percentage by age band has remained stable, thus not suggesting major drift towards older age groups within the older population. However, within the >65y group, frailty syndromes are more prevalent with the older age bands.

Prevalence rates of frailty vary depending on population and operational definition used in reported studies. Reported prevalence in community dwelling adults varies tremendously (from 4.0% to 59.1%)(36). A recent systematic review reported pooled frailty prevalence across *21 community dwelling study cohorts* as 10.7% (N=61,500)(36). The recent Survey of Health, Ageing and Retirement in Europe (SHARE) study reported frailty prevalence as 4.1% in *community dwelling adults > 50 years*(N=16,584) in 10 European countries (prevalence of 17% in those over 65 years)(37). In the UK, the Hertfordshire Cohort Study(38) reported an overall prevalence of 6.3% for 638 *community dwelling 64-74 year olds*, while the English Longitudinal study of ageing(39) reported a prevalence of 8% and 13% for 3055 *community dwelling over 65 year olds* (using the Phenotype(8) and Frailty Index(10) definitions respectively).

The prevalence of inpatient frailty in our study was lower than expected from smaller reported clinical studies within secondary care (range 24.7% - 80%): (n=220 *>70 years admitted to acute geriatric ward from Emergency department(40)*, (n=6701)40% [Phenotype] and 32.5%[SOF(41)]; (n=1388 *>70 years admitted to cardiology service(42)*, (n=9008 27%[Phenotype] and 63%[Frailty Scale(43)]); (n=298 *>75 years admitted to 5 different specialist wards*, 50%-80%[Groningen Frailty Index(44, 45)]); *(n=307 > 75 years with diagnosed non-ST elevation myocardial infarction(46)*, 48.5%[n=2305 >65 years Clinical Frailty Scale(47)); (n=752 *medical inpatients > 75 years(48)*,. In the UK, 2 recent studies (12, 13) reported frailty prevalence for n=667 *patients >70 years admitted to Acute Medical Units(AMU*) at 69%[ISAR(49)], 17.9%[Phenotype], 66.4%[SOF], 24.9%[Avila-Funes],

24.1%[Rothman] and 30.9%[Frailty index]. Importantly, these studies mainly consisted of non-elective admissions, while our study cohort comprised of both elective and non-elective admissions to hospital. However, it may be that this methodology truly underestimates the prevalence of frailty within HES.

Not all frailty syndromes are observed, within HES, to be equally prevalent, nor do they appear to be increasing at the same rate. The observed differences and increase in frailty syndromes in this study (Figure 4) may reflect improvements in coding practice within HES due to the introduction of Healthcare Resource Group (HRG version 4 introduced in April 2007) and Payment by Results (since April 2009). The national dementia strategy was also published in 2009. However, this observed rising trend may also reflect a genuine increase in number of diagnosis. Correlation with clinical datasets for comparison is consequently a necessary research priority.

The frailty syndromes are more prevalent in the very elderly (>85), with a rising trend. The exception to this is anxiety and/or depression, where the most prevalent age-band is 75-84 years, which exhibits a declining trend, while the increase in this anxiety and/or depression from 2010 appears to mainly be in the 65-74 age-band, a pattern noted independently by the HSCIC(50). Correlation with clinical datasets is warranted to ensure accuracy.

This analysis suggests that coexistence of multiple frailty syndromes is uncommonly coded within HES; even though we used coded frailty syndromes within all 20 of HES diagnostic domains, incomplete coding may still be a cause, as not all morbidities will be acknowledged and coded for each admission, only those deemed relevant to care at that time. However, it has been noted that accumulation of deficit beyond a certain level is incompatible with survival (51), and thus multi-morbidity would have a ceiling effect. Further investigation on multiple frailty syndromes could be profitable.

Inpatient mortality trends in this population exhibit seasonality with peaks during winter, which persist after adjustment for number of admissions (spells). These peaks, coupled with rising 30-Day readmissions (particularly in the very elderly) suggest differences in service provision over the year. A question arises here: is this seasonality appropriate for the UK population and the provision of care?

Geographic variation in frailty burden appears to be in keeping with known distribution of prevalence of the English elderly population and location of NHS acute provider sites, particularly within urban areas. Healthcare providers and commissioners should consider their local populations when planning services, where frailty may be a larger consideration than other locations. Further study into environmental factors in relation to frailty is a necessary next step.

Limitations:

This study is a retrospective analysis reliant on data coded from hospital data warehouses, and subsequently cleaned into HES. As such, its validity is dependent on accuracy of data coding. Including all 20 diagnostic coding fields may help to mitigate this, but correlation with clinical datasets may be warranted for local investigations. Resultant prevalence rates described may underestimate frailty syndromes in this population.

Anxiety and/or depression was only recently recognised as a geriatric syndrome by the Education Committee Writing Group of the American Geriatrics Society(16). It appears to fulfil several criteria that makes it an attractive putative candidate for a frailty syndrome(51): poor mental health is often associated with chronic physical deficits(52), it appears to increase with age(Fig 4), it is associated

with adverse outcome(53), it is neither to rare or too common(Fig 4) Recent study has linked it to frailty (52, 54) in older persons, though comprehensive study of its relationship to adverse outcomes with relation to frailty is still lacking. Further study, including correlation with clinical datasets, is warranted.

Conclusion:

To our knowledge this study is the first to attempt to use frailty syndromes as an operational definition within an English secondary care dataset. While the study is dependent on the accuracy, reliability and retrospective nature of coding within HES, its strengths include being a whole population analysis, with robust trend analysis examining coding reliability. It utilizes routinely collected data and is comprehensive in its coding of frailty within all of the diagnostic coding positions in the HES dataset. Future studies to correlate with clinical datasets are needed to further investigate the phenomena discovered in this study.

This study provides a methodology to reliably quantify frailty. Applications include the ability to evaluate the effect of interventions over time allowing for health service quality improvement. Geographic analysis allows both providers and payers to highlight areas of need, unmet or otherwise for more intelligent targeting of resources, from a public health or clinical perspective. A reliable and quantifiable metric for frailty enables the development of risk-prediction models and clinical scoring systems that will aid targeted interventions to vulnerable populations that will benefit most.

Ethics

As per Governance Arrangements for Research Ethics Committees (GAfREC), Research limited to secondary use of information previously collected in the course of normal care (without an intention to use it for research at the time of collection), provided that the patients or service users are not identifiable to the research team in carrying out the research.

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The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Contributorship:

JS conceived study, designed analysis, interpreted results and wrote first draft
AJP designed analysis, interpreted results, contributed to ongoing writing
SS and KD designed analysis
TW designed SPC analysis
DL designed GIS analysis
DB conceived study, designed analysis, interpreted results and contributed to ongoing writing

Data sharing:
No additional data

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Figure Legend

Figure 1a: Daily average admission spells for month and percentage total frailty burden for England NHS acute trusts and Figure 1b: The number and percentage of spells for patients > 65 years by age-band admitted to English acute providers

Figure 2: The percentage of admissions to English acute providers coded with at least one frailty syndrome

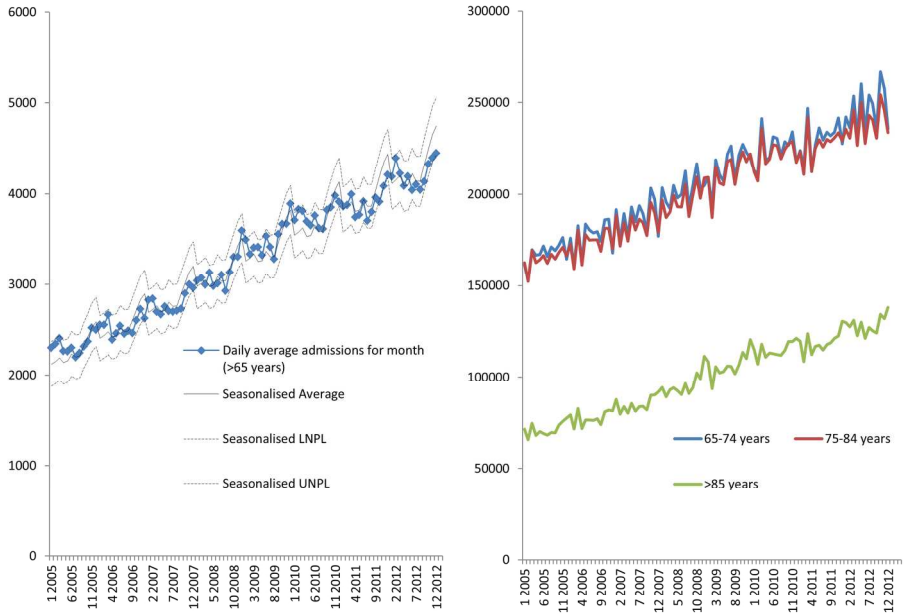
Figure 3: Trends for the prevalence of count of frailty syndromes and total frailty burden for patients >65 years admitted to NHS acute provider hospitals between April 2006 to December 2012

Figure 4: Trends for the prevalence of frailty syndromes for patients > 65 years admitted to NHS acute provider hospitals between January 2005 and March 2013

Figure 5: Percentage of spells for patients >65 years with admission to NHS acute Trusts with at least one frailty syndrome by PCT by quintiles (Numerator=admission spells with at least one frailty syndrome; Denominator=total admission spells to NHS acute Trusts within English PCT)

