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Original Article

Factors associated with length of stay in hospital for men and women aged 85 and over: A quantile regression approach

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ABSTRACT

Objectives: Explore characteristics of hospital use for adults aged 85 and over in their last year of life and examine factors associated with cumulative overnight length of stay (LOS).
Data source/study setting: NSW 45 and Up Study linked with hospital data.
Study design: Longitudinal cohort study.
Methods: Quantile regression models were performed for men and women ($N = 3145$) to examine heterogeneity in predictors of overnight hospital admissions. Coefficients were estimated at the 25th, 50th, 75th and 90th percentiles of the LOS distribution.
Principal findings: 86% had at least one hospitalisation in their last year of life, with 60% dying in hospital. For men, first admission for organ failure was associated with a 26 day increase at the 90th LOS percentile, and a 0.22 day increase at the 10th percentile compared to men with cancer. Women admitted with influenza had decreased LOS of 20.5 days at the 75th percentile and 6 to 8 fewer days at the lower percentiles compared to those women with cancer.
Conclusions: Poor health behaviours were a major driver of highest LOS among older men, pointing to opportunities to achieve health care savings through prevention. For older women, influenza was associated with shorter LOS, which could be an indicator of the high and rapid mortality rates at older ages, and may be easily prevented. Other factors associated with LOS among women, included where they lived before they were admitted, and discharge destination.

1. Introduction

Projected increases to life expectancy will see a large portion of the global population living to very old age [1]. In Australia, the proportion of adults living beyond 85 years is expected to increase by 40% in the next 40 years [2]. Currently, hospitalisations are the prime contributor to healthcare expenditure and hospital spending is increasing faster than inflation [3].

While older adults have often been identified as high hospital users [4], others have argued that proximity to death rather than chronological age is responsible for increased health service use [5]. International research has found that among people aged 65 years or over at the time of death, up to 80% were hospitalised at least once in the six months prior to death, with 37% of hospital use concentrated in the last month of life [6,7]. It has been argued that length of stay (LOS) in the very old is influenced by patient, provider and systemic factors. Gender in particular may play a role in the frequency and length of hospital admissions in this population. Findings from a Finnish study of adults aged 90 and over found that men were admitted to hospital as often as women but spent fewer days on average in hospital compared to women (19 v 46 days) [8]. When specifically focused on end of life, Abarshi and colleagues [9] found that 50% of men had a care transition in the last month of life compared to 40% of women with the most frequent trajectory being home-to-hospital (48%).

Admission to hospital at the end of life has also been found to differ according to cause of death (COD). One study found that people who died of cancer were admitted 108 days prior to death and those who died of causes other than cancer were admitted 83 days prior to death

Abbreviations: LOS, Length of stay; NSW, New South Wales; BMI, Body mass index; ICD-10, International Statistical Classification of Diseases and Related Health Problems (10th revision); COD, Cause of death; OLS, Ordinal least square; IQR, Inter-quartile range

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[10]. More recently, we were able to demonstrate the compression of hospital use over the last 12 months of life for five causes of death for older people [11]. We found women who died of cancer, diabetes and 'other' causes were admitted to hospital earlier than those who died of organ failure, dementia and influenza. Likewise, women who died of diabetes were most likely to have an acute level LOS in the last year of life ($\leq$5.8 days), while those who died of dementia were most likely admitted for a medium level LOS ($>$ 5.8 days and $\leq$ 11.9 days) and those that died of cancer or organ failure were most likely to be admitted for a LOS consistent with palliative care ($\geq$11.9 days). More generally, increased hospitalisations among older adults have been found to be associated with self-rated health [12], obesity, smoking [13], geriatric problems [14], sociodemographic characteristics [15] and functional capacity [16,17] [18].

Improving end of life care is a global public health priority [19]. Hospitalisations at the end of life are undesirable and associated with poorer outcomes for patients and families [20,21]. Age has been found to significantly impact on clinical decision-making practices, with non-treatment decisions most frequently made for adults aged 80 and over [22]. Very old adults are less likely to receive specialist palliative care and have poorer symptom control than younger adults [23]. Yet, up to 60% of older people admitted to hospital in the last year of life have been found to die in hospital [24]. Therefore an understanding of factors contributing to hospital use at the end of life for very old adults is required. This study uses administrative datasets linked with population health data to characterise hospital use and examine factors associated with cumulative overnight hospital LOS for men and women aged 85 years and over in their last year of life. It is hypothesised that factors such as chronic condition at first admission and care transition at discharge will influence LOS and that there will be heteroscedasticity of effect across different quantiles. Further, since men and women have different health care needs and health care use, we conducted the analyses separately for men and women.

2. Methods

2.1. Data collection and data source

This study involved data from the Sax Institute's 45 and Up Study linked via a master linkage key to the New South Wales (NSW) Admitted Patient Data Collection and the Register of Births, Deaths and Marriages. The 45 and Up Study is a population-based Australian health study comprising 267,153 NSW residents aged 45 and over (representing 10% of the population in that age bracket). Participants were randomly sampled from the Department of Human Services enrolment database (formerly Medicare Australia) in 2006, with a deliberate oversampling of participants aged $\geq$80 years and those from rural and remotes areas [25].

The Admitted Patient Data Collection contains records of all admitted patients services provided by NSW public and private hospitals. The data contain information about hospital inpatients' admission and separation details including principal cause of hospitalisation, procedures performed, and LOS in hospital [26]. For all 45 and Up study participants, Admitted Patient Data Collection data were extracted from 1 July 2004 until 30 June 2012. Probabilistic linkage to the administrative datasets were performed by the Centre for Health Record Linkage unit, with a false positive rate of 5/1000 records (0.5%) (http://www.cherel.org.au) using commercially available software (ChoiceMaker; ChoiceMaker Technologies Inc). Data on death was ascertained from the NSW Register of Births, Deaths and Marriages.

2.2. Study population and study design

Of the 267,153 participants within the 45 and Up Study cohort, 9173 were aged 85 years and over at the time of completing the 45 and Up baseline survey. The study consisted of 3145 participants who died between 1 January 2006 and 31 December 2011 aged 85 years and over.

3. Measures

3.1. Outcome variable length of stay (LOS)

Hospital admissions in the last year of life were determined from the Admitted Patient Data Collection. Firstly, LOS was classified as a continuous variable based on the total number of overnight bed days in the last year of life; and secondly as a binary variables (no hospitalisation vs at least one overnight stay in hospital).

