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First incident hospitalisation for Australian women aged 70 and beyond: a 10 year examination using competing risks

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Abstract

There are increasing concerns regarding high hospital use among older adults and the capacity to manage the economic impact of the ageing population trend on healthcare systems. First hospitalisation in old age may act as a catalyst for ongoing intensification of health problems and acute care use. This study examined factors associated with first incident hospitalisation in women aged over 70, accounting for the health inequalities associated with geographic location. Survey data from 3,780 women from the 1921–1926 cohort of the Australian Longitudinal Study on Women's Health were matched with the Admitted Patients Data Collection and National Death Index. Days to first event (hospitalisation or death) were modelled using competing risks methods. A total of 3,065 (80.3%) women had at least one hospital admission. More than half of the top 15 reasons for first hospitalisation were related to cardiovascular disease, with atrial fibrillation the most common. Proportional subdistribution hazards models showed that first hospital admission was driven by enabling and need factors including asthma/bronchitis diagnosis (HR=1.16;p=0.047), private health insurance (HR=1.16;p=0.004) more than two prescribed medications in previous month (HR=1.31;p=0.001), more than four general practitioner visits in previous year (HR=1.50;p=0.034), lower physical functioning (HR=0.99;p<0.001) and living in an inner regional area (HR=1.17;p=0.003). First overnight hospitalisation was primarily related with potentially preventable and treatable chronic diseases. Primary and secondary strategies aimed at chronic disease generally, and better chronic disease management particularly for cardiovascular and respiratory diseases, may play a vital role in disease prevention or delay in readmissions among this population.

Keywords women; old age; hospital; admission; longitudinal; competing risks

1. Introduction

There are increasing concerns regarding high hospital use among older adults and the capacity to manage the economic impact of the current ageing population trend on healthcare systems, even in Australia.[1] Over the last decade, the proportion of Australians aged 65 and over has increased by about 30%, with those aged 85 and over representing the fastest growing cohort. Approximately 2% of the total Australian population are aged 85 and over, 65% of which are women.[2] This figure is projected to quadruple by 2050. This global trend is expected to have widespread implications for developing and developed nations, with the gap in life expectancy set to narrow.[3] In Australia, ageing and health pressures are projected to result in increased healthcare expenditure, particularly in terms of hospital use.[1,4] Understanding factors contributing to hospitalisations in the older population is therefore a key public health priority.

Hospitalisation (particularly in frail older adults) has been associated with a sequence of events that can result in deleterious outcomes, including reduced functioning, transition into aged care, and even death.[5,6] Increased hospitalisation has been attributed to a number of factors depending upon the study design and population examined. Drivers of hospitalisation, (particularly readmission), have been attributed to clinical factors such as specific chronic diseases (including multimorbidity).[7] Non-disease health factors (e.g. self-rated health, functional decline, obesity, smoking, falls)[8-11] as well as sociodemographic and psychosocial factors (e.g. social support, geographic location)[12-14] have also been associated with hospital admissions (and healthcare utilisation, more broadly), although less consistently.

Currently, there is a lack of evidence regarding factors that predict first incident hospital admission (which can be the catalyst for ongoing intensification of health problems and acute care service use) in older adults. Understanding such factors may play a critical role in future healthcare planning and the targeting of preventive interventions to reduce poor health

outcomes for this population. In Australia, however, geographic location complicates the healthcare picture with significant health, and healthcare inequalities identified between rural and remote communities and those in metropolitan areas.[15] Health disparities across geographic location have primarily been attributed to the prevalence of predisposing biomedical and behavioural risk factors, relative socioeconomic disadvantage, and limited access to health services.[15,16] This suggests that geographic location may confound the relationship with healthcare utilisation. Further, studies examining hospitalisation (and healthcare utilisation more broadly) have failed to account for the competing risk associated with death in analyses. Competing risks occur when participants can experience one or more events which 'compete' with the outcome of interest. The competing risk hinders the observation of interest and modifies the chance that this event occurs.[17] In this instance, death competes with being admitted to hospital and modifies the chance of hospitalisation. As such, accounting for only one event may introduce bias. Therefore, conceptualised within the Andersen-Newman behavioural model of health service utilisation,[18] the aim of this study is to examine factors associated with first incident hospitalisation, in women aged over 70, accounting for the health inequalities associated with geographic location.

2. Methods

2.1. Overview of study design and participants

This study used data from the 1921-1926 cohort of the Australian Longitudinal Study on Women's Health (ALSWH). Baseline surveys were completed in 1996 when the women were aged 70-75 years (N=12,432). Of these women, 11,726 (94%) consented to having their survey data linked to various administrative datasets. The cohort has been surveyed every three years since 1996. Participants were eligible for inclusion in this analysis if they were New South Wales (NSW) residents. Of the women meeting this criterion (N=4,364), 3,780 were residents

for the entire period between 1 July, 2000 and 30 December, 2010 (when the administrative hospital data were available), consented to data linkage, and had not been hospitalised during 1998-2000.