Figure 6a: Percentage of spells with inpatient mortality admitted to English providers and Fig 6b: non-elective 30D readmission in patients > 65 years admitted to English acute providers

Figure 7: Number and Percentage non-elective readmissions in patient > 65 years admitted to NHS acute providers by age-band



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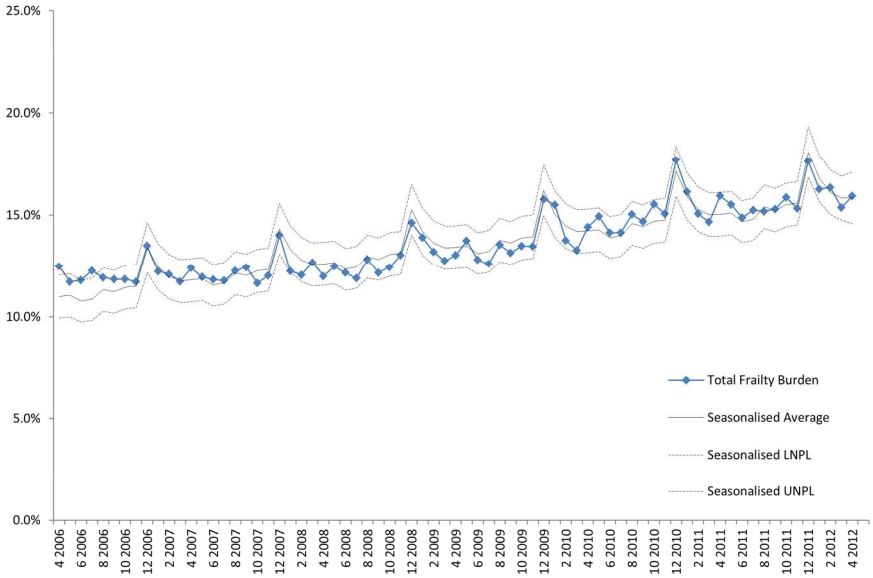

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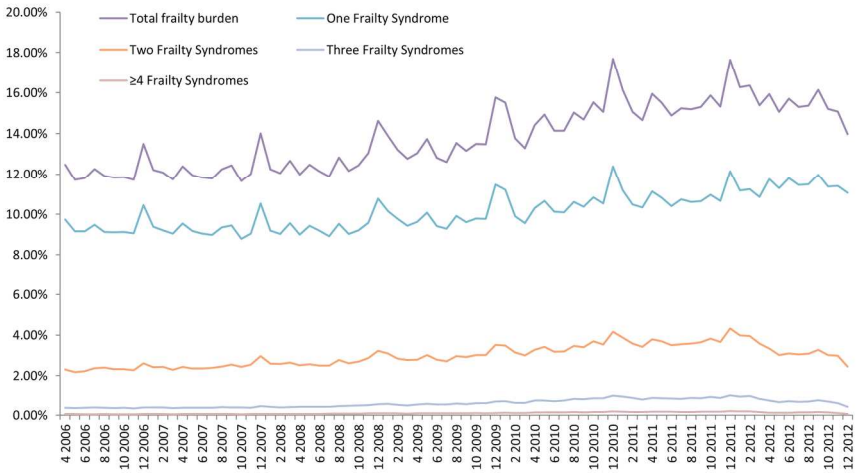

Count of Frailty Syndromes	Patient Spells	Percentage
1 Frailty Syndrome	3462383	10.2%
2 Frailty Syndromes	1029957	3.0%
3 Frailty Syndromes	203781	0.6%
≥4 Frailty Syndrome	36002	0.1%
Total Frailty Burden	**4732123**	**13.9%**

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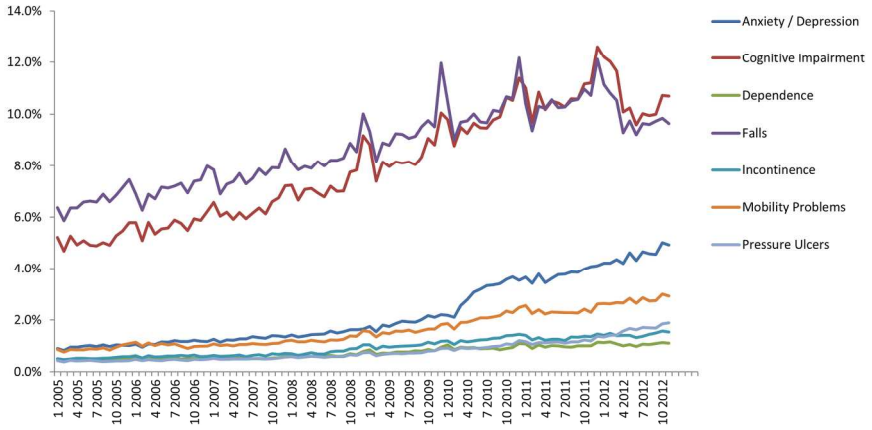

Frailty Syndrome	Patient Spells(N)	Percentage
Anxiety / Depression	1189699	2.4%
Functional Dependence	491266	1.0%
Falls (& significant fracture)	4408748	8.7%
Incontinence	560308	1.1%
Mobility Problems	992597	2.0%
Pressure Ulcers	556205	1.1%
Cognitive Impairment (composite of Delirium, Dementia and Senility)	4558063	9.0%
Delirium	257895	0.5%
Dementia	3570714	7.1%
Senility	1215456	2.4%

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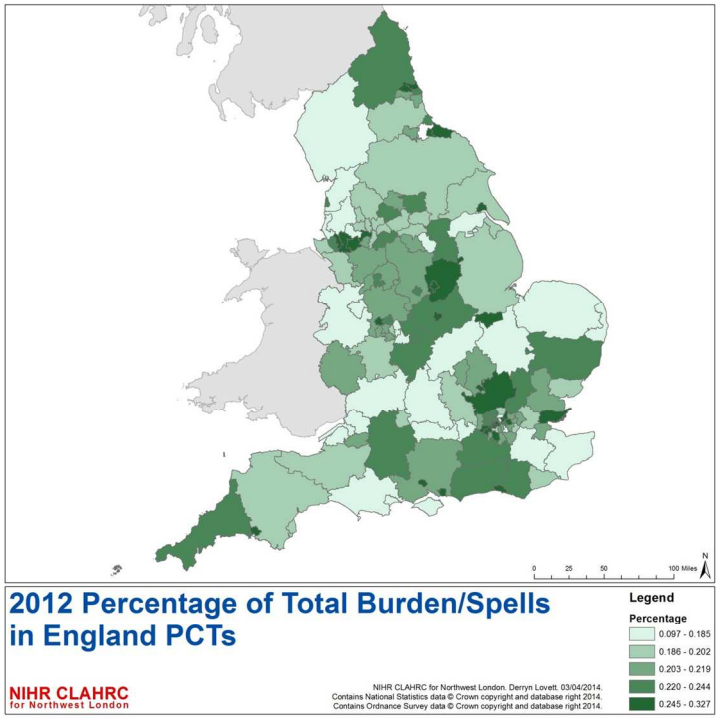

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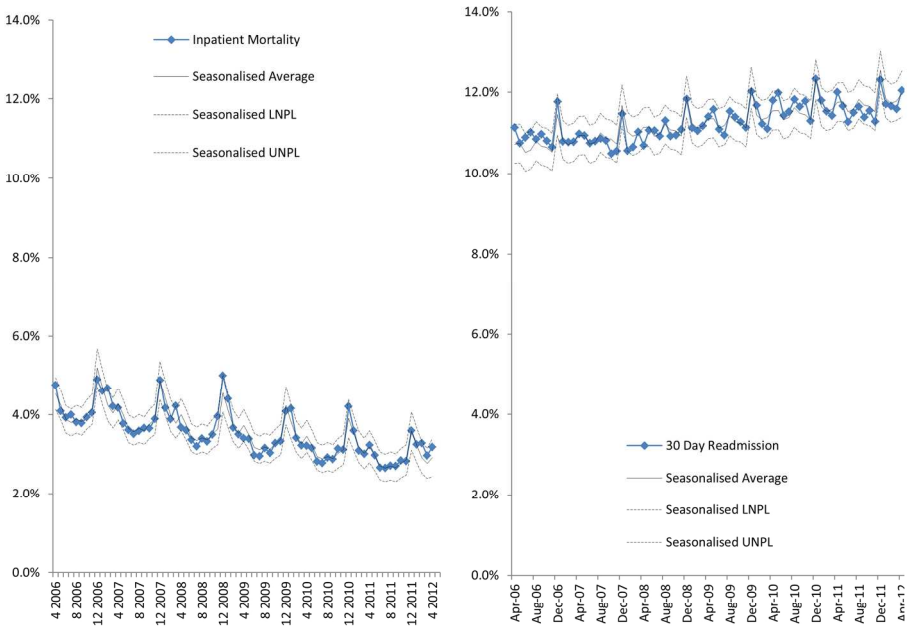