3.2. Explanatory variables

Age at death was calculated using the NSW Register of Births, Deaths and Marriages. Sociodemographic and health-related data were measured from the 45 and Up baseline survey [25]. Socio-demographic factors included gender (men, women), marital status (widowed, not widowed including those never married), highest level of education (intermediate level - up to Year 10 schooling or "leaving certificate") reflecting the highest level of education attained by most people in the age group, post-schooling (Year 11–12 schooling, technical education, or University degree)) and country of birth (Australian/non-Australian born). Health behaviours included smoking status (never smoked, ex/current smoker), alcohol consumption (number of alcoholic drinks per week) and walking activity was measured after asking the participants 'In the last week how many times have you walked continuously for about 10 minutes for recreation or exercises or to get to or from places?' (walks per week was divided by 7 to estimate average number of walks in a day, and categorised as none, one walk a day, more than one walk per day), while health status included perceived general health (excellent/very good/good, fair/poor), perceived quality of life (excellent/very good/good, fair/poor), physical functioning (using the SF36-subscales between 0 and 100, where higher scores represent better physical functioning), psychosocial distress measured using the K10-depression scale ($<$ 22 low probability of psychological distress, 22$\leq$30, 30 or more high probability of distress), self-reported doctor's diagnosis of diabetes, hypertension or heart disease separately (yes, no for each), number of falls experienced in the last 12 months (none, 1–2 falls, $>$ 2 falls) and body mass index (BMI) which was calculated from self-report height and weight [27]. Living arrangements (own home/apartment, nursing home, hostel/retirement village) and area of residence. The variables time between the survey and the date of death was also included in the models.

Hospital activity factors selected from the Admitted Patient Data Collection included last known transfer from hospital (died in hospital, transferred to palliative care unit, or transferred to home/other). Reason for first hospitalisation were classified using the principal diagnosis code from each index admission classified to reflect the five main causes of death for this age group: cancer (ICD-10 codes C00-C997, D37, D44.0-D48.7), organ failure (i.e. heart, lung, kidney and liver) (ICD-10 codes I255.5, I42, I50-I51, J43-J44, J47, J61, J84, N18, K74), and Alzheimer's disease/dementia (ICD-10 codes F03, R54, A81, F01, F03, G30). Diabetes (ICD-10 codes E10-E14) was also included as a major cause of morbidity and health care use in this age group, along with influenza/pneumonia (ICD-10 codes J09-J18) as a more acute cause of death [28] [11]. All remaining causes of death were classified as 'other'.

3.3. Ethical approval

The 45 and Up Study was approved by the University of New South Wales Human Research Ethics Committee. Ethical approval for linkage of the 45 and Up Study survey data to the NSW Admitted Patient Data Collection and Register of Births, Deaths and Marriages was received from the NSW Population and Health Services Research Ethics Committee and registered with the University of Newcastle. Participants are non-identifiable and personal information is not disclosed to the researcher.

3.4. Analytical approach

Characteristics of the sample were described using Pearson's χ^2-test of association for the categorical variables. We examined median differences of the continuous dependent variables LOS. Since LOS was not normally distributed the Kruskal-Wallis test of rank sums were used to examine associations with the categorical explanatory variables (significance level of $p < 0.05$ was used for all analyses).

Quantile regression was then used to examine LOS in the last year of life, allowing for a conditional distribution. Quantile regression is a regression model in which a specified conditional quantile of the outcome (LOS) is expressed as a linear or nonlinear function of the covariates in the model [29,30]. Quantile regression focuses inference directly on the specified quantile of interest and does not require distributional assumptions for the outcome of interest. Models were estimated at the 0.10, 0.25, 0.50, 0.75 and 0.90 quantiles. The simplex method within the QuantReg procedure was used to calculate parameter estimates and the rank score method was used to estimate confidence intervals. Firstly, univariate quantile regression models were performed to examine association of each covariate with LOS alone (results not shown) and ordinal least square (OLS) regression models were also performed for comparison purposes.

Separate quantile regression models were constructed for men and women using a model building process: (i) with age at death alone; then adding other explanatory variables (ii) the remaining socio-demographic factors (iii) health behaviours (iv) area of residence and living arrangements (v) health status (vi) hospital activity factors and (vii) time between collection of explanatory data and death. The final models included the covariates age at death, education, country of birth, smoking status, alcohol consumption per week, area of residence, type of housing, last known transfer from hospital, first reason for hospitalisation, self-rated health, k10-score, self-reported doctor's diagnosis of hypertension, heart disease or diabetes, number of falls, physical functioning, and time between collection of explanatory data and death for both men and women. The final models for men also included marital status and number of walks in a day.

Wald tests were implemented to test results of heteroskedasticity for each covariate across each quantile, while the *pseudo*R^2 model fit tests were used to test the goodness of fit for each new model [29] [31]. *Pseudo*R^2 measures were calculated for each quantile in every new model and graphed to measure improvement of the new model's fit in comparison to the previous model. The most adequate model was selected (Supplementary 1). Finally, test for equality of coefficients were performed to compare statistically significant differences in parameter estimates across quantiles for each explanatory variable. Although the association between each explanatory variable and LOS was examined using quantile graphs, only those explanatory variables hypothesised.to influence LOS will be shown. Analyses were performed using SAS, version 9.4 (SAS Institute, Inc., Cary, NC).

4. Results

4.1. Hospital use

Of the 3145 eligible participants, 442 (14%) had no hospitalisations and 2703 (86%) had at least one hospitalisation in their last year of life. The mean, median and 25th and 75th percentiles for all continuous variables are presented in Table 1. The 75th percentile (indicating the minimum value for 25% of the participants) was four for hospital admissions and 39 for overnight bed stays. In comparison, participants at the 25th percentile were admitted to hospital no more than once and had no more than five days in hospital in the last year of life. Participants' ages ranged from 85 to 108 years at death. The 50th percentile was 23.8 for BMI (mean: 24) and 30 for physical functioning (mean 37), indicating that more than a quarter of the participants were overweight (BMI > 25) and more than half had significant functional limitation (physical functioning < 40).

Table 2 shows the distribution of sociodemographic and health status characteristics according hospital stay. There were proportionally more men among those who had hospital admission(s) in their last year of life than among those with no admission (57% vs 48%, $p = 0.0006$), more participants who had a number of walks per week (54% vs 47%, $p = 0.02$) and whose housing type was own home/apartment (77% vs 66%, $p \leq 0.001$), respectively. However, there were significantly fewer participants with moderate psychosocial distress scores associated with hospital stay in the last year of life (10% vs 7%, $p = 0.047$).