Participant status was defined by their first event (hospitalisation or death) within the observation period. Deaths records were obtained from the National Death Index[19] (which contains records of all deaths occurring in Australia since 1980) and matched on identifying information including name, address, gender, state, date of birth and age at last contact. For this study, data on first admission to hospital was collected from the NSW Admitted Patients Data Collection (APDC). This database is a census of all admitted patients services provided by NSW public and private hospitals for each resident. The database includes but is not limited to admission and separation dates, as well as reason for admission (www.cherel.org.au). As hospital care in Australia is provided by a tax-funded universal healthcare system which is managed separately by each state or territory, continuous hospital data was provided for each participant during the observation period. Good agreement has been found between hospital records and the ALSWH self-report data.[20] Time to participant's first event was measured in days from 1 July 2000 to the date of the event, with data censored at 30 December 2010.

2.2. Confounder

Geographic location was assessed according to the Accessibility/Remoteness Index of Australia Plus (ARIA+)[21] which measures distance to services including access to tertiary teaching hospitals, and classified as 'metropolitan', 'inner regional', and 'outer regional/remote/very remote'.

2.3. Predictors

Baseline measures were collected from the 1999 survey. Variables were included in the models according to the Andersen-Newman framework[18] which proposes that health service is driven by predisposing (distal factors such as demographics and health beliefs), enabling (individual or community-specific factors such as income, health insurance and social network) and need (illness level factors such as perceived health status and diagnoses) characteristics. **Predisposing factors** included age, marital status (widowed, not widowed), highest educational qualification (no formal schooling/year 10, post-schooling), Country of birth (Australia, other), language spoken at home (English, other) and smoking status (current smoker, ex-smoker, non-smoker). **Enabling factors** included receiving a government pension (yes, no), contributing to private health insurance (yes, no) and perceived social support.[22] **Need factors** included number of general practitioner (GP) services (0, 1, ≥2), prescribed medications (0, 1, ≥2) and BMI categorised according to World Health Organization guidelines[23] ('underweight' <18.5, 'healthy' 18.5-24.99, 'overweight/obese' >25). As previous research has indicated that traditional BMI cut points may not be suitable for adults aged over 65 years (with overweight and mild obesity found to be protective against mortality)[24] sensitivity analyses were conducted using the following BMI cut points: (i) high risk (<22), healthy weight (22-24.9), minimal risk (25.0-34.9) and obese (≥35)[24] (ii) high risk (<18.5), healthy weight (18.5-24.9), minimal risk (25.0-29.9) and obese (≥30).[25] Other need factors included the presence of pre-existing chronic conditions (yes, no) such as diabetes, cancer, heart disease, stroke, hypertension, asthma/bronchitis or arthritis, and falls in the last 12 months. Health perceptions such as perceived general health (excellent/good, not good/poor) as well as the physical functioning and mental health subscales of the SF-36 were also included.

2.4. Ethical approval

The ALSWH project has ongoing ethical clearance from both the University of Newcastle and University of Queensland's Human Research Ethics Committees. Ethical approval for the

linkage of ALSWH survey data to the NSW APDC was received from the NSW Population and Health Services Research Ethics Committee and registered with the University of Newcastle.

2.5. Statistical analyses

Women were grouped according to whether they had been hospitalised, died without prior hospitalisation, or survived. Descriptive analyses were performed to compare participant characteristics using Pearson's chi-square for categorical variables and Kolmogorov-Smironov test for continuous variables. Missing data for individual survey items were back-filled using data from either the previous or subsequent survey.

Life tables were constructed comparing risk events for the baseline characteristics. Competing risks methods were used to estimate the cumulative incidence of each event (hospitalisation or death) over the ten year follow-up period, and Cox regression analysis applied. Data for women were modelled to their first event within the observation period (i.e. death or hospitalisation) all surviving participants were censored at the 31 December 2010. Each competing risk was then characterised according to each model's hazard function based on covariate adjusted models using geographic location and predictors. Model 1 focused on women who died before any hospital admission compared to other women, and Model 2 focused on women who were hospitalised compared to other women. Models were built by firstly adding all predisposing covariates, followed by enabling covariates, and then need covariates. Initial models adjusted for all potential predictors. As language spoken at home was strongly correlated with country of birth, it was removed from further models. Final models (adjusted for geographic location) were built with components analysed across the three event types. Variables not statistically significant for all event types were excluded from the final model. Covariate effects for significant predictors were compared across the models using the Wald chi-square test. A

subdistribution hazard model[26] was also constructed to estimate the cumulative incident probabilities for each of the events of interest (hospitalisation or death) adjusting for geographic location. All analyses were performed using SAS v9.4 (x64), with statistical significance set at $p<0.05$.

