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# Predictors of hospitalisations and emergency department presentations shortly after entering a residential aged care facility in Australia: a retrospective cohort study

Maria C Inacio ,[1,2] Robert N Jorissen,[2] Steve Wesselingh,[3] Janet K Sluggett,[1,2] Craig Whitehead,[4,5] John Maddison,[6] John Forward,[6] Alice Bourke,[7] Gillian Harvey,[8] Maria Crotty ,[4,5] STAAR-SA Study Collaborators

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For numbered affiliations see end of article.

**Correspondence to**
Dr Maria C Inacio;
Maria.inacio@sahmri.com

## ABSTRACT

**Objectives** To: (1) examine the 90-day incidence of unplanned hospitalisation and emergency department (ED) presentations after residential aged care facility (RACF) entry, (2) examine individual-related, facility-related, medication-related, system-related and healthcare-related predictors of these outcomes and (3) create individual risk profiles.

**Design** Retrospective cohort study using the Registry of Senior Australians. Fine-Gray models estimated subdistribution HRs and 95% CIs. Harrell's C-index assessed risk models' predictive ability.

**Setting and participants** Individuals aged ≥65 years old entering a RACF as permanent residents in three Australian states between 1 January 2013 and 31 December 2016 (N=116 192 individuals in 1967 RACFs).

**Predictors examined** Individual-related, facility-related, medication-related, system and healthcare-related predictors ascertained at assessments or within 90 days, 6 months or 1 year prior to RACF entry.

**Outcome measures** 90-day unplanned hospitalisation and ED presentation post-RACF entry.

**Results** The cohort median age was 85 years old (IQR 80–89), 62% (N=71 861) were women, and 50.5% (N=58 714) had dementia. The 90-day incidence of unplanned hospitalisations was 18.0% (N=20 919) and 22.6% (N=26 242) had ED presentations. There were 34 predictors of unplanned hospitalisations and 34 predictors of ED presentations identified, 27 common to both outcomes and 7 were unique to each. The hospitalisation and ED presentation models out-of-sample Harrell's C-index was 0.664 (95% CI 0.657 to 0.672) and 0.655 (95% CI 0.648 to 0.662), respectively. Some common predictors of high risk of unplanned hospitalisation and ED presentations included: being a man, age, delirium history, higher activity of daily living, behavioural and complex care needs, as well as history, number and recency of healthcare use (including hospital, general practitioners attendances), experience of a high sedative load and several medications.

**Conclusions** Within 90 days of RACF entry, 18.0% of individuals had unplanned hospitalisations and 22.6% had ED presentations. Several predictors, including modifiable factors, were identified at the time of care entry. This is an actionable period for targeting individuals at risk of hospitalisations.

## Strengths and limitations of this study

- Our study provides population-based estimates of the incidence and predictive factors for unplanned hospitalisations and emergency department (ED) presentations for aged care recipients of three Australian states (covering 68% of Australians residential aged care facility residents) and are generalisable to the Australian population and Western countries with similar aged care sectors and similarly ageing populations.
- Our models can moderately well categorise individuals according to their risk of unplanned hospitalisations and ED presentation and provide insightful information about the factors that contribute to these risks, which can be used by clinicians and aged care providers in their care planning and risk mitigation strategies.
- Only public hospitalisation data were used to ascertain outcomes in this study.
- Our analysis focused on predictive models for the studied outcomes that provide interpretable estimates for the factors studied, which likely resulted in lower performing models than more sophisticated machine learning models.
- We cannot infer causality from any of the relationships presented in our findings given the nature of the data and analysis.

## INTRODUCTION

In 2016, in 26 Organisation for Economic Co-operations and Development participant countries, almost five million older people lived in residential aged care facilities (RACF) (ie, nursing homes or long-term care

facilities).[1] In Australia, where approximately 240 000 people live as permanent residents of RACFs each year, who have a 25%–30% reported yearly mortality rate, an approximately 70 000 new residents enter RACFs each year.[2 3] Aged care services in Australia, which include long-term care in RACFs or at home and other transition, respite or home support services, are subsidised by the federal government, while the healthcare services Australians receive are funded by both state (hospitals) and federal government (eg, health services, procedures).[3 4] Over the last decade individuals entering RACFs have increasingly entered care older, with a higher burden of functional limitations, greater burden of comorbid conditions, and significantly frailer.[5] It is well documented that the period of transition into permanent care is one of significant vulnerability for older individuals. The events leading to entry into an RACF (eg, major changes in health status) combined with the transition itself, which includes unfamiliarity with a new environment, new carers, changes in healthcare providers, medications and routines, can pose challenges to individuals, leading to poor health events after entering care.[6–12]