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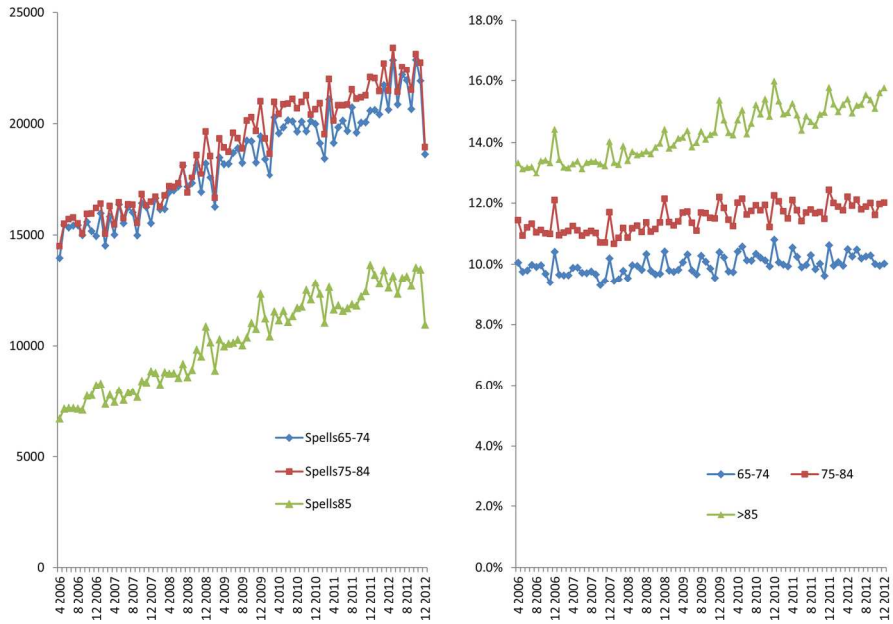

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Appendix 1

Frailty Syndrome	ICD-10 Diagnostic Code
Anxiety and Depression	F320 F320- F320-- F320-D F3200 F3200- F3200A F3200D F3201 F3201A F3201D F3207 F320X F321 F321 1 F321- F321-- F321-D F3210 F3210- F3210A F3210D F3211 F3211- F32110 F32111 F3211A F3211D F3219 F322 F322 D F322- F322-D F32211 F3229 F322X F323 F323 D F323- F323-- F323-D F3230 F3231 F3239 F324 F325 F326 F327 F328 F328 A F328- F3289 F328A F329 F329 A F329 D F329- F329-- F329-A F329-D F329. F329/ F3290 F3292 F3293 F3295 F3296 F3298 F3299 F329A F329D F329J2 F329M F329Q F32X F32X- F33#- F330 F330- F330-D F3300 F3300A F3301 F3301A F3301D F331 F331 1 F331- F331-D F3310 F3310- F3310A F3310D F3311 F3311- F3311A F3311D F332 F332- F332-- F332-D F3320 F3329 F333 F333- F333-D F3330 F3331 F3333 F334 F334- F335 F336 F337 F338 F338- F338-D F3380 F339 F339 A F339- F339-- F339-D F3396 F33X F380 F380- F3800 F3800A F3800D F381 F381- F3810 F3810A F3810D F388 F388- F38X F410 F410- F410-- F4100 F4101 F4103 F410D F411 F411- F411-D F412 F412- F412-- F4122 F412D F413 F413- F418 F418- F419 F419- F419-- F4193 F4199 F419X F41X F430 F430- F430-D F4300 F4301 F4302 F431 F431- F431-- F432 F432 0 F432 2 F432 3 F432 5 F432- F432-- F432-D F4320 F4320A F4320D F4320X F4321 F4321- F4321A F4321D F4322 F4322- F4322A F4322D F4323 F4323A F4323D F4324 F4325 F4325- F4325A F4325D F4328 F4328A F4328D F4329 F432X F438 F438- F439 F439- F43X F440 F440- F441 F441- F442 F442- F4422 F443 F443- F444 F444- F445 F445- F446 F446- F447 F447- F448 F448- F4480 F4481 F4481A F4481D F4482 F4488 F449 F449-
Delirium	F050 F050 A F050- F051 F051 A F051 D F051- F051-A F051-D F0513 F051D F058 F058- F058-- F059 F059 D F059- F059--
Dementia	F000 F000 A F000 D F000* F000+ F000- F000-A F000-D F0000 F00001 F00002 F0000A F0001 F00010 F0001A F0002 F0002A F0003 F00031 F00032 F0004 F00040 F00041 F00042 F0004A F0009 F0009A F000a F001 F001 0 F001 1 F001 A F001 D F001* F001+ F001- F001-A F001-D F0010 F00101 F00102 F0010A F0011 F00111 F00112 F0011A F0012 F00122 F0012A F0013 F00130 F00131 F00132 F0014 F00140 F00141 F00142 F0014A F001A F001AG F001D F002 F002 A F002 D F002* F002*A F002+ F002- F002-A F002-D F0020 F0020A F0021 F00211 F0022 F0023 F0023A F0024 F0024A F002A F008 F009 F009 * F009 A F009 D F009* F009+ F009- F009-A F009-D F009.A F0090 F00901 F0090A F0091 F00912 F0091A

		F0092	F0092A	F0093	F0093A	F0094	F0094A	F009A	F009A\
		F009AG	F009D	F009DG	F009X	F009XA	F00A-A	F00X	F00X-
		F010	F010*	F010-	F010-D	F0100	F01001	F01002	F0100A
		F0100D	F0101	F01012	F0101A	F0101D	F0102	F0102A	F0102D
		F0103	F0104	F01042	F0104A	F0104D	F011	F011 A	F011 D
		F011-	F011--	F011-A	F011-D	F0110	F01100	F01101	F01102
		F0110A	F0111	F01111	F01112	F0111A	F0112	F01120	F01121
		F01122	F0113	F01131	F01132	F0114	F01141	F01142	F0114A
		F0114D	F0117	F0119	F011A	F011D	F012	F012 A	F012 D
		F012-	F012-D	F0120	F0120A	F0121	F01211	F01232	F0124
		F012A	F013	F013 A	F013 D	F013*	F013-	F013-D	F0130
		F01301	F01302	F0130A	F0131	F01310	F01312	F0133	F01330
		F0134	F01340	F01341	F01342	F018	F018 A	F018-	F018-A
		F0180	F0181	F0182	F0183	F0184	F018D	F019	F019 *
		F019 A	F019 D	F019*	F019-	F019--	F019-A	F019-D	F0190
		F0191	F01910	F0192	F01921	F0192A	F0193	F0194	F01941
		F01942	F0197	F0199	F019A	F019D	F019N	F019Z8	F01X
		F01X-	F02.	F020	F020 A	F020 D	F020*	F020-	F020-A
		F020-D	F0200	F02001	F0200A	F0201	F02012	F0202	F0203
		F0203A	F0204	F0204A	F020A	F020D	F021	F021 A	F021*
		F021-	F021-A	F0210	F0211	F0214	F021A	F022	F022 A
		F022 D	F022*	F022-	F022-A	F0220	F0220A	F0222	F0223
		F0224	F022A	F023	F023 A	F023 D	F023*	F023+	F023-
		F023-A	F023-D	F0230	F02301	F0230A	F0231	F0231A	F0232
		F02320	F02321	F0232A	F0233	F02331	F0233A	F0234	F02341
		F02342	F0234A	F023A	F023AG	F023D	F023X	F023XA	F024
		F024 A	F024*	F024-A	F0240	F0241	F02412	F0242A	F0243
		F0244	F024A	F028	F028 !	F028 *	F028 A	F028 D	F028*
		F028+	F028-	F028-A	F028-D	F0280	F02801	F0280A	F0281
		F02811	F0281A	F0282	F02821	F0282A	F0283	F0284	F0284A
		F028A	F028D	F028XA	F029	F02X	F03-	F030	F0300
		F03011	F0304	F03X	F03X *	F03X A	F03X D	F03X*	F03X+
		F03X-	F03X--	F03X-A	F03X-D	F03X0	F03X0*	F03X00	F03X01
		F03X02	F03X0D	F03X1	F03X11	F03X12	F03X2	F03X20	F03X2A
		F03X2D	F03X3	F03X4	F03X41	F03X42	F03X6	F03X9	F03XD
		F03XG	F03XI	F03XS	F03XZ	F04X	F04X-	R410	R410 D
		R410-	R410--	R4100	R4104	R4109	R410D	R410L	R410X
		R411	R411-	R411X	R412	R412-	R413	R413-	R413--
		R418	R418 D	R418-	R418--	R4185			
Functional Dependence	Z741	Z741-	Z742	Z742-	Z7421	Z743	Z743-	Z748	Z748-
		Z749	Z749-	Z74X	Z750	Z750-	Z7500	Z751	Z751-
		Z751--	Z751-D	Z7511	Z7513	Z752	Z752-	Z7520	Z753
		Z753-	Z754	Z754-	Z7548	Z755	Z755-	Z755-D	Z7555
		Z758	Z758-	Z759	Z759-	Z75X			
Falls and Fractures	R55X	R55X D	R55X*	R55X+	R55X-	R55X--	R55X-D	R55X7	R55XA
		R55XD	R55XX	S320	S320 0	S320-	S320-D	S3200	S3200D
		S3201	S3202	S3205	S3206	S3209	S320D	S321	S321 0
		S321 D	S321-	S3210	S3210D	S3211	S32130	S322	S322-