3. Results

3.1. Participant characteristics

Over the ten years of observation, 1,398 (35.7%) women died, 3,065 (80.3%) women had at least one admission to hospital and 133 (3.6%) died before they could go to hospital. Table 1 shows events and baseline characteristics for the 3,780 eligible women and Figure 1 shows the progression to first event. Table 1 also shows the women with missing data at baseline (Survey 2).

Table 1. Baseline characteristics for the 1921-1926 cohort according to first event.[a]

Variable	No Event N (%)	Hospitalisation N (%)	Death N (%)	P value
Completed 1999 survey	526 (89.3)	2,770 (89.8)	108 (82.3)	0.02
Withdrew before the end of study period	184 (32.3)	1026 (33.2)	48 (33.9)	0.91
Deaths prior to 2012	582 (2.6)	1249 (39.5)	100 (100.0)	NA
Proxy				
Participant told answers	18 (11.4)	173 (6.1)	5 (4.5)	0.006
Proxy used own judgement	3 (0.8)	39 (1.2)	4 (4.1)	
Geographic location				
Metropolitan	266 (72.6)	1237 (67.6)	60 (70.5)	
Inner regional	221 (19.2)	1304 (23.8)*	53 (21.9)	0.14
Outer regional/remote/very remote	95 (8.2)	523 (8.7)	21 (7.6)	
Predisposing				

Age	72.2 (1.4)*[d]	72.5 (1.5)	72.8 (1.6)	
Marital status				
Widowed	168 (29.9)*	1078 (35.0)	51 (41.4)	
Not widowed	408 (69.0)	1940 (63.5)	80 (56.1)	0.02
Missing	*6 (1.1)*	*47 (1.5)*	*2 (2.5)*	
Education				
No formal school/year 10	407 (68.6)	2227 (70.3)	98 (71.4)	
Post school	157 (28.2)	679 (24.6)	25 (21.5)	0.06
Missing	*18 (3.2)**	*159 (5.1)*	*10 (7.1)*	
Born in Australia	418 (68.1)	2361 (72.9)	106 (79.8)	0.007
English speaking				
No	44 (10.2)	181 (8.1)	4 (4.1)	
Yes	484 (80.2)	2635 (84.2)	110 (83.0)	0.009
Missing	*54 (9.6)*	*249 (7.7)*	*19 (13.0)*	
Smoking status				
Non-smoker	386 (65.9)	1832 (60.2)	61 (45.7)*	
Ex-smoker	128 (21.6)	816 (26.2)	41 (34.5)	<0.001
Current smoker	25 (4.8)	216 (7.0)	23 (14.4)*	
Missing	*43 (7.7)*	*201 (6.6)*	*8 (5.5)*	
Enabling				
Receiving Australian Government Pension	384 (65.9)	2089 (66.5)	83 (60.0)	0.002
Private health insurance				
Yes	246 (43.8)	1334 (44.7)	48 (36.1)	
No	244 (17.5)	1154 (36.0)	47 (34.5)	0.007
Missing	*92 (16.6)*	*577 (19.3)*	*38 (29.5)**	
Perceived social support	32.3 (4.9)	31.9 (5.4)	31.8 (5.6)	0.36[d]
Need				
Perceived general health				
Good/excellent	439 (75.0)	1929 (62.6)	70 (54.2)	<0.001

Poor/not good	(14.2)*	(26.9)	(27.7)	
Missing	*61 (10.8)*	*311 (10.4)*	*26 (18.1)*	
GP services				
None	23 (3.0)	42 (1.2)	4 (2.3)	
1-4	260 (41.3)*	1016 (29.6)	40 (28.4)	<0.001
>4	237 (46.7)*	1690 (58.2)	64 (51.6)	
Missing	*62 (12.0)*	*317 (11.0)*	*25 (17.8)*	
Prescribed medications				
None	94 (13.8)*	279 (8.0)	14 (10.3)	
1-2	111 (19.7)*	401 (13.0)	14 (10.3)	<0.001
> 2	300 (51.6)*	2010 (65.7)	77 (58.8)	
Missing	*77 (14.0)*	*375 (12.8)*	*28 (20.6)*	
BMI				
Healthy weight	273 (45.2)	1260 (41.2)	46 (35.4)	
Underweight	13 (2.4)	91 (3.0)	9 (8.4)	<0.001
Overweight/obese	217 (38.0)	1242 (39.8)	38 (26.7)	
Missing	*79 (14.5)*	*471 (15.9)*	*39 (29.5)**	
[b]Chronic conditions				
Diabetes	31 (5.3)	277 (9.1)	14 (10.5)	<0.001
Cancer	87 (16.9)	561 (20.5)	22 (19.6)	0.86
Heart disease	43 (7.4)	455 (14.9)	24 (18.1)	<0.001
Stroke	6 (1.1)*	106 (3.5)	13 (9.8)*	<0.001
Hypertension	181 (31.1)	1114 (36.4)	38 (28.6)	<0.001
Asthma/bronchitis	56 (9.6)	434 (14.2)	23 (17.3)	0.006
Arthritis	186 (36.2)	1207 (44.6)	37 (34.6)	<0.001
Falls	169(28.2)*	1057 (34.9)	47 (36.4)	0.004
[c]Physical functioning score	73.1 (20.1)	61.0 (26.2)	55.7 (30.0)	<0.001
[c]Mental health score	81.8 (14.6)	78.5 (16.7)	77.8 (16.5)	0.001