Older individuals, especially those living in RACFs have frequent hospitalisations.[13 14] In Australia, 37% of RACF residents had at least one hospitalisation and 37% at least one emergency department (ED) presentation in 2018/2019.[14] The period of entry into an RACF is also one of significant risk for residents to experience events that may lead to hospitalisations,[8 15] with international estimates of 'short-term' hospitalisations after entering care ranging from 6.8% to 62%.[8 9 15] To date, in Australia, we have population-based estimates of hospitalisation of individuals in RACFs[14] but no estimates of unplanned hospitalisations or ED encounters, important measures of potential adverse events occurrences at care transitions. Frequent care transitions can be distressing, particularly for the 50% of residents who have been diagnosed with dementia entering RACFs,[5] and can be hampered by quality and safety issues such as problems accessing urgent health and medication information, lack of person-centred care and poor communication and handover.[16] As entry into permanent residential care is a period where significant time is spent on assessing individuals' care needs, creating and implementing care plans, and engaging with allied health providers, risk profiling of individuals during this important period can inform care plans and risk mitigation strategies.

Using the national and state-based integrated healthcare and aged care data from the Registry of Senior Australians (ROSA) historical national cohort[5] we have: (1) identified the incidence of unplanned hospitalisations and ED presentations within 90 days in individuals entering permanent care; (2) examined individual, medication, system and healthcare factors, known at RACF entry, and their associations of these events and (3) developed risk profiles for these events.

## METHODS

### Study design, setting and data source

A retrospective cohort study was conducted using the ROSA.[5] Briefly, ROSA contains deidentified linked information from the Australian Institute of Health and Welfare's National Aged Care Data Clearinghouse, which includes the National Death Index, and the Australian Government Medicare Benefits Schedule (MBS) and Pharmaceutical Benefits Scheme datasets, and state health authorities' ED and inpatient hospitalisations data collections. ROSA captures individuals being assessed for eligibility and accessing aged care services for which an eligibility assessment is required, namely residential aged care, home care packages, transition care and respite care.

### Study cohort

The cohort includes all non-indigenous individuals ≥65 years old who had a first-time entry as a permanent resident in an RACF in the states of South Australia (SA), New South Wales (NSW) and Victoria (VIC), between 1 January 2013 and 31 December 2016 and who did not receive Department of Veterans' Affairs subsidised services and were not considered residents in palliative care at entry (N=120 221). Aged care recipients from these three states represent 68% of the national cohort. Individuals missing the basic assessment to determine fundamental care needs, which is required for government funding allocation (named the 'Aged Care Funding Instrument') were excluded (N=4029, 3%). The final study cohort was N=116 192.

### Outcomes of interest

Unplanned hospitalisation and ED presentations at public hospitals within 90 days (or 'short term') of a first-time entry as a permanent RACF resident were the outcomes of interest. Unplanned hospitalisations were hospitalisations where the 'Admission Urgency Status' specified 'Emergency' and not 'Scheduled.' The follow-up period was 1 January 2013–31 March 2017.

### Predictors of interest

The candidate variables for our prediction models included individuals' characteristics, their RACFs' characteristics, pharmaceutical claims history and health services utilisation, inclusive of primary care, hospitals and specialist's healthcare services, which were available in the ROSA datasets.

Individual factors (table 1 and online supplemental table 1) ascertained from assessments performed for service eligibility determination or entry into permanent care included: date of birth, sex, partner status, frailty index score,[17] levels of need regarding activities of daily living (ADL), levels of need regarding cognition and behaviour, levels of need regarding complex healthcare, health conditions and Socio-Economic Indexes for Areas', relative socioeconomic disadvantage index and education and occupation index.[18] Geriatric health