	S3220 S3221 S323 S323 0 S323- S3230 S3230D S3231 S3236 S324 S324 0 S324- S3240 S3240A S3240D S3241 S324D S325 S325 0 S325 D S325- S325-D S3250 S3250- S3250A S3250D S3251 S3252 S3254 S3255 S3256 S3258 S3259 S327 S327 0 S327- S3270 S3270D S3271 S328 S328 0 S328- S328-D S3280 S3280D S3281 S3288 S32X S330 S330- S331 S331- S331-D S3310 S331D S332 S332- S3320 S333 S333- S3330 S3331 S333D S334 S334- S3340 S335 S335- S3350 S336 S336- S337 S337- S3370 S33X S420 S420 0 S420- S420-A S4200 S4200D S4201 S4201D S4206 S421 S421 0 S421- S4210 S4210- S4210D S4211 S4212 S4213 S422 S422 0 S422- S4220 S4220- S4220D S4221 S42210 S4222 S422O S423 S423 0 S423 D S423- S4230 S4230D S4231 S4231D S4232 S42340 S4236 S4239 S423D S424 S424 0 S424- S4240 S4240D S4241 S4241D S4244 S4248 S4249 S427 S427- S4270 S4270D S4271 S428 S428- S4280 S4281 S429 S429 0 S429- S4290 S4290D S4291 S4299 S430 S430 0 S430- S430-- S4300 S4302 S4309 S430D S431 S431- S4310 S4316 S431D S432 S432- S4320 S433 S433- S4330 S434 S434- S4340 S4341 S434D S435 S435- S436 S436- S436D S437 S437- s620 S620 0 S620- S6200 S6200D S6201 S6204 S6208 S621 S621 0 S621- S6210 S6211 S6211D S6218 S622 S622 0 S622- S6220 S6220D S6221 S6221D S6228 S623 S623 0 S623- S623-- S6230 S6230D S6231 S6231D S6234 S6236 S6239 S624 S624 0 S624- S6240 S6240D S6241 S6241D S6244 S625 S626- S627 S627 0 S6271 S6274 S628 S628 0 S628- S6280 S6280- S6280D S6281 S6288 S6289 S628O S629 S720 S720 0 S720- S720-D S720.0 S7200 S7200- S72000 S72009 S7200A S7200D S7201 S7201D S7203 S7204 S7205 S7208 S7209 S720A S720D S721 S721 0 S721- S7210 S72100 S7210D S7211 S7215 S7219 S721D S721O S722 S722 0 S722- S7220 S7220D S7221 S72210 S7221D S7222 S723 S723 0 S723 1 S723- S7230 S7230D S7231 S7236 S723D S724 S724 0 S724- S7240 S7240A S7240D S7241 S7246 S727 S727- S7270 S7271 S728 S728 0 S728- S7280 S7280D S7281 S728D S729 S729 0 S729- S7290 S7290D S7291 S7295 S7299 S729D S72X S730 S730- S730-D S7300 S730D S731 S731- S7310 S7315 S731D S73X S73X- W000 W000- W0009 W000A W001 W001- W0010 W0012 W0019 W002 W002- W002A W003 W003- W0033 W003A W004 W004- W0040 W0049 W004A W004D W005 W005- W006 W006- W007 W007- W008 W008- W0080 W008A W009 W009- W0090 W0099 W009A W010 W010 A W010 D W010- W010-A W0100 W0101 W0103 W0104 W0108 W0109 W010A W011 W011- W0111 W0118 W0119 W011A W012 W012- W012-- W0120 W0122 W0123

	W0128 W0129 W012A W012X W013 W013- W0130 W0131 W0139 W013A W014 W014- W0140 W0141 W0148 W0149 W014A W015 W015- W0150 W0152 W0158 W0159 W015A W016 W016- W0160 W016A W017 W017- W018 W018- W0180 W0181 W0182 W0185 W0188 W0189 W018A W019 W019- W0190 W0191 W0192 W0195 W0198 W0199 W019A W020 W020- W020A W021 W021- W022 W022- W023 W023- W0230 W0239 W023A W024 W024- W024A W025 W025- W026 W026- W027 W028 W028- W0280 W0281 W0282 W028A W029 W029- W0290 W0291 W0293 W0299 W029A W030 W030- W0300 W0301 W0309 W030A W031 W031- W0319 W031A W032 W032- W0320 W0329 W032A W033 W033- W0330 W0331 W0333 W0339 W033A W034 W034- W0349 W035 W035- W036 W036- W037 W037- W038 W038- W0380 W0383 W038A W039 W039- W0390 W0398 W0399 W039A W040 W040- W0409 W040A W041 W041- W0410 W0419 W042 W042- W0429 W043 W043- W044 W044- W045 W045- W046 W0460 W0469 W047 W048 W048- W049 W049- W0491 W0499 W049A W050 W050- W0504 W0509 W050A W051 W051- W0519 W051A W052 W052- W0528 W0529 W052A W053 W053- W054 W054- W0549 W054A W055 W055- W056 W056- W057 W057- W058 W058- W0581 W0589 W058A W059 W059- W0598 W0599 W059A W060 W060- W0600 W0601 W0604 W0608 W0609 W060A W061 W061- W061-A W0611 W0619 W061A W062 W062- W062-- W0624 W0628 W0629 W062A W063 W063- W064 W064- W065 W065- W065A W066 W066- W067 W068 W068- W0689 W069 W069- W0690 W0691 W0692 W0699 W069A W070 W070- W0700 W0701 W0706 W0708 W0709 W070A W071 W071- W0711 W0718 W0719 W071A W072 W072- W0720 W0728 W0729 W072A W073 W073- W074 W074- W075 W075- W0752 W0759 W076 W076- W077 W077- W078 W078- W0782 W079 W079- W0790 W0798 W0799 W079A W080 W080- W0808 W0809 W080A W081 W081- W0810 W0819 W082 W082 AW082- W0829 W082A W083 W083- W0830 W084 W084- W085 W085- W0850 W085A W086 W086- W0860 W087 W087- W088 W088- W0889 W089 W089- W0899 W089A W090 W090 AW090- W0900 W0901 W0909 W090A W091 W091- W092 W092- W0920 W0921 W092A W093 W093- W0939 W093A W094 W094- W095 W095- W0959 W095A W096 W096- W097 W097- W098 W098- W0981 W0988 W0989 W098A W099 W099- W0990 W0991 W0999 W099A W100 W100- W100-A W1000 W1008 W1009 W100A W101 W101- W1011 W1012 W1019 W101A W102 W102- W1029 W102A W103 W103 DW103- W1030 W1039 W103A W104 W104- W1049 W105 W105- W1052 W1058 W1059 W105A W106 W106 DW106- W1062 W107 W107-