[a] Weighted by area of residence
[b] Fishers exact test was used to assess statistical significance; chronic conditions were measured at baseline.
[c] Means and standard deviations are reported,

[d] Kolmogorov-Smironov test was used to assess statistical differences across groups. For age, statistically significant differences were found for both pairwise comparisons.
*greatest contribution to the overall chi-square

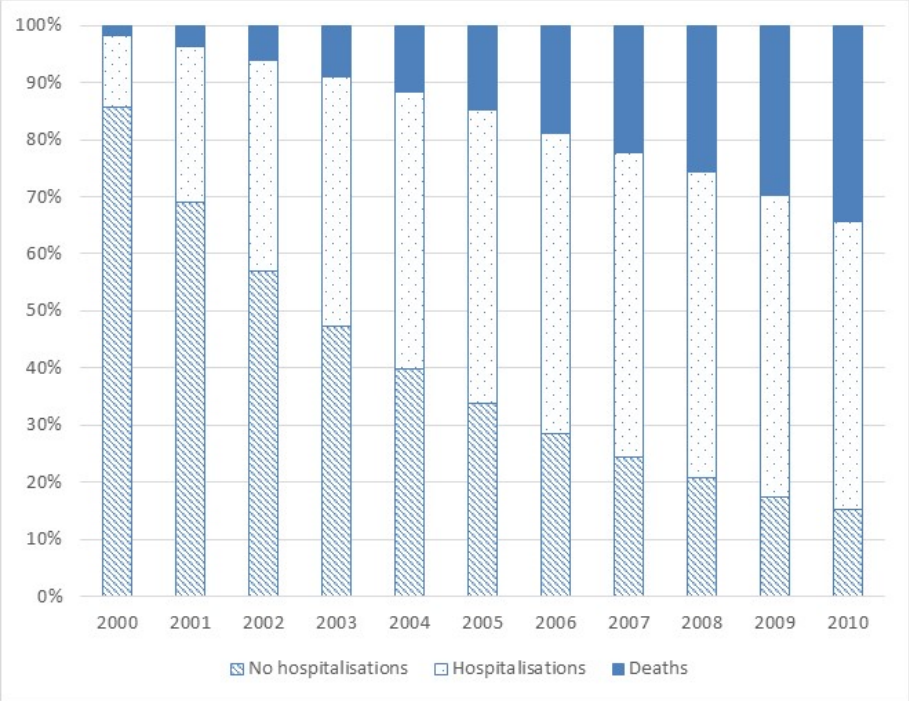

Figure 1. Proportion of women from the 1921-1926 cohort according to first event

3.2. Reasons for hospital admission

Table 2 shows the most common principle diagnoses (ICD-10) for women who reported hospitalisation as their first event. More than half of the top 15 reported reasons were related to cardiovascular issues, with atrial fibrillation and flutter (I48), the most common. Other common admissions related to arthrosis of the knee (M17.1), cataracts (H26.9) and pneumonia (J18.9).

Table 2. Top 15 principle ICD diagnoses for women reporting a hospital admission as the first event (N=3,064)[a]

ICD10 code	Description	N	%

G45.9	Transient cerebral ischaemic attack, unspecified	32	1.04
H26.9	Cataract, unspecified	75	2.45
I20.0	Unstable angina	65	2.12
I20.9	Angina pectoris, unspecified	35	1.14
I21.4	Acute sub endocardial myocardial infarction	27	0.88
I48	Atrial fibrillation and flutter	89	2.90
I50.0	Congestive heart failure	32	1.04
I64	Stroke, not specified as haemorrhage or infarction	37	1.21
J18.9	Pneumonia, unspecified	65	2.12
K80.10	Calculus of gallbladder with other cholecystitis	31	1.01
M16.1	Other primary coxarthrosis	49	1.60
M17.1	Other primary gonarthrosis [arthrosis of knee]	83	2.71
N39.0	Urinary tract infection, site not specified	42	1.37
R07.4	Chest pain, unspecified	44	1.44
R55	Syncope and collapse	47	1.53

[a]Please note: These figures refer to the number of women reporting a hospitalisation for each of the specific conditions as their principle diagnosis on admission. The number of women reporting these conditions as a secondary diagnosis (i.e. a condition reported as relevant to the admission) has not been included here. As an example, while 2.90% of women had atrial fibrillation and flutter as their primary diagnosis, it was relevant to the admission (i.e. a secondary diagnosis) in 21.2% of women.