For those 2703 participants who had an admission to hospital in their last year of life statistically significant differences were found with regard to median LOS and gender (males (33.2 (23.0)) vs females (30.3 (20.0)), $p = 0.013$), smoking status (non-smoker (30.6 (20.0) vs ex/current smoker (33.4 (23.0)), $p = 0.035$), number of falls in the last 12 months (none (31.1 (21.0)) vs one to two (31.8 (21.0)) vs more than one (25.7 (26.3)), $p = 0.046$), reason for first hospitalisation ($p < 0.001$), last known transfer from hospital ($p < 0.001$) and housing type ($p < 0.001$) (Column 5 of Table 2).

Almost one quarter of participants having a hospital stay in the last year of life were first admitted for a diagnosis related to organ failure (22.9%) and almost one sixth due to cancer (17.1%). Participants first admitted to hospital for organ failure or diabetes were more likely to have a longer median LOS in hospital. Additionally, around 60% of participants who were admitted to hospital in their last year of life died in hospital. However, participants transferred to palliative care were more likely to have a longer mean LOS in hospital compared to participants transferred to their own residence or another accommodation or for those dying in hospital. In contrast, participants living in a hostel/retirement home were more likely to have a shorter median LOS in hospital in the last year of life compared to those living independently or in a nursing home.

Tables 3 and 4 summarise findings from the least square regression (OLS) and quantile regression models for the selected percentiles (10th, 25th, 50th (median), 75th and the 90th) for the distribution of LOS, for men and women. Fig. 1 has been provided to illustrate the LOS associated with last known transfer and reason for first hospitalisation, showing different associations for the different conditions. Importantly, the contribution of each explanatory variable is shown by the size of the estimate and its positive (days increase) or negative (decrease in LOS days) influence on the outcome. For the OLS regression models (Tables 3 and 4: column 2) LOS in hospital was associated with last known transfer from hospital for both men and women, while covariates age at death, post-school education, alcohol consumption per week, reason for first hospitalisation organ failure, and death in hospital were also statistically significant for men ($p < 0.001$), and living in a major city was significant for women (Est: −9.03, 95%CI: (−16.84, −1.22), $p < 0.001$).

In men (Tables 3), the main difference between smokers is at the extreme values with little or no difference between smokers and non-smokers in the middle of the distribution. The 90th percentile of the LOS distribution differs of 11 days with smokers having longer LOS while the 10th percentile of the LOS distribution is two day longer for non-smokers. The LOS distribution in smokers is more skewed to the right and with greater variation than that of smokers, turning to the equivalent table for women (Table 4), the effects of smoking are less apparent.

Poor self-rated health in men is associated with longer LOS but mostly for long LOS. This means that the distribution of LOS becomes more skewed to the right for people that rate their health poor with

Table 1
Summary statistics for continuous covariates ($N = 3145$).

Variable	Mean	Minimum	25th percentile	50th percentile (Median)	75th percentile	Maximum
Length of stay days	27.5	0	5	17	39	359
Number of hospitalisations	2.7	0	1	2	4	25
Alcohol consumption per week	4.4	0	0	0	7	84
Time between collection of explanatory data and death	27.6 months	1 day	16.8 months	27.6 months	37.2 months	69.6 months
Body mass index (10–54)	24	12.1	21.3	23.8	26.6	46.6
Physical functioning (0 − 100)	37.4	0	7.1	30	65	100
Age at death	89.9	85	87	89	92	108

Table 2
Summary statistics for categorical covariates by hospitalisation event and length of stay.

	No hospitalisation $N = 442$ (14.1%) N (%)	Hospitalisations $N = 2703$ (85.9%) N (%)	χ^2-test P-value	Length of stay in hospital[b] N = 2703 Mean (Median)	Kruskal-Wallis test P-value
Gender					
Male	214(48.4)	1546 (57.2)	< 0.001	33.2 (23.0)	0.013
Female	228(51.6)	1157 (42.8)		30.3 (20.0)	
Education					
Intermediate level	216(51.1)	1299 (50.6)	0.873	31.2 (21.0)	0.052
Post-school	207(48.9)	1266 (49.4)		32.9 (23.0)	
Smoking status					
Non-smoker	242(54.9)	1419 (52.7)	0.399	30.6 (20.0)	0.035
Ex/current smoker	199(45.1)	1273 (47.3)		33.4 (23.0)	
K10-Score					
< 22	355 (88.1)	2227 (91.0)	0.047	32.2 (22.0)	0.302
22- < 30	40 (9.9)	161 (6.6)		28.5 (18.0)	
30 or More	8 (2.0)	60 (2.5)		33.6 (20.0)	
General health					
Good/excellent	229(57.4)	1336 (54.4)	0.265	31.1 (21.0)	0.083
Fair/poor	170(42.6)	1120 (45.6)		32.9 (22.0)	
Quality of life					
Good/excellent	229 (57.4)	1465 (62.3)	0.289	31.1 (21.0)	0.083
Fair/poor	170 (42.6)	886 (37.7)		32.9 (22.0)	
Falls					
None	215(52.8)	1384 (56.0)	0.295	31.1 (21.0)	0.046
One to two	111(27.3)	669 (27.1)		31.8 (21.0)	
More than two	81(19.9)	418 (16.9)		25.7 (26.5)	
Walks in a day					
None	178 (45.2)	945 (37.9)	0.020	33.4 (22.0)	0.495
One walk a day	185 (47.0)	1347 (54.0)		30.6 (22.0)	
More than one	31 (7.9)	201 (8.1)		31.1 (21.0)	
Principal diagnosis for first hospitalisation[a]					
Cancer	-	462 (17.1)	n/a	29.5 (21.5)	0.001
Influenza	-	182 (6.7)		28.3 (17.5)	
Organ failure	-	620 (22.9)		35.4 (23.5)	
Dementia/Alzeihmer's	-	172 (6.4)		27.4 (16.5)	
Diabetes	-	122 (4.5)		34.8 (27.5)	
Other	-	1145 (42.4)		32.1 (22.0)	
Last known transfer from hospital[a]					
Other/home	-	772 (28.6)		27.4 (18.0)	< 0.001
Died in hospital	-	1575 (58.3)		32.1 (22.0)	
Palliative care	-	356 (13.2)		41.3 (32.0)	
Housing type					
Own home/apartment	286(66.4)	2048 (77.0)		32.9 (22.0)	
Hostel/retirement village	36(8.4)	62 (2.3)	< 0.001	19.1 (10.5)	< 0.001
Nursing home	109(25.3)	550 (20.7)		29.5 (22.0)	

n/a represents no chi-squared test was performed between groups.
[a] Only for the subgroup of the sample who had at least one hospital admission.
[b] Represent Length of Stay for only participants who had a hospitalisations in the last year of life.