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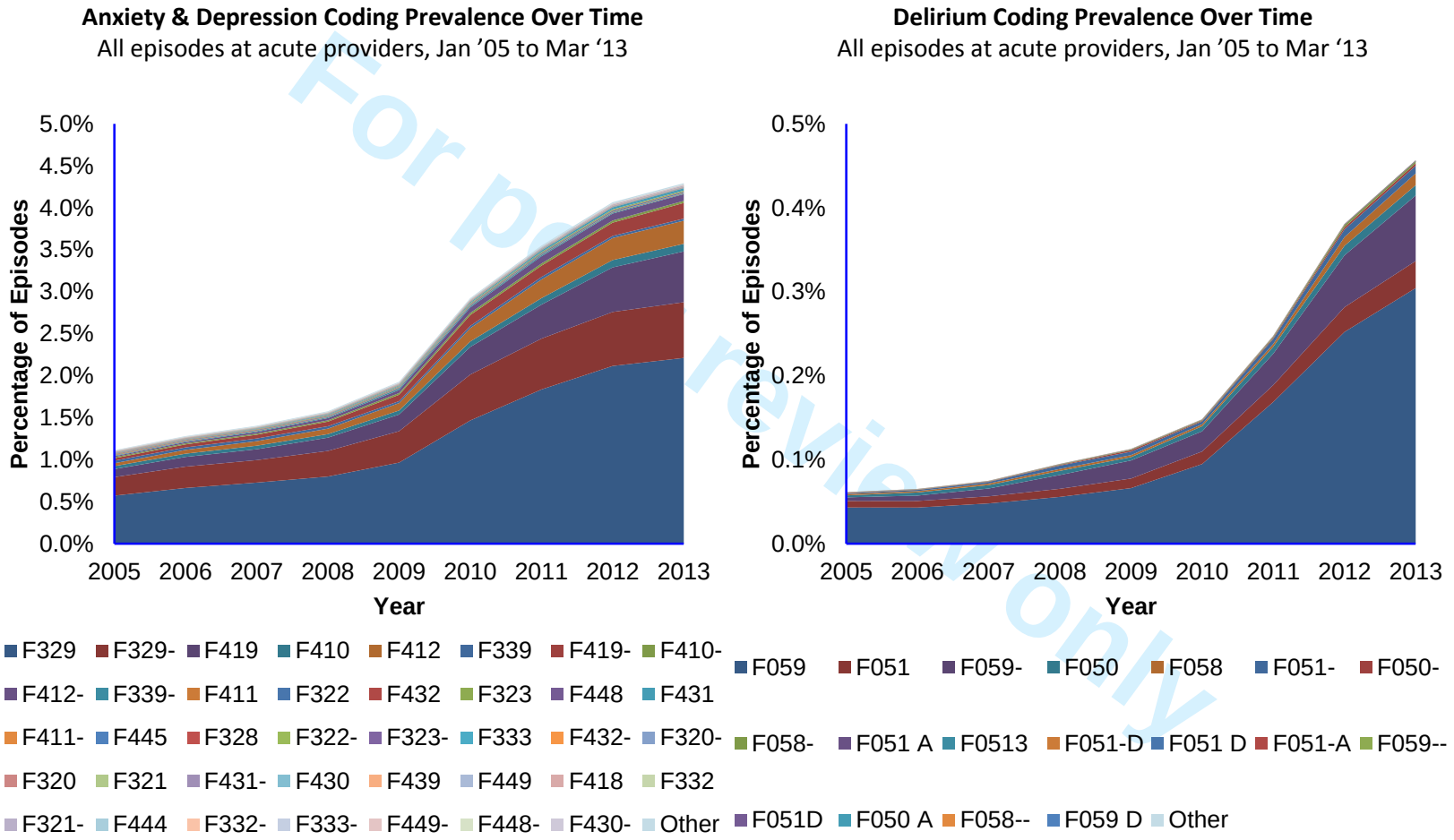
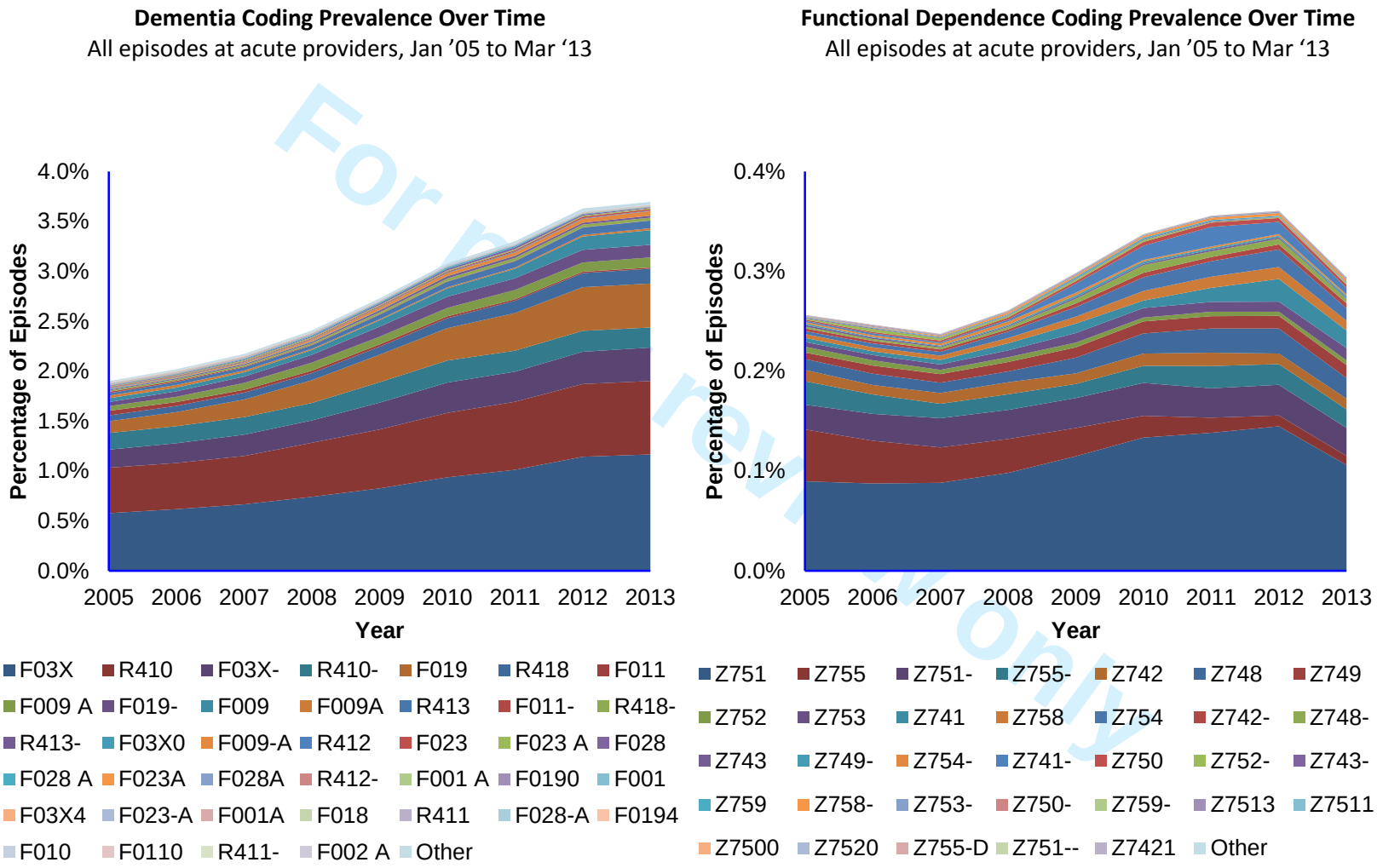
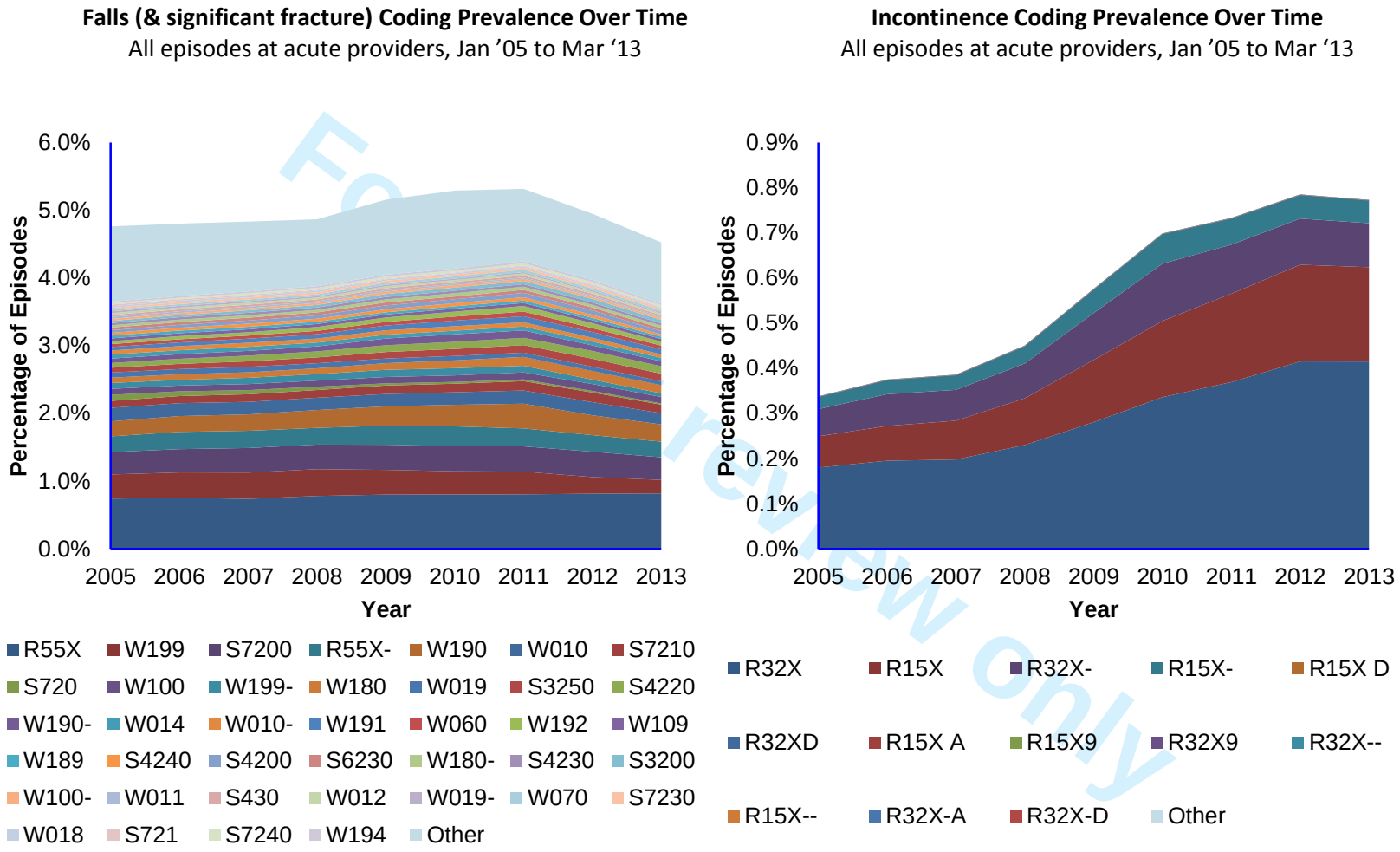
		W1992 W199D	W1993 W19X	W1994	W1995	W1996	W1998	W1999	W199A
Incontinence	R15X	R15X A R32X-A	R15X D R32X-D	R15X- R32X0	R15X-- R32X1	R15X9 R32X3	R32X R32X9	R32X- R32XD	R32X--
Mobility problems	R260	R260- R2621 R2683 Z740--	R260D R2623 R2686 Z740-D	R261 R263 R2689 Z740.	R261- R263- R268D Z7400	R261D R263D R269 Z7401	R262 R268 Z740 Z7404	R262 A R268- Z740 Z Z740C	R262- R268-- Z740- Z740D
Pressure Ulcers	L890	L890- L892-- L89X L89X-	L890-- L893 L89X - L89X--	L890D L893- L89X A L89X-D	L891 L893-A L89X D L89X1	L891- L899 L89X E L89X5	L891-- L899 A L89X I L89X9	L892 L899- L89X J L89XD	L892- L899-- L89X Z
Senility	R54X	R54X A R54X9	R54X D R54XA	R54X- R54XD	R54X-D R54XI	R54X. R54XW	R54X0 R54XX	R54X6	R54X7