3.3. Competing risk models

Separate cause-specific proportional hazards models for first event are shown in Table 3. Increased hazard ratios for death as the first event were found for age, born outside Australia, current or ex-smokers, having a BMI <18.5 (underweight) and having had a stroke. Decreased hazards were found for having a BMI >25 (overweight or obese) and being diagnosed with arthritis. Decreased hazards were also found for every unit increase in physical functioning.

On the other hand, women with hospitalisation as their first event had decreased hazards associated with having a BMI >25 (overweight or obese) and every unit increase in physical

functioning score. Increased hazards were found for age, born outside Australia, having private health insurance and taking more than two prescribed medication in the year. Having previously been diagnosed/treated for asthma/bronchitis and heart disease was also associated with increased hazards for hospitalisation. Importantly, living in a regional area was associated with a significant increase in having a hospitalisation as the first event.

Table 3. Covariate adjusted hazards ratios for cause-specific Cox proportional hazards model of first event for women from 1921-1926 cohort (N=2,543).

	Focus on Deaths		Focus on Hospitalisations		Subdistribution Hazards[a]	
	Hazard Ratio 95% CI	P value	Hazard Ratio 95% CI	P value	Hazard Ratio 95% CI	P value
Geographical location (ref: metropolitan)						
Inner regional	1.21 (0.69, 2.13)	0.50	1.21 (1.09, 1.35)	<0.001	1.17 (1.06, 1.30)	0.003
Outer regional/remote/very remote	0.90 (0.39, 2.10)	0.81	1.06 (0.90, 1.25)	0.49	1.06 (0.93, 1.22)	0.38
Predisposing						
[b]Age	1.20 (1.02, 1.41)	0.03	1.03 (1.00, 1.07)	0.04	1.03 (1.00, 1.06)	0.08
Post school qualifications (ref: no formal schooling/year 10)	0.87 (0.49, 1.52)	0.61	0.93 (0.84, 1.04)	0.20	0.92 (0.83, 1.03)	0.16
Widowed	1.44 (0.89, 2.34)	0.14	1.09 (0.99, 1.20)	0.08	1.07 (0.97, 1.18)	0.15
Born outside Australia	2.47 (1.24, 4.93)	0.01	1.14 (1.02, 1.27)	0.03	1.09 (0.97, 1.24)	0.16
Smoking status (ref: non-smoker)						
Ex-smoker	2.64 (1.56, 4.46)	<0.001	1.01 (0.99,1.22)	0.07	1.04 (0.94, 1.15)	0.47
Smoker	4.54 (2.17, 9.52)	<0.001	1.14 (0.93,1.39)	0.21	1.09 (0.88, 1.36)	0.44
Enabling						
Private health insurance	0.82 (0.50, 1.35)	0.43	1.12 (1.02, 1.24)	0.02	1.16 (1.05, 1.28)	0.004

Receiving government pension	1.13 (0.59, 2.17)	0.72	1.07 (0.95, 1.21)	0.29	1.10 (0.97, 1.25)	0.13
GP consultations (ref: none)						
1-4 visits	0.47 (0.12, 1.85)	0.28	1.10 (0.73, 1.66)	0.66	1.33 (0.92, 1.92)	0.13
>4 visits	0.71 (0.17, 3.00)	0.64	1.30 (0.85, 1.97)	0.23	1.50 (1.03, 2.19)	0.03
Need						
Perceived general health	1.29 (0.69, 2.43)	0.43	0.95 (0.84,1.07)	0.41	0.96 (0.85, 1.09)	0.55
Prescribed medications (ref: none)						
1-2	0.63 (0.24, 1.65)	0.35	1.07 (0.89, 1.30)	0.48	1.15 (0.97, 1.38)	0.11
> 2	0.90 (0.40, 2.04)	0.80	1.28 (1.08, 1.52)	0.004	1.31 (1.12, 1.53)	0.001
BMI (ref: healthy weight)						
Underweight	3.28 (1.56, 6.90)	0.002	1.05 (0.81, 1.37)	0.70	0.90 (0.67, 1.21)	0.47
Overweight/obese	0.40 (0.23, 0.68)	0.001	0.91 (0.82, 1.00)	0.04	0.99 (0.90, 1.09)	0.80
[c]Chronic conditions						
Arthritis	0.47 (0.28, 0.81)	0.006	1.07 (0.97, 1.18)	0.18	1.08 (0.98, 1.19)	0.11
Diabetes	1.46 (0.55, 3.91)	0.45	1.10 (0.93, 1.31)	0.23	1.16 (0.96, 1.39)	0.12
Stroke	2.97 (1.03, 8.58)	0.04	1.16 (0.89, 1.51)	0.26	1.05 (0.79, 1.40)	0.75
Heart disease	1.57 (0.79, 3.13)	0.20	1.19 (1.04, 1.37)	0.01	1.11 (0.96, 1.29)	0.17
Asthma/Bronchitis	0.96 (0.47, 2.00)	0.92	1.19 (1.04, 1.37)	0.01	1.16 (1.00, 1.34)	0.05
Physical functioning score	0.97 (0.96, 0.98)	<0.001	0.99 (0.99, 0.99)	<0.0001	0.99 (0.99, 1.00)	<0.001