respect to those who rate their health excellent. Men who rate their health fair/poor have longer LOS in the upper percentile compared to women at the 50th, 75th and 90th percentile with fair/poor health who have 3, 6 and 8 days shorter LOS than women with excellent self-rated health. Men living in major cities had longer length of stay compared to those who lived in outer regional/very remote areas across all quartiles. In addition men at the 50th and 90th percentile who lived in major cities have 5 and 9 days longer LOS than men in outer regional/very remote areas. However, men at the 75th and 90th percentile who live in inner regional areas have 7 days shorter LOS than men in outer regional/very remote areas (Table 3). Similar to men, for women living in major cities the distribution of LOS becomes more skewed to the right. At the 50th, 75th and 90th percentile women living in major cities have at least 3 days longer LOS compared to women in outer regional/very remote areas. Alternatively, women living in inner regional areas at the 75th and 90th percentile had at least 8 days shorter LOS than women in outer regional/very remote areas (Table 4).

For men in the 75th percentile of LOS, those who died in hospital or

Table 3
Difference in total LOS for men estimated with OLS and quantile regression for different level of the covariates.

Covariate and category	OLS model Est (95%CI)[a]	10th Percentile Est (95%CI)[a]	25th Percentile Est (95%CI)[a]	50th Percentile Est (95%CI)[a]	75th Percentile Est (95%CI)[a]	90th Percentile Est (95%CI)[a]	Test for Equality
Age at death	−0.83 (−1.54–0.12)[b]	−0.14 (−0.27–0.02)[b]	−0.31 (−0.54–0.08)[b]	−0.34 (−0.94 0.26)	−1.16 (−1.81–0.52)[b]	−1.4 (−3.05 0.24)	0.011[b]
Education							
School level	Reference	Reference	Reference	Reference	Reference	Reference	
Post-school level	6.22 (1.49 10.95)[b]	0.95 (−0.09 1.98)	0.61 (−0.94 2.16)	3.98 (0.01 7.96)[b]	5.05 (−0.53 10.62)	9.9 (−0.22 20.02)	0.202
Marital status							
Not widowed	Reference	Reference	Reference	Reference	Reference	Reference	
Widowed	3.19 (−1.44 7.82)	−0.08 (−0.9 0.74)	0.39 (−1.53 2.31)	1.98 (−2 5.96)	1.49 (−3.5 6.47)	3.27 (−7.31 13.85)	0.873
Country of birth							
Non-Australian	Reference	Reference	Reference	Reference	Reference	Reference	
Australian	2.56 (−2.23 7.35)	0.47 (−0.35 1.28)	1.22 (−0.43 2.88)	4.29 (0.32 8.26)[b]	2.9 (−2.2 7.99)	6.55 (−3.56 16.66)	0.350
Smoking status							
Ex/current smoker	Reference	Reference	Reference	Reference	Reference	Reference	
Never smoked	−2.16 (−6.99 2.67)	1.62 (0.68 2.55)[b]	0.21 (−1.49 1.9)	−0.82 (−5.23 3.59)	−0.86 (−5.82 4.1)	−10.81 (−20.39–1.24)[b]	0.047[b]
Alcohol consumption per week	−0.36 (−0.63–0.09)[b]	−0.05 (−0.1 0)[b]	−0.11 (−0.2–0.01)[b]	−0.14 (−0.3 0.02)	−0.34 (−0.66–0.03)[b]	−0.43 (−0.97 0.12)	0.369
Self-rated health							
Excellent/good health	Reference	Reference	Reference	Reference	Reference	Reference	
Fair/poor health	−0.15 (−5.39 5.09)	0.15 (−0.87 1.17)	1.46 (−0.49 3.41)	1.87 (−2.68 6.43)	5.3 (−1.25 11.85)	5.44 (−7.45 18.32)	0.373
Area of residence							
Outer/remote/very remote	Reference	Reference	Reference	Reference	Reference	Reference	
Major cities	0.14 (−7.26 7.54)	0.5 (−0.58 1.59)	2.54 (0.45 4.64)[b]	4.95 (−4.32 14.22)	1.65 (−8.2 11.5)	8.82 (−4.11 21.75)	
Inner regional	−5.04 (−13.16 3.08)	1.07 (−0.13 2.28)	0.93 (−1 2.86)	−1.27 (−10.47 7.92)	−7.46 (−18 3.08)	−6.58 (−23.48 10.33)	0.011[b]
Type of housing							
Own/hostel/retirement village	Reference	Reference	Reference	Reference	Reference	Reference	
Nursing home	−4.42 (−10.46 1.62)	0.67 (−0.78 2.12)	0.5 (−1.6 2.6)	−3.18 (−7.8 1.43)	−0.18 (−5.73 5.37)	−7.7 (−18.98 3.58)	0.212
Last known transfer from hospital							
Palliative Care/nursing home	Reference	Reference	Reference	Reference	Reference	Reference	
Died in hospital	−10.86 (−17.79–3.93)[b]	−4.85 (−6.02–3.68)[b]	−7.62 (−10.24–4.99)[b]	−11.86 (−20.67–3.04)[b]	−18.97 (−25.88–12.06)[b]	−11.77 (−32.89 9.34)	
Other	−16.83 (−24.31–9.35)[b]	−6.34 (−7.39–5.3)[b]	−9.89 (−12.75–7.04)[b]	−15.83 (−24.71–6.95)[b]	−22.39 (−29.84–14.94)[b]	−17.11 (−38.86 4.64)	< 0.001[b]
First reason for hospitalisation							
Cancer	Reference	Reference	Reference	Reference	Reference	Reference	
Dementia	−2.59 (−14.05 8.87)	−1.59 (−3.3 0.13)	−5.62 (−8.85–2.38)[b]	−3.49 (−11.26 4.27)	0.17 (−8.74 9.08)	−9.79 (−24.35 4.77)	
Diabetes	5.76 (−7.66 19.18)	0.93 (−1.16 3.02)	−1.59 (−8.17 4.98)	7.92 (−8.62 24.46)	14.32 (−2.13 30.76)	21.26 (−31.35 73.87)	
Influenza	−0.21 (−9.59 9.17)	0.68 (−0.95 2.31)	−3.12 (−6.07–0.17)[b]	2.38 (−5.32 10.08)	2.02 (−5.9 9.95)	3.01 (−16.49 22.52)	
Organ failure	11.46 (4.53 18.39)[b]	1 (−0.91 2.91)	0.22 (−3.2 3.65)	5.28 (−0.1 10.66)	14.34 (3.55 25.12)[b]	25.87 (8.82 42.91)[b]	
Other	4.54 (−1.68 10.76)	−2.16 (−3.44–0.87)[b]	−4.11 (−6.86–1.36)*	2.36 (−2.57 7.28)	6.55 (−0.53 13.63)	12.52 (1.02 24.03)*	0.001*
K10-Score							
< 22	Reference	Reference	Reference	Reference	Reference	Reference	
≥ 22 to high	−4.81 (−13.38 3.76)	−0.19 (−1.28 0.91)	−1.65 (−3.83 0.53)	−7.34 (−14.29–0.4)[b]	−8.78 (−17.35–0.2)[b]	−3.02 (−20.74 14.69)	0.149
Diagnosis of hypertension							
No	Reference	Reference	Reference	Reference	Reference	Reference	
Yes	−0.33 (−4.84 4.18)	−1.4 (−2.25–0.55)[b]	−1.59 (−3.2 0.03)	−2.1 (−5.94 1.73)	0.97 (−4.51 6.45)	0.33 (−9.22 9.89)	0.793
Diagnosis of heart disease							
No	Reference	Reference	Reference	Reference	Reference	Reference	
Yes	−3.67 (−8.4 1.06)	0.36 (−0.57 1.3)	0.7 (−1.02 2.43)	0.58 (−3.28 4.45)	−4 (−9.27 1.28)	−13.26 (−22.69–3.83)[b]	0.042[b]
Diagnosis of diabetes							
No	Reference	Reference	Reference	Reference	Reference	Reference	
Yes	−0.97 (−7.86 5.92)	0.94 (−0.58 2.47)	−0.5 (−2.25 1.24)	−2.61 (−8.65 3.42)	−5.87 (−19.06 7.32)	−1.04 (−13.78 11.69)	0.446
Number of falls in the last 12 months							
None	Reference	Reference	Reference	Reference	Reference	Reference	
One to two	−2.23 (−7.55 3.09)	−0.57 (−1.52 0.37)	−0.37 (−1.94 1.2)	−0.92 (−5.62 3.77)	3.68 (−2.32 9.68)	10.22 (−2.22 22.66)	
More than two	5.58 (−1.09 12.25)	0.2 (−0.88 1.27)	3.07 (−1.18 7.31)	5.48 (−0.24 11.21)	4.91 (−4.18 13.99)	9.65 (−9.5 28.8)	0.343
Number of walks in a day							
None walks	Reference	Reference	Reference	Reference	Reference	Reference	