**Table 1** Study cohort description, highlights of individual, medication and facility-related factors by unplanned hospital admission or emergency department presentation status within 90 days of entry into a residential aged care facility

| | Total, N (%) | Hospitalisation within 90 days, N(%) | ED presentation within 90 days, N(%) |
|---|---|---|---|
| No participants | 116 192 (100) | 20 919 (18.0) | 26 242 (22.6) |
| Age, years median (IQR) | 85 (80–89) | 84 (79–88) | 84 (79–89) |
| Women | 71 861 (61.8) | 11 641 (16.2) | 14 733 (20.5) |
| Select geriatric syndrome health conditions* | | | |
| Delirium | 6608 (5.7) | 1543 (23.4) | 1905 (28.8) |
| Malnutrition | 6542 (5.6) | 1040 (15.9) | 1325 (20.3) |
| Incontinence | 41 126 (35.4) | 7448 (18.1) | 9414 (22.9) |
| History of skin disease | 11 435 (9.8) | 2162 (18.9) | 2640 (23.1) |
| Dementia | 58 714 (50.5) | 9948 (16.9) | 12 943 (22.0) |
| Depression | 60 667 (52.2) | 11 410 (18.8) | 14 397 (23.7) |
| ROSA frailty index score† | | | |
| 0 to <0.1 | 450 (0.4) | 48 (10.7) | 67 (14.9) |
| ≥0.1 to <0.2 | 11 315 (9.7) | 1511 (13.4) | 1909 (16.9) |
| ≥0.2 to <0.3 | 60 238 (51.8) | 10 581 (17.6) | 13 241 (22.0) |
| ≥0.3 | 31 841 (27.4) | 6556 (20.6) | 8150 (25.6) |
| Activities of daily living needs level | | | |
| None | 1431 (1.2) | 142 (9.9) | 198 (13.8) |
| Low | 28 577 (24.6) | 3809 (13.3) | 4852 (17.0) |
| Medium | 38 689 (33.3) | 6199 (16.0) | 7993 (20.7) |
| High | 47 495 (40.9) | 10 769 (22.7) | 13 199 (27.8) |
| Behavioural needs level | | | |
| None | 9784 (8.4) | 1581 (16.2) | 1923 (19.7) |
| Low | 25 262 (21.7) | 4167 (16.5) | 5068 (20.1) |
| Medium | 30 030 (25.8) | 5321 (17.7) | 6613 (22.0) |
| High | 51 116 (44.0) | 9850 (19.3) | 12 638 (24.7) |
| Complex healthcare needs level | | | |
| None | 7400 (6.4) | 659 (8.9) | 927 (12.5) |
| Low | 30 934 (26.6) | 4439 (14.3) | 5827 (18.8) |
| Medium | 30 900 (26.6) | 4945 (16.0) | 6364 (20.6) |
| High | 46 958 (40.4) | 10 876 (23.2) | 13 124 (27.9) |
| No of medications | | | |
| 0–2 | 11 490 (9.9) | 1531 (13.3) | 2012 (17.5) |
| 3–5 | 24 953 (21.5) | 3468 (13.9) | 4549 (18.2) |
| 6–9 | 40 624 (35.0) | 6833 (16.8) | 8672 (21.3) |
| 10+ | 39 125 (33.7) | 9087 (23.2) | 11 009 (28.1) |
| ARIA facility remoteness† | | | |
| Major cities | 82 971 (71.4) | 16 123 (19.4) | 20 186 (24.3) |
| Inner regional | 26 065 (22.4) | 3634 (13.9) | 4776 (18.3) |
| Outer regional | 6822 (5.9) | 1107 (16.2) | 1218 (17.9) |
| Remote or very remote | 249 (0.2) | 45 (18.1) | 41 (16.5) |
| Provider type | | | |
| For profit | 51 007 (43.9) | 9812 (19.2) | 12 362 (24.2) |
| Not for profit | 59 124 (50.9) | 10 371 (17.5) | 13 066 (22.1) |
| Government | 6061 (5.2) | 736 (12.1) | 814 (13.4) |

*All, except dementia, were ascertained from the aged care eligibility and entry into care assessments. Dementia was ascertained from the aged care eligibility assessment, entry into care assessment and the RxRisk-V medication-based comorbidity condition indicator for dementia.
†Missing data: ROSA Frailty Index Score n=12 348 (10.6%), ARIA remoteness n=85 (0.07%).
ARIA, Accessibility/Remoteness Index of Australia; ED, emergency department; IQR, Interquartile range; ROSA, Registry of Senior Australians.

conditions were ascertained from the union of data from both assessments and when appropriate (eg, for dementia) both assessments and the condition from the prescription-based comorbidity measure RxRisk-V in the 6 months prior to cohort entry. The RxRisk-V also ascertained the count of individuals' co-morbid conditions using the 6 months prior to cohort entry history. For falls ascertainment specifically, in addition to the assessments, a 1-year history of public hospitalisations where fall was reported (using ICD-10-AM codes W00*, W01*, W03*-W19* and R29.6) was also used.