[a]Survival analysis over-estimates the probabilities of both the event of interest (hospitalisation) and the competing event (death). The subdistribution hazards model (or Cumulative Incidence Competing Risk method accounts for all types of events. The cumulative incidence function is estimated for both the event of interest (hospitalisation) and all competing events (deaths), and their estimates are dependent on one another

[b]analyses controlled for age regardless of univariate significance

[c]Chronic conditions were measured at baseline (survey 2)

The effect of this association is highlighted in Figure 2. The cumulative incidence function graph shows that women from inner regional areas had higher incidence of hospitalisation compared to women living in metropolitan areas (p=0.01). Women living in outer regional, remote and very remote areas displayed higher patterns of hospital use up to the age of 80-85 years (approximately 2,200 days or in the year 2006), but showed lower incidence of hospitalisations thereafter.

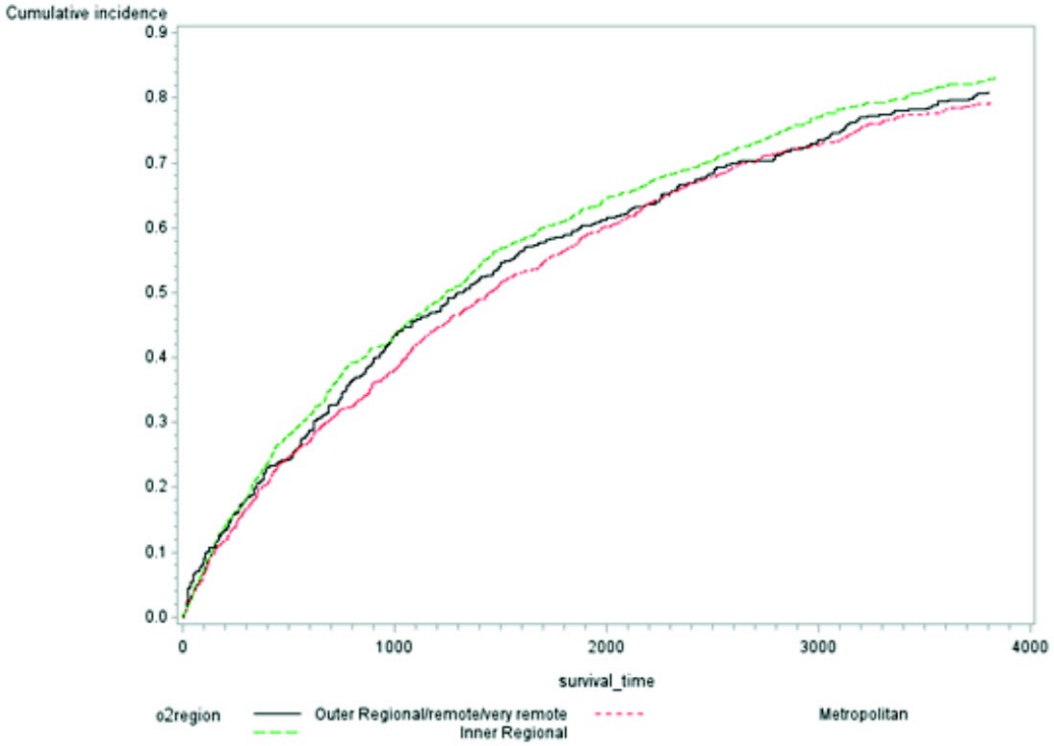

Figure 2. Cumulative incidence for first event by geographic location. Final subdistribution models were modelled using the Andersen-Newman Framework holding all predictor variables constant. Survival time was measured in days. Predictors excluded from the model included language spoken at home, income management, falls experienced in the last 12 months, hypertension and perceived social support.