(*continued on next page*)

Table 3 (*continued*)

Covariate and category	OLS model Est (95%CI)[a]	10th Percentile Est (95%CI)[a]	25th Percentile Est (95%CI)[a]	50th Percentile Est (95%CI)[a]	75th Percentile Est (95%CI)[a]	90th Percentile Est (95%CI)[a]	Test for Equality
One walk a day	−2.23 (−7.55 3.09)	−0.81 (−1.79 0.16)	1.16 (−0.79 3.11)	−3.11 (−8.08 1.86)	−4.67 (−11.35 2.01)	−7.72 (−19.61 4.17)	
More than one	0.83 (−7.69 9.35)	0.16 (−1.48 1.81)	2.06 (−0.75 4.87)	−3.8 (−9.96 2.36)	0.05 (−11.41 11.52)	3.04 (−27.25 33.32)	0.043[b]
SF36 Physical functioning	−0.08 (−0.18 0.02)	0 (−0.01 0.02)	0 (−0.03 0.04)	−0.02 (−0.1 0.06)	−0.04 (−0.14 0.06)	−0.15 (−0.36 0.05)	0.656
Time between collection of explanatory data and death	0.001 (0 0)	0 (0 0)	0 (0 0)	0 (0 0)	0 (0 0.01)	0 (−0.01 0.01)	0.945

[a] Est = estimate; 95%CI = 95% confidence interval

[b] Indicates statistically significant in the model using the Wald test

were transferred to another residence had a decrease in LOS of around 19 days [95%CI: −22.5, −15.5) and 22 days [95%CI: −26.2, −18.6), respectively, compared to men transferred to a palliative care or nursing home unit (Table 3). Similarly, for women in the 75th percentile last known transfer to another residence was associated with a 16 day decrease [95%CI: −22.6, −9.7) in LOS days compared to women transferred to a palliative care unit (Table 4). Significant reductions in LOS were also seen for all other percentiles, except for the 90th percentile. Fig. 1a and b further illustrate, the strength of the effect of last known transfer from hospital.

There was reduced LOS if the first admission was for dementia for those in the lower LOS quantiles for men and women, increased LOS for organ failure across the upper quantiles (75th and 90th percentile) of LOS for men (seen in Table 3 and Fig. 1c), and decreased LOS for influenza across most of the range of LOS for women (Table 4, Fig. 1d). Men first admitted to hospital for organ failure had a 25.9 day [95%CI: 17.2, 34.6) higher LOS in hospital in the 0.90 quantile but only a 0.22 day [95% CI: −1.53, 1.97) higher LOS in hospital at the 0.25 quantile compared to men first admitted to hospital in the last year of life with cancer (Table 3). There was no significant difference in LOS for women admitted with organ failure (Table 4). Women, with a first admission to hospital for influenza in the last year of life had a decrease in LOS in all but the 90th percentile. First admission to hospital with influenza was associated with a 20.5 [95%CI: −37.8, −3.2) days lower LOS in hospital at the 0.75 quantile and a decrease of 6 to 9 days LOS at the lower quantiles compared to women first admitted for cancer (Table 4).

Differences in LOS across gender are seen. Men with heart disease have 13 days shorter LOS at the 90th percentile compared to men without heart disease. Alternatively, the distribution of LOS has a reverse u-shape for women with heart disease, with those women at the 50th and 75th percentile having at least 4 days longer LOS than those without heart disease. However, women at the 25th and 90th percentile had at most 3 days longer LOS than women without heart disease. In addition, men with diabetes have 6 days shorter LOS at the 75th percentile compared to men without diabetes, while women with diabetes have 2 days longer LOS at the 75th percentile compared to women without diabetes.

Furthermore, while men who have at least one fall in the last 12 months have 4 to 10 days longer LOS in the upper percentiles (75th and 90th, respectively) than those not having a fall. These results are similar for women at the upper percentiles who have at least one fall in the last 12 months having up to 5 days longer LOS than women not having a fall.