The facility characteristics examined included: location of facility (state, geographical remoteness)[19] and type (not for profit, for profit or government).

Medication-related factors (table 1 and online supplemental table 2) were ascertained from pharmaceutical claims records in the 90-day period prior to RACF entry and included: number of medications supplied (categorised by Anatomical, Therapeutic and Chemical classification (ATC) codes, fifth level chemical substance),[20] sedative load rating (ie, cumulative effect of medications with sedative properties)[21] and medication class (ie, ATC fourth level, chemical, pharmacological or therapeutic subgroup level).

Healthcare-related factors (table 2 and online supplemental table 3) ascertained using the history of public hospitalisations in the year prior to RACF entry included: number of hospitalisations (unplanned and potentially preventable hospitalisations),[21] number of ED presentations (overall and potentially preventable), cumulative length of hospital stays and 30-day history of hospitalisations or ED presentations (unplanned and potentially preventable hospitalisations). Additional factors were ascertained using the MBS subsidised services (online supplemental table 4) in the year prior to care entry and included: primary healthcare (eg, general practice (GP) attendances, health assessments) or specialist services frequently used by older individuals (eg, geriatric services).

### Statistical analysis

The cohort was described using means, SD, medians, IQR, frequencies and proportions. Fine and Gray models with death as a competing risk, using a modified version of the Hosmer and Lemeshow's purposeful selection of variables approach, for each outcome were employed.[22] This approach involved the repeated elimination of candidate covariates whose omission were not statistically significant from application of the likelihood ratio test; these omissions were stopped when removal of covariates were found to be statistically significant (using a p=0.001 cut-off due to large cohort size). Covariates with less than 5% prevalence (ie, some medications and health services) or collinear with other covariates (determined from Pearson correlation >0.75) were a priori omitted from model building. When collinearity was confirmed, covariates with fewer missing data or easier to model (ie, functional form) were chosen. Terms for covariate effect modification (interaction) with either age or sex were added if they were considered statistically significant from application of the likelihood ratio test, and then simplified post hoc as appropriate. Continuous variables' functional forms were examined, and best distributions modelled, which included non-linear terms or truncation for certain variables. Subdistribution sHRs and 95% CIs were presented. Models' discrimination was examined by calculating Harrell's C-index, which assesses the proportion of subject pairs that have the same ordering of predicted and observed survival times, within-sample using a 10-fold cross-validation and out-of-sample using a cohort of individuals not included in the derivation cohort, that is, N=26 314 city-dwelling individuals with aged care eligibility assessments in 2012. All calculations used complete-case analysis and facility remoteness was the variable with greatest number of missing records (0.07% missing).

### Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting of our research. Consumer representatives will be consulted in the dissemination of this work.

## RESULTS

### Cohort description

In the 116 192 individuals studied the median age was 85 years (IQR 80–89), 61.8% (N=71 861) were women, 50.5% (N=58 714) had dementia and 27.4% (N=31 841) had a frailty index score of ≥0.3 (most frail). See table 1 and online supplemental table 1 for the full cohort description. These individuals entered 1967 distinct RACFs, with 43.9% (N=51 007) entering a for profit, 50.9% (N=59 124) a non-profit and 5.2% (N=6061) a government managed facility. Of the cohort, 69.0% (N=80 139) had at least one unplanned hospitalisation, 17.3% (N=20 129) had at least one potentially preventable hospitalisation and 72.3% (N=83 896) at least one ED presentation in the year prior to care entry (See table 2 and online supplemental tables 3 and 4 for hospital and other health services utilisation).

### Incidence of 90-day unplanned hospitalisations and ED presentations after care entry

Within 90 days of RACF entry the crude incidence of individuals with unplanned hospitalisations was 18.0% (N=20 919) and of ED presentations was 22.6% (N=26 242). During the 90 days after entry into RACF 9.4% (N=10 910) of individuals died (see online supplemental figure S1 for cumulative incidence curves).