When hospitalisations were examined using the proportional subdistribution hazards model (adjusting for the effect of death), similar results were found for the enabling factors, living in an inner regional area (HR=1.17, 95% CI: 1.06, 1.30; p=0.003) and having private health

insurance (HR=1.16, 95% CI: 1.05, 1.28; p=0.004) (see Table 3). Need factors related to being prescribed more than two medications in the previous month (HR=1.31, 95% CI: 1.12, 1.53; p<0.0001), having been diagnosed with asthma/bronchitis (HR=1.16, 95% CI: 1.00, 1.34; p=0.047) and physical functioning (HR=0.99, 95% CI: 0.99, 1.00; p<0.0001) were also similar between models. When the subdistribution model was employed, predisposing factors age and country of birth along with the need factors being overweight/obese or being diagnosed with heart disease were no longer statistically associated with hospitalisation. Reporting more than four visits to a GP in the previous year was not significantly associated with hospitalisation as the first event in the cause-specific model, but became significant when the subdistribution hazards model was applied (HR=1.50, 95% CI: 1.03, 2.19; p=0.034).

When sensitivity analyses were conducted using alternate BMI cut points, BMI remained non-significant in the model and little change was found in the model estimates. These results are highlighted in Supplementary Tables S1.

4. Discussion

This is the first study to examine factors associated with first overnight hospitalisation among a representative community cohort of older Australian women. As expected, over the ten year observational period, the majority of women were admitted to hospital at least once. When the inequalities associated with geographic location were taken into account, first incident overnight hospitalisation was primarily related with chronic diseases (i.e. need factors according to the Andersen-Newman model). These findings suggest that primary and secondary prevention strategies aimed at chronic disease generally, and better chronic disease management, particularly for cardiovascular disease, may play a vital role in the prevention, or delay in readmissions among this population.

While chronic conditions have long been recognised as significant predictors of hospitalisation, more recently increased attention has been paid to reducing potentially avoidable chronic disease-related hospital admissions (i.e. admissions that could have been prevented through preventative measures, health promotion or timely access to primary care). Previously, information regarding potentially preventable hospitalisations has come from examining disparities between geographic or health administrative areas.[27] In this study we accounted for the disparity associated with geographic-related access to healthcare. Yet, the majority of the top fifteen principle reasons for first hospitalisation were attributed to potentially preventable and treatable conditions. The majority of these admissions were related to cardiovascular disease.

Previous research in the U.S., found that three-quarters of readmissions within the first month were attributed to cardiac-related cases (namely heart failure).[28] Here, we found that atrial fibrillation and flutter was the top principle diagnosis for first hospitalisation (as documented in the hospital records). In Australia atrial fibrillation has increased significantly over the past two decades.[29] It is associated with significant morbidity and mortality, particularly for individuals with pre-existing cardiac conditions.[29,30] A Scottish study found that 33% of hospital activity was related to atrial fibrillation, accounting for approximately one-quarter of total cardiovascular costs, with women accounting for 41% more hospital bed days and 20% higher total costs than men.[31] In our study, atrial fibrillation was recorded as relevant to the first admission in 21.2% of women. Therefore, while atrial fibrillation on its own is not perceived as particularly life-threatening; it has far reaching economic and health consequences. Increased primary interventions around health behavioural risk factors (e.g. obesity, smoking) as well as improved monitoring of individuals at risk of poor cardiovascular outcomes (e.g. hypertension and diabetes) are required in order to reduce frequent cardiac-related hospitalisation and the burden on the healthcare system.

In the multivariate subdistribution model, pre-existing asthma/bronchitis was associated with increased hazards of a first hospitalisation. Breathlessness, a key symptom of asthma has been found to affect up to one third of older people. As with pain in osteoarthritis,[32] many older adults underestimate the severity and significance of asthma by perceiving breathlessness as a normal part of ageing, particularly in the presence of disease comorbidity.[33] As such, hospital admissions for asthma in older women may be a result of under treatment or poor medication adherence.

Despite the fact that we applied statistical methods to balance the access inequities associated with geographic location, women who resided in inner regional areas had increased risk of hospitalisation compared to women living in metropolitan areas. Falster and colleagues[34] found in a multi-level analysis that supply of GP services explained as little as 3% of the geographic variation in rates of preventable hospitalisations. One-third of the geographic variation was driven by personal sociodemographic and health characteristics, suggesting that preventable hospitalisations may be more representative of gradients in health rather than healthcare. Future research is required in order to unpack reasons for this disparity, including a focus on provider factors such as care quality and access to residential aged care facilities.

Findings from the subdistribution analysis also revealed that other healthcare factors including health practitioner visits impacted on first incident hospital admission for older women. In addition to contributing to private health insurance, the number of medications and general health practitioner visits predicted this event. Despite primary healthcare being the cornerstone of the healthcare system, research has been equivocal regarding its role in hospital admissions. While some studies have supported either an inverse or u-shape relationship between primary care and hospitalisations,[35,36] findings from this study provide additional support for the positive relationship between primary care visits and hospitalisations.