For men, test results for equality of coefficients were significantly different across the quantiles for age at death ($p = 0.011$), area of residence ($p = 0.011$), last known hospital transfer ($p < 0.001$), first reason for hospitalisation ($p = 0.001$) and physical activity ($p = 0.03$) (Table 3). For women test results for equality of coefficients were significantly different across the quantiles for alcohol consumed in a week ($p = 0.035$), area of residence ($p = 0.013$), last known type of residence ($p = 0.002$), having a diagnosis for heart disease ($p = 0.011$) and physical activity ($p = 0.03$) were significantly different (Table 4). Additionally, first reason for hospitalisation showed significant heteroskedasticity across the entire distribution for men ($p = 0.001$) but not for women ($p = 0.376$). While the overall test for equality was not significant, the length of stay for the 90th percentile was around 8.5 days higher for women in poor health than for those in good health. Likewise, for men in the 90th percentile, heart disease was associated with shorter length of stay. However, in many other cases, comparisons of the estimates for each percentile show wide confidence intervals and include zero.

5. Discussion

Admission to hospital in the last year of life for older members of the

Table 4
Difference in LOS for women estimated with OLS and quantile regression for different level of the covariates.

	OLS model Est (95%CI)[a]	10th Percentile Est (95%CI)[a]	25th Percentile Est (95%CI)[a]	50th Percentile Est (95%CI)[a]	75th Percentile Est (95%CI)[a]	90th Percentile Est (95%CI)[a]	Test for equality
Age at death	−0.29 (−0.92, 0.34)	−0.1 (−0.19, −0.01)[b]	−0.23 (−0.41, −0.04)[b]	−0.56 (−0.99, −0.13)[b]	−0.53 (−1.43, 0.37)	−1.23 (−2.54, 0.08)	0.126
Education							
School level	Reference	Reference	Reference	Reference	Reference	Reference	
Post-school level	1.55 (−3.47, 6.57)	1.41 (0.63, 2.19)[b]	0.78 (−1.0, 2.55)	0.3 (−3.24, 3.83)	3.5 (−4.0, 11.0)	3.53 (−5.23, 12.28)	0.741
Country of birth							
Non-Australian	Reference	Reference	Reference	Reference	Reference	Reference	
Australian	0.83 (−4.35, 6.01)	−0.2 (−1.07, 0.66)	−2.99 (−5.71, −0.27)[b]	−2.26 (−6.28, 1.76)	1.89 (−5.19, 8.98)	0.92 (−7.81, 9.65)	0.131
Smoking status							
Ex/current smoker	Reference	Reference	Reference	Reference	Reference	Reference	
Never smoked	−0.93 (−6.36, 4.5)	−0.95 (−2.15, 0.25)	−1.69 (−3.38, 0)	1.66 (−2.08, 5.4)	−2.49 (−10.85, 5.86)	2.04 (−6.64, 10.72)	0.090
Alcohol consumption per week	0.42 (−0.07, 0.91)	−0.08 (−0.17, 0.01)	−0.12 (−0.37, 0.12)	0.44 (−0.19, 1.08)	0.85 (0.13, 1.58)[b]	0.78 (0.28, 1.28)[b]	0.035[b]
Self-rated heath							
Excellent/good health	Reference	Reference	Reference	Reference	Reference	Reference	
Fair/Poor health	−2.62 (−7.88, 2.64)	0.7 (−0.22, 1.61)	0.08 (−1.55, 1.71)	−3.22 (−7.2, 0.76)	−5.81 (−13.75, 2.14)	−8.46 (−16.24, −0.67)[b]	0.086
Area of residence							
Outer/remote/very remote	Reference	Reference	Reference	Reference	Reference	Reference	
Major cities	−9.03 (−16.84, −1.22)	0.5 (−0.53, 1.53)	1.72 (−0.56, 4.01)	3.47 (−1.17, 8.11)	2.85 (−8.1, 13.8)	4.53 (−19.79, 28.85)	
Inner regional	−4.21 (−11.1, 2.68)	0.88 (−0.49, 2.25)	0.51 (−2.1, 3.12)	0.93 (−3.62, 5.48)	−7.99 (−19.19, 3.2)	−12.74 (−37.88, 12.4)	0.013[b]
Type of housing							
Own/hostel/retirement village	Reference	Reference	Reference	Reference	Reference	Reference	
Nursing home	−3.23 (−8.61, 2.15)	1.37 (0.54, 2.21)[b]	−0.27 (−1.71, 1.16)	0.08 (−4.15, 4.3)	−2.54 (−9.42, 4.34)	−13.87 (−23.15, −4.58)[b]	0.002[b]
Last place known for transfer from hospital							
Palliative care, nursing home	Reference	Reference	Reference	Reference	Reference	Reference	
Died in hospital	−6.34 (−13.29, 0.61)	−3.24 (−5.56, −0.92)[b]	−7.63 (−12.02, −3.25)[b]	−8.29 (−13.94, −2.64)[b]	−11.94 (−24.12, 0.23)	−10.52 (−22.57, 1.53)	
Other	−11.57 (−18.99, −4.15)[b]	−3.95 (−6.22, −1.67)[b]	−9.64 (−14.09, −5.19)	−11.6 (−17.4, −5.8)	−16.13 (−28.79, −3.47)[b]	−14.15 (−27.39, −0.92)[b]	0.100
First reason for hospitalisation							
Cancer	Reference	Reference	Reference	Reference	Reference	Reference	
Dementia	1.19 (−8.76, 11.14)	−2.61 (−3.82, −1.41)	−4.31 (−6.71, −1.91)[b]	−6.38 (−12.4, −0.37)[b]	−9.72 (−22.61, 3.18)	1.75 (−20.98, 24.48)	
Diabetes	−3.19 (−17.43, 11.05)	−0.89 (−5.44, 3.65)	−2.5 (−7.09, 2.09)	−4.07 (−15.56, 7.43)	1.17 (−16.48, 18.82)	−5.47 (−22.39, 11.45)	
Influenza	−10.38 (−22.39, 1.63)	−5.81 (−7.42, −4.2)	−7.77 (−11.21, −4.32)	−8.75 (−15.29, −2.21)[b]	−20.52 (−37.85, −3.18)[b]	−8.74 (−24.48, 7.01)	
Organ failure	−1.14 (−9.3, 7.02)	−1.5 (−3.28, 0.29)	−0.45 (−3.18, 2.28)	−1.04 (−6.69, 4.61)	−2.93 (−14.28, 8.42)	5.67 (−5.22, 16.56)	
Other	−1.01 (−8.17, 6.15)	−3.23 (−4.23, −2.22)[b]	−3.02 (−4.87, −1.16)[b]	−2.23 (−7.28, 2.83)	−3.5 (−13.43, 6.43))	6.47 (−2.89, 15.82)	0.376
K10-score							
< 22	Reference	Reference	Reference	Reference	Reference	Reference	
≥ 22 to high	−1.6 (−8.9, 5.7)	0.44 (−0.4, 1.28)	0.41 (−1.67, 2.49)	0.36 (−5.38, 6.1)	−0.6 (−10.98, 9.77)	−1.86 (−17.99, 14.28)	0.999
Diagnosis of hypertension							
No	Reference	Reference	Reference	Reference	Reference	Reference	
Yes	1.29 (−3.42, 6.00)	0.39 (−0.44, 1.22)	1.34 (−0.23, 2.92)	2.27 (−1.41, 5.95)	0.91 (−6.47, 8.29)	2.42 (−5.96, 10.8)	0.627
Diagnosis of Heart disease							
No	Reference	Reference	Reference	Reference	Reference	Reference	
Yes	2.73 (−2.10, 7.56)	0.75 (−0.1, 1.6)	3.28 (1.28, 5.28)[b]	6.98 (2.97, 10.99)[b]	6.65 (−0.49, 13.8)	2.5 (−5.9, 10.91)	0.011[b]
Diagnosis of diabetes							
No	Reference	Reference	Reference	Reference	Reference	Reference	
Yes	−0.08 (−7.65, 7.49)	−1.53 (−2.89, −0.18)[b]	−0.68 (−3.72, 2.36)	−1.28 (−6.49, 3.93)	1.68 (−8.39, 11.74)	−1.71 (−11.44, 8.03)	0.897
Falls in the last 12 months							
None	Reference	Reference	Reference	Reference	Reference	Reference	
One to two	2.69 (−2.65, 8.03)	−0.46 (−1.54, 0.61)	−0.28 (−2.3, 1.74)	1.95 (−2.1, 6)	4.66 (−3.73, 13.05)	4.8 (−4.21, 13.8)	
More than two	1.71 (−4.88, 8.3)	0.93 (0.07, 1.8)[b]	0.03 (−2.11, 2.16)	3.89 (−2.08, 9.86)	4.96 (−4.95, 14.86)	0.16 (−12.83, 13.16)	0.569
SF36 physical functioning	−0.07 (−0.17, 0.03)	0.01 (−0.01, 0.03)	−0.01 (−0.04, 0.02)	0.0 (−0.07, 0.08)	−0.07 (−0.21, 0.07)	−0.14 (−0.29, 0.01)	0.186