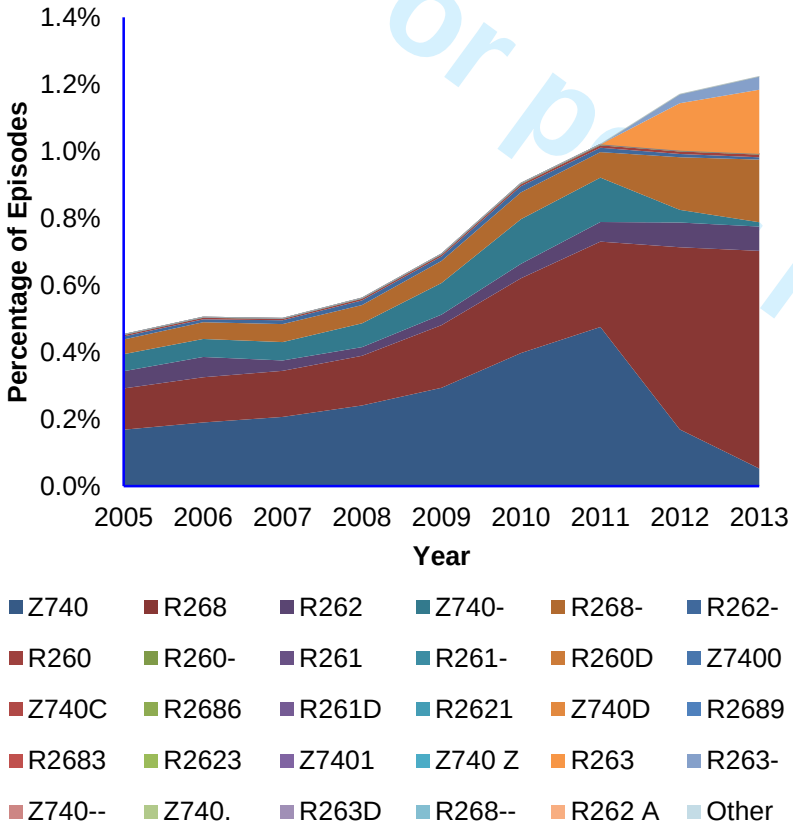
APPENDIX 2:



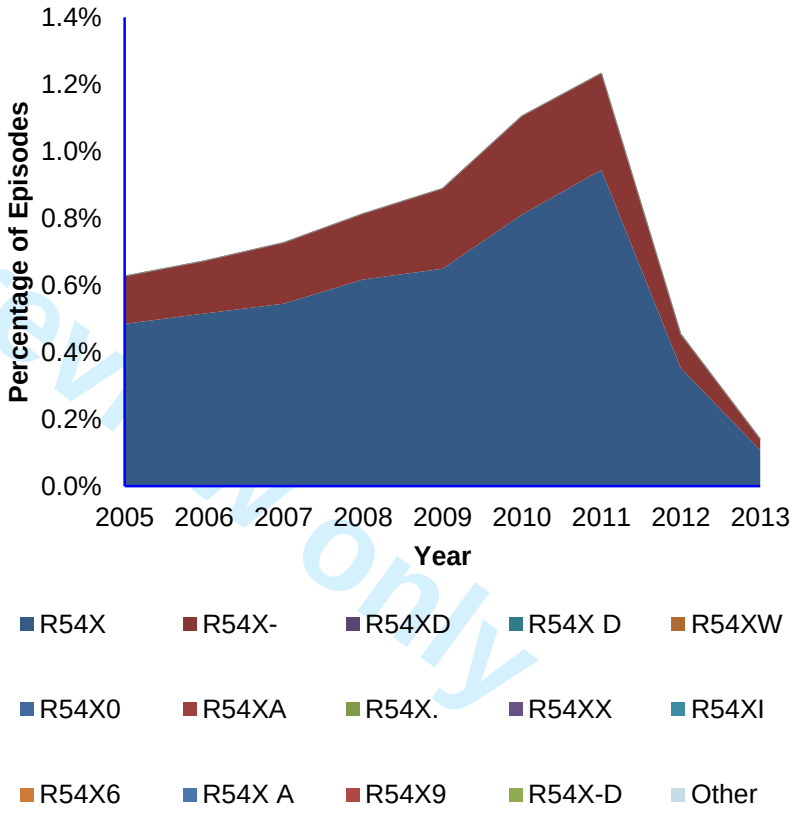


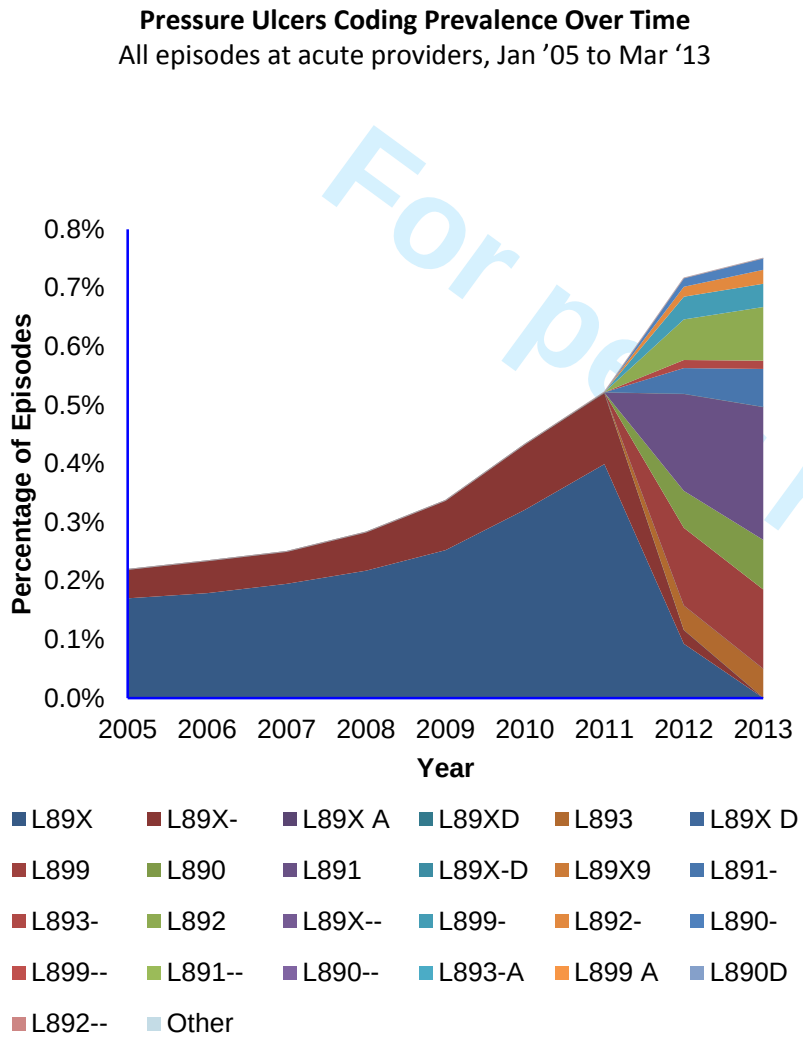


Mobility Problems Coding Prevalence Over Time
All episodes at acute providers, Jan '05 to Mar '13