Improving care quality through increased integration (and efficiencies) between primary healthcare and hospital interfaces may be at the core of achieving optimal health outcomes for older women and reducing costs associated with potentially preventable admissions. At present, approaches to chronic disease management are built around a single disease model of care. Moving beyond a "one size fits all" approach to healthcare by implementing person-centred care plans, particularly for women with complex disease, may reduce care fragmentation and assist patient empowerment through increased knowledge (including self-management practices) regarding their condition, improved medication adherence, as well as early detection and early intervention regarding disease exacerbations. Written personal action plans for asthma have resulted in lower preventable emergency admissions.[37] It must be noted though, that going to hospital is not necessarily a negative event when it is for preventative or restorative procedures (e.g. in the case of arthritis).

Moreover, while recent research has found a U shape relationship between BMI and health outcomes (in particular mortality) at older age, [24,25,38] we found a J shape associated with first hospital admission, and a reverse J shape with mortality. Our finding is partially supported by Flegal and colleagues[39] who found that underweight was positively associated with mortality, while overweight was negatively associated with excess deaths. Obesity however was found to have a neutral relationship with mortality for all conditions except cardiovascular disease. Importantly, low BMI may be an indicator of undernutrition. Undernutrition, reported in up to 61% of hospitalised old adults[40] has been found to be associated with a number of adverse consequences including increased mortality, frequency of hospitalisations and increased hospital length of stay.[41-43] In our study however we found that low BMI (underweight) was predictive of a first hospitalisation, suggesting that undernourishment among community dwelling older Australian women may be a serious undiagnosed and under recognised condition despite the existence of clinical guidelines recommending routine nutrition

screening.[44] While overweight and obesity may be protective against both morality and hospitalisation after controlling for mortality (and other health-related factors), our findings suggested no difference between those who are underweight or overweight and obese. However, these findings should be viewed with caution.

Strengths of our study revolve around the longitudinal data, with older women followed over a ten year period. We were also able to link this nationally representative self-reported data to a large administrative dataset (involving both and public hospitals) in order to identify a comprehensive set of predictors that were associated with first hospitalisations. Inclusion of subdistribution hazards models, alongside cause-specific models allowed us to consider the effect of death on the outcome of interest (hospitalisation). Likewise, we were able to account for the known imbalances associated with morbidity and mortality in rural and remote areas. This is particularly novel as previously, rural and remote regions of Australia have been under-represented in national surveys. This study however, focused on predictors of overnight hospitalisations. Risk factors for first emergency department admission may differ. In addition, although participants did not have a hospital admission in the two years prior to our observation period, there is the potential that they may have had a hospital admission. However, were interested in the first admission to hospital in old age (≥70 years) as this may act as a catalyst for ongoing intensification of health problems and acute care use. We were also unable to assess disease severity prior to hospitalisation and did not assess disease comorbidity. Disease comorbidity is known to complicate chronic disease management and an increased risk for a potentially avoidable admission is compounded by each additional condition. Although we did not assess disease comorbidity being administered two or more medications was associated with an increased risk of hospital admission in the subdistribution models. Adverse drug reactions, particularly those related to cardiovascular disorders have been associated with increased hospitalisations.[45] In addition, a major limitation of the study was not being able to

assess the impact of cognitive impairment and dementia as a pre-existing chronic condition. It has been found that dementia contributes to worse clinical outcomes, longer lengths of stay, and increased likelihood for readmission compared to those without dementia.[46] Another limitation of this study concerned missing data on BMI and other health-related variables (e.g. medication use and access to primary care) for women who died during the observation period compared to women in the other groups. Further, this study was focused solely on women. Factors associated with hospital use may be markedly different for men. While women more likely to survive into very old age (and therefore more likely to use health services), future studies are required to examine the gender differences associated with drivers of first hospitalisation in older adults in line with the projected increase in life expectancy for males.[47]

5. Conclusion

With hospitals found to be a 'dangerous playground' for older adults and potentially avoidable admissions touted as key health system performance indicators, the findings of this study indicate that investment in health promotion (particularly around cardiovascular and respiratory health) and chronic disease management strategies are required to reduce the healthcare burden associated with ageing population. Additional keys to healthcare system sustainability may lie in understanding the long-term health patterns of women who delay entry into hospital into very old age as well as those who have very low hospital use throughout old age. Importantly, moving towards more individualised care, and improving care transitions may not only meet the needs of this vulnerable population but may also have positive widespread implications to ensure future generations age well.

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Conflict of interest

The authors have no conflict of interest to declare.

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