(continued on next page)

Table 4 (*continued*)

	OLS model Est (95%CI)[a]	10th Percentile Est (95%CI)[a]	25th Percentile Est (95%CI)[a]	50th Percentile Est (95%CI)[a]	75th Percentile Est (95%CI)[a]	90th Percentile Est (95%CI)[a]	Test for equality
Time between collection of explanatory data and death	0.003 (0.00, 0.01)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.01)	0.0 (−0.01, 0.01)	0.0 (−0.01, 0.01)	0.562

[a] Est = estimate; 95%CI = 95% confidence interval
[b] indicates statistically significant in the model using the Wald test

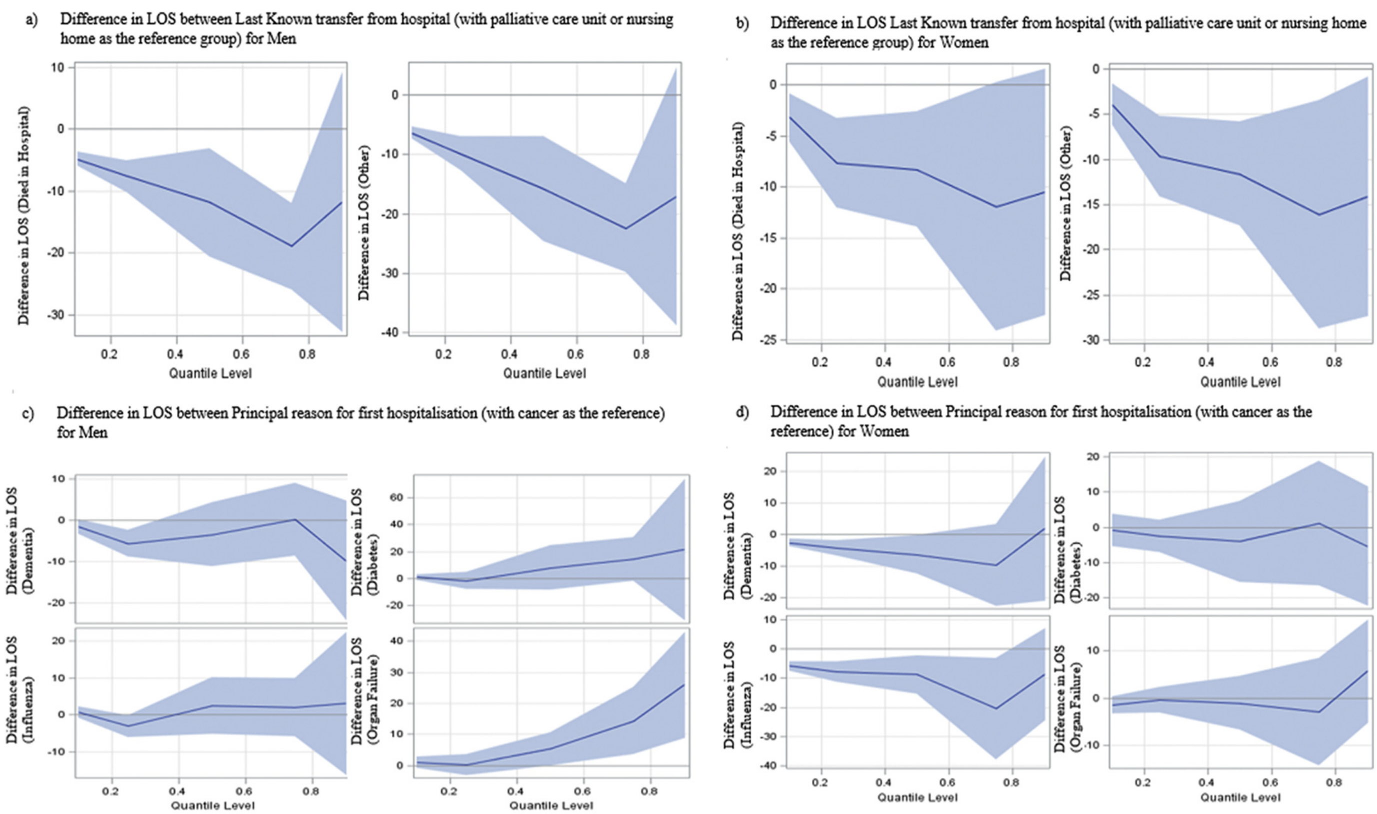
community has been identified as an escalating problem and the health care cost to government continuing to rise as the proportion of the population aged 85 years and over increases [32]. By linking the 45 and Up Study data to the NSW Admitted Patient Data Collection and Births, Deaths and Marriages Registry dataset we were able to examine factors associated with overnight hospital stay in the last year of life for men and women aged 85 years and over. We found heterogeneity in terms of the number of admissions and length of stay in the last year of life, with different associations across the distribution of LOS. Factors that increased length of stay are smoking (for men), alcohol consumption (for men), fair/poor self-rated health, area of residence, transfer (with shorter length of stay for those in palliative or residential care), reason for first admission, and other underlying conditions particularly heart disease.