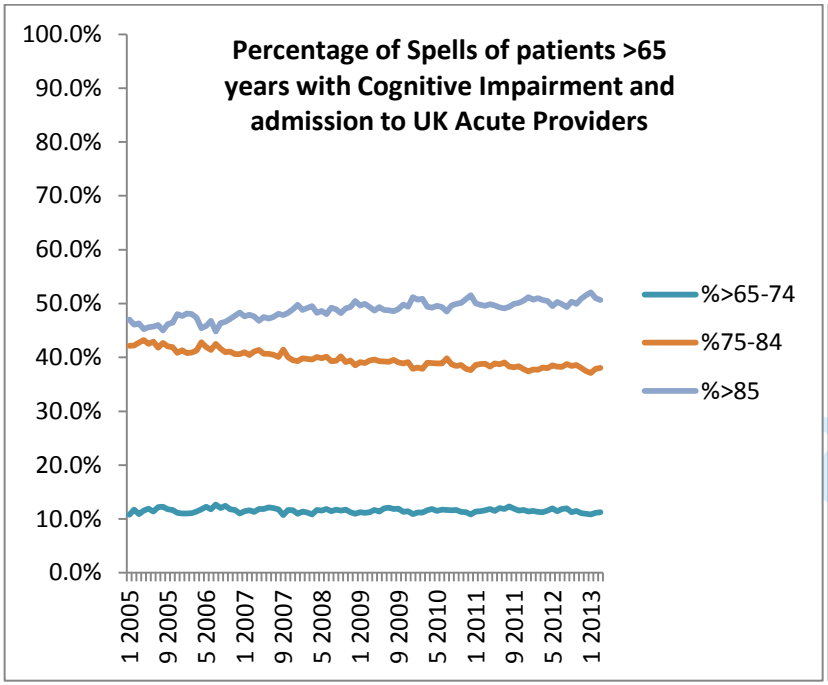


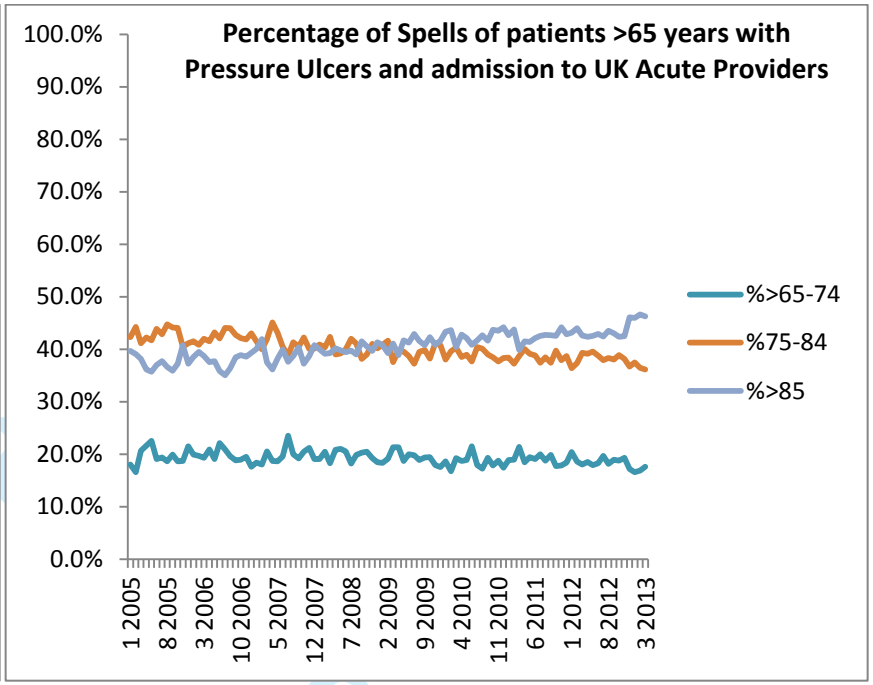
Senility Problems Coding Prevalence Over Time
All episodes at acute providers, Jan '05 to Mar '13

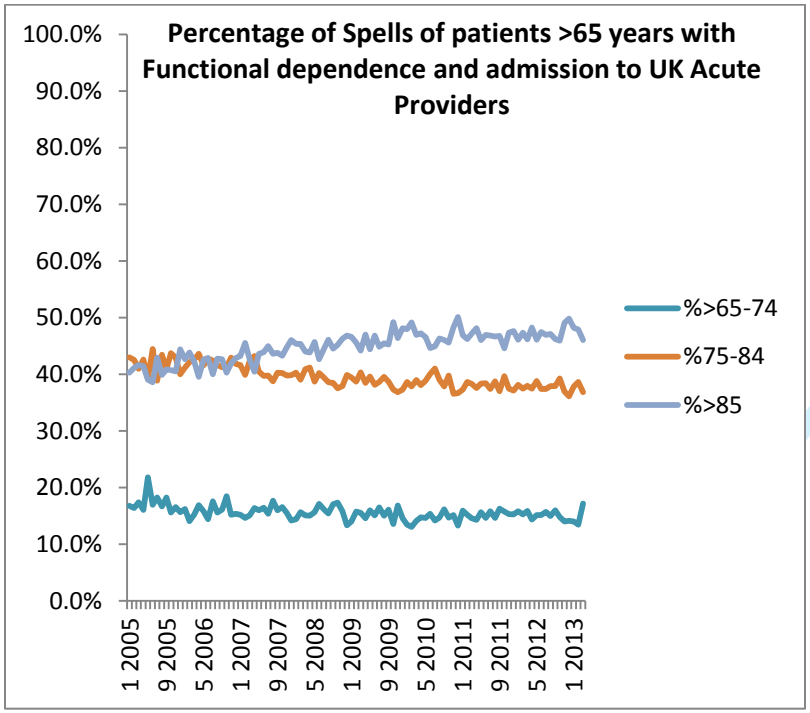


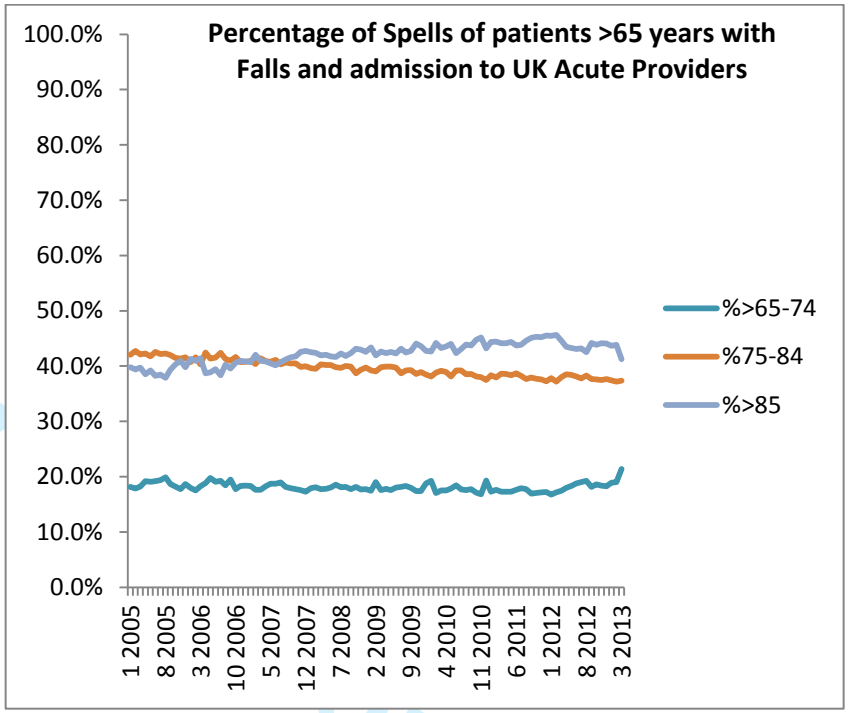


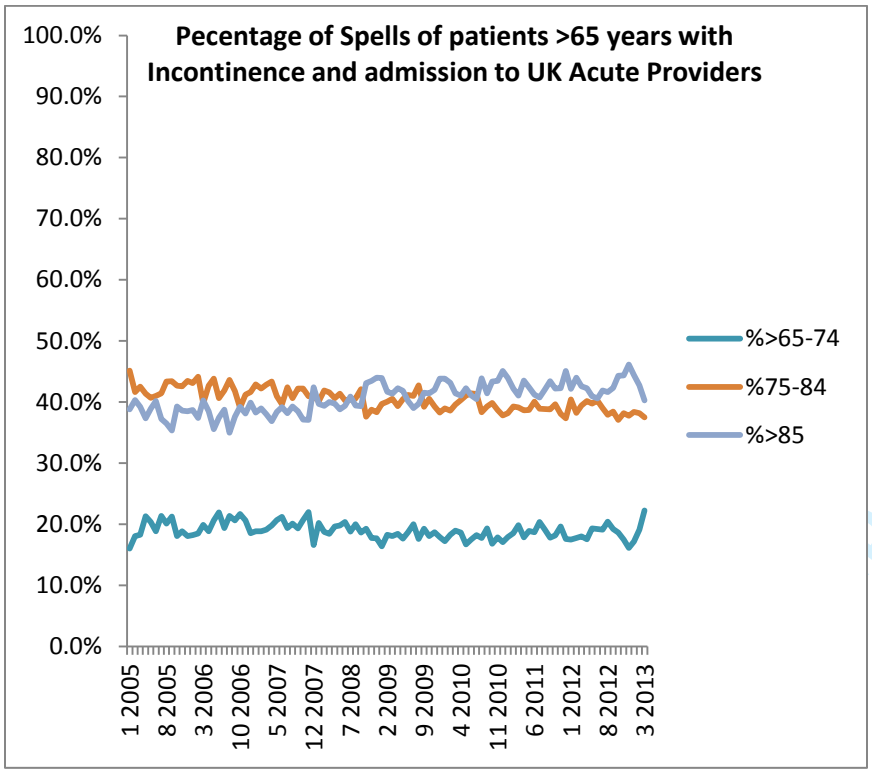
Appendix 3

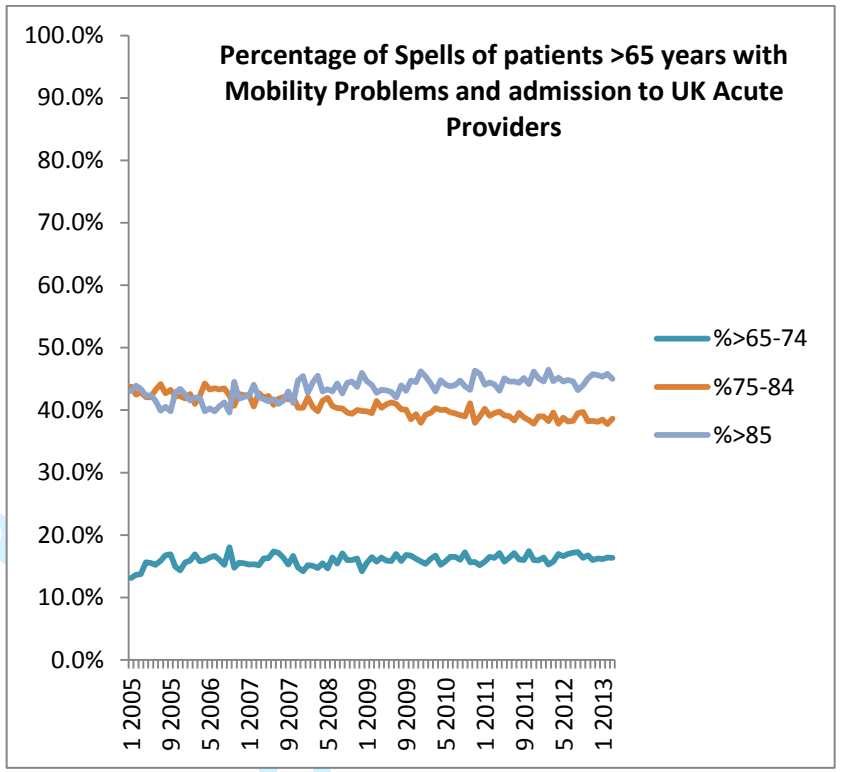


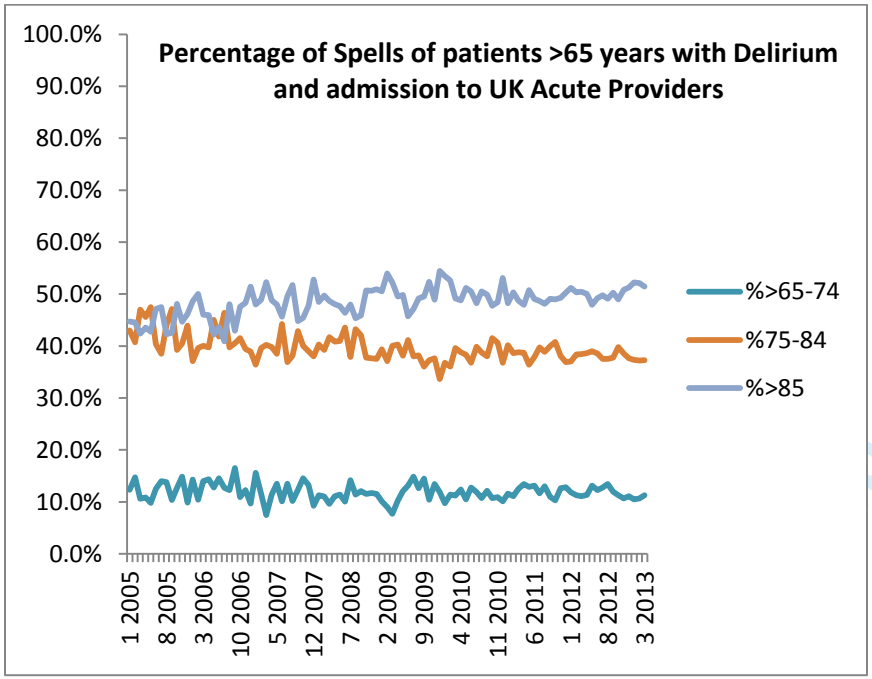


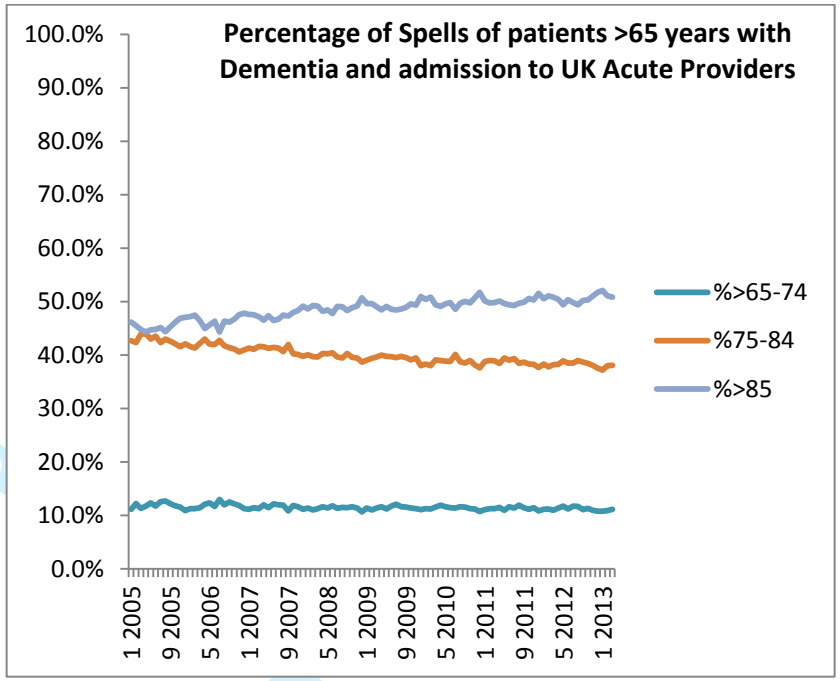


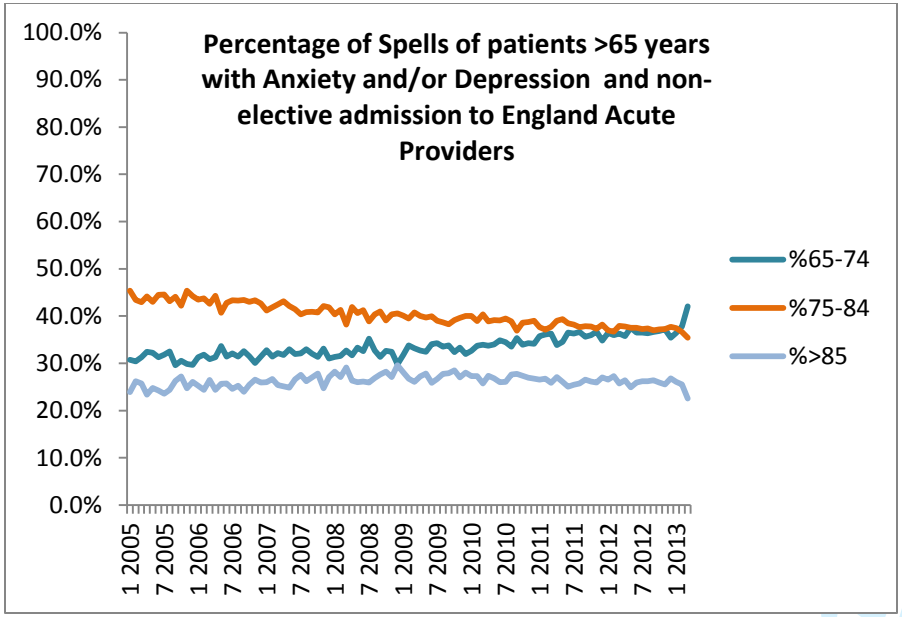











Percentage of Spells of patients >65 years with Anxiety and/or Depression and non-elective admission to England Acute Providers
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
1 2005
7 2005
1 2006
7 2006
1 2007
7 2007
1 2008
7 2008
1 2009
7 2009
1 2010
7 2010
1 2011
7 2011
1 2012
7 2012
1 2013
%65-74
%75-84
%>85

Appendix 4

http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Population+Estimates

ENGLAND	2005	2013	% change
All ages	50606000	53865817	6.44%
65-74	4189100	5023573	19.92%
75-84	2855100	3043739	6.61%
85+	986800	1237867	25.44%

% of population

ENGLAND	2005	2013	% change
Denominator, all ages	50606000	53865817	6.44%
65-74	8.28%	9.33%	12.66%
75-84	5.64%	5.65%	0.16%
85+	1.95%	2.30%	17.85%

% of >65yo population

ENGLAND	2005	2013	% change
Denominator, o65s	8031000	9305179	15.87%
65-74	52%	54%	3.50%
75-84	36%	33%	-7.99%
85+	12%	13%	8.27%

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3
Objectives	3	State specific objectives, including any pre-specified hypotheses	Page 3
Methods			
Study design	4	Present key elements of study design early in the paper	Page 3-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 3-4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Page 4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 4, Appendix 1
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 4, Appendix 1
Bias	9	Describe any efforts to address potential sources of bias	Page 4, Appendix 2
Study size	10	Explain how the study size was arrived at	Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 3-4, Appendix 1
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 4
		(*b*) Describe any methods used to examine subgroups and interactions	Page 4
		(*c*) Explain how missing data were addressed	Page 4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	Page 4

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 4
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 4
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	Page 4-5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 4-5
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 5-7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 7
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 5-7
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 5-7
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 8

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.