One Australian study showed at least 17% of people aged 65 years and older had no hospitalisation in their last year of life [33]. These findings are similar to our study where 15% older adults in the study had avoided any hospitalisation in the last year of their life, with men disproportionately represented among those admitted to hospital. When examining hospitalisations, over half of the admitted participants died in hospital, reflecting other studies examining hospital use in the last year of life [11,32]. Age at death was associated with lower LOS across all quantiles for men and in the lower quantiles for women. This finding is consistent with another study which found that hospital costs for the last year of life reduced with increasing age at death, with people aged 95 years of over incurring less than half the average cost of people who died age 65–74 years [34]. Similar findings have also been reported in the Netherlands [35], Denmark [36] and Switzerland [37]. While well tested in many settings, it is important to underscore this finding to mitigate arguments about the impact of population ageing on health care costs.

An important factor may be COD, with conditions such as organ failure driving higher LOS. Among men in our study, those who presented to hospital in the last year of life with organ failure were more likely to have longer LOS in hospital in the last year of life compared to participants with first admission to hospital for cancer. These findings extend on current literature which demonstrated longer LOS due to other chronic conditions (circulatory system) compared to cancer [32,33]. Additionally, our study found a stronger effect on LOS in hospital for men than for women if the first admission to hospital was for organ failure. Chronic disease is a major driver of health care costs at all ages, which is driven by health behaviour, and is preventable to a large degree [38]. Moreover, we found that health behaviour factors of not smoking, having better physical functioning and walking once a day also were associated with shorter LOS, but only for men. These results are similar to others, which found poor health behaviours lead to differences in life expectancy between genders [39–41]. The results also reflect those of others [42,43] including Smolin et al. [44] who demonstrated physical status and activity were among the more powerful predictors of poor outcomes including mortality following acute hospitalisation.

For women, first admission with influenza had a decrease in LOS, compared to cancer, across all quantiles. Women at the fourth quantile (75th percentile) first admitted with influenza have 20 days shorter LOS than women with cancer. However, at the 10th percentile they only have 6 days shorter LOS. In other research, we showed that older women who died of influenza, were likely to have had no hospital admissions until very close to the month of death [45]. Older adults are particularly susceptible to mortality from influenza [46], but deaths can be prevented through adult vaccination.

Our findings showed other gender differences in the factors associated with hospitalisation and LOS in the last year of life. Factors contributing to men having longer overnight stays in hospital in the last year of life may be attributed to falls, having fair/poor general health and diagnosed hypertension. Just over half of the people aged 80 years or over presenting to hospital with falls are males, with a majority



For each graph shown, the x-axis represent quantiles of the distribution for total LOS and the y-axis represents the difference in LOS between the reference category of the explanatory variable and the category of interest for different quantiles of LOS. Where covariates cross zero on the y-axis at any given quantile the graph represents no statistically significant difference in the covariate category compared to the reference level for that covariate. A negative parameter estimate indicates lower rates of the covariate category in that quantile having a shorter LOS compared to the reference.

Fig. 1. Quantile regression plots for men and women for variables last known transfer from hospital and principal reason for hospitalisation.

remaining in hospital for more than eight days [47]. The same study showed that one-fifth of over 80 year old people admitted following falls died in hospital, and another 30% were transferred to a nursing home, rehabilitation or other unit not their own home [47]. Our study adds to the current literature by demonstrating that the covariates falls, general health and diagnosed hypertension increases LOS in hospital for men, particularly in the upper LOS quantiles.

Women living on their own were more likely to have longer LOS in hospital compared to women living in a nursing home or residential aged care. Given that this effect is strongest at the longest lengths of stay, this may reflect that some people who are admitted to hospital from the community are awaiting places in long-term care. In Australia, around 11% of people aged 65 years are discharged from hospital to residential aged care [48] and one in every 1000 patient days are for patients waiting for a residential care place [48].

6. Limitations

We note that the sample of aged 85 years and over from the 45 and Up Study are potentially not representative of this age group, however the data while having some limitations provides valuable information about older men and women in their last year of life. First, the time period between survey and date of death varies substantially, only 25% of the participants died within 18 months of returning the survey. Therefore, the survey may not correctly reflect the health status of the participants in the year prior to death. This may underestimate the impact of poor health (especially for covariates self-rated health, heart disease, hypertension and number of falls) in the model. However, the models were adjusted to take into account time of survey completion to death resulting in no significant changes across the quantiles for both men and women. Second, our study used administrative data and lacked information on laboratory and clinical indicators. However, these variables reflect enduring health conditions and not likely to change once diagnosed. Third, we examined the reason for first hospitalisation and not the reported COD, due to the limitation of our administrative data. Finally, some estimates have resulted in wide confidence intervals in the 90th percentile suggesting possible bias in the results in the tails of the distribution. Regardless of these limitations, the study demonstrates how resourceful quantile regression models are in revealing the factors associated with LOS in hospital in the last year of life, and the importance of separating analyses for men and women.

7. Conclusions

These quantile regression models using a data from large linked survey and administrative datasets provide information on predictors of health service use for the very old adults at the end of life, with different effects across different lengths of stay for men and women. Poor health behaviours and organ failure were drivers of higher LOS among older men, pointing to opportunities to achieve health care savings through prevention. For older women, admission for influenza was associated with shorter LOS. Other factors associated with LOS among women, included where they lived before they were admitted, and their destination on discharge. However, these covariates did not have such a strong effect across the quantiles.

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Conflict of interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejim.2019.02.011.

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