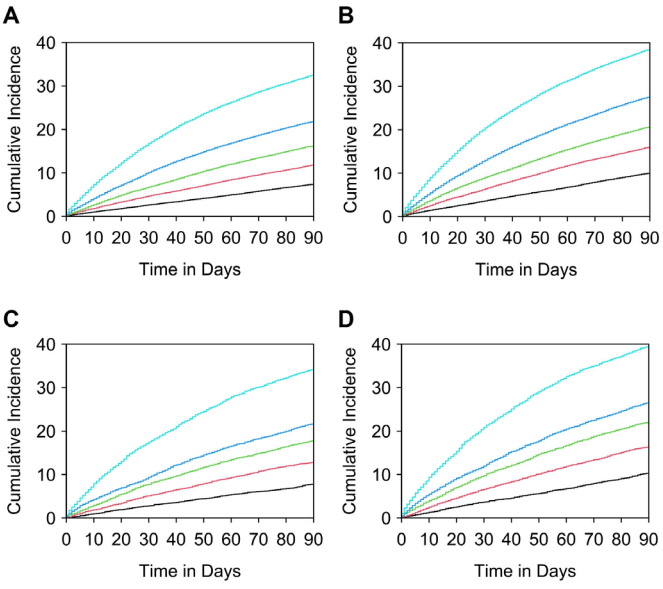
The three most common groups of diagnosis leading to unplanned hospitalisations included: 22.1% for injury, poisoning and certain other consequences of external

**Table 2** Study cohort description, highlights of hospital and healthcare-related factors* by unplanned hospital admission or emergency department presentation status within 90 days of entry into a residential aged care facility

| | Total, N (%) | Hospitalisation within 90 days, N(%) | ED presentation within 90 days, N(%) |
|---|---|---|---|
| No participants | 116 192 (100) | 20 919 (18.0) | 26 242 (22.6) |
| No unplanned hospitalisations | | | |
| 0 | 36 053 (31.0) | 3873 (10.7) | 5249 (14.6) |
| 1 | 41 383 (35.6) | 7097 (17.1) | 8982 (21.7) |
| 2–4 | 34 321 (29.5) | 8215 (23.9) | 10 035 (29.2) |
| 5+ | 4435 (3.8) | 1734 (39.1) | 1976 (44.6) |
| No potentially preventable hospitalisations | | | |
| 0 | 96 063 (82.7) | 15 477 (16.1) | 19 815 (20.6) |
| 1 | 14 691 (12.6) | 3505 (23.9) | 4236 (28.8) |
| 2–4 | 4969 (4.3) | 1712 (34.5) | 1943 (39.1) |
| 5+ | 469 (0.4) | 225 (48.0) | 248 (52.9) |
| No emergency department presentations | | | |
| 0 | 32 296 (27.8) | 3393 (10.5) | 4141 (12.8) |
| 1 | 34 475 (29.7) | 5602 (16.2) | 7143 (20.7) |
| 2–4 | 40 278 (34.7) | 8921 (22.1) | 11 225 (27.9) |
| 5+ | 9143 (7.9) | 3003 (32.8) | 3733 (40.8) |
| GP attendances (MBS Group A01) | | | |
| 0–4 | 23 827 (20.5) | 3535 (14.8) | 4548 (19.1) |
| 5–10 | 38 948 (33.5) | 6594 (16.9) | 8387 (21.5) |
| 11+ | 53 417 (46.0) | 10 790 (20.2) | 13 307 (24.9) |
| Services for patients in RAC facilities (MBS Group A35) | | | |
| 0–4 | 97 056 (83.5) | 17 179 (17.7) | 21 658 (22.3) |
| 5–10 | 15 197 (13.1) | 2885 (19.0) | 3560 (23.4) |
| 11+ | 3939 (3.4) | 855 (21.7) | 1024 (26.0) |
| Urgent attendance after hours (MBS Group A11) | | | |
| 0 | 88 322 (76.0) | 15 086 (17.1) | 19 130 (21.7) |
| 1 | 17 676 (15.2) | 3502 (19.8) | 4272 (24.2) |
| 2–4 | 8868 (7.6) | 1999 (22.5) | 2431 (27.4) |
| 5+ | 1326 (1.1) | 332 (25.0) | 409 (30.8) |
| GP after hours attendances (MBS Group A22) | | | |
| 0 | 77 219 (66.5) | 12 994 (16.8) | 16 351 (21.2) |
| 1 | 20 459 (17.6) | 3911 (19.1) | 4878 (23.8) |
| 2–4 | 13 562 (11.7) | 2850 (21.0) | 3535 (26.1) |
| 5+ | 4952 (4.3) | 1164 (23.5) | 1478 (29.8) |

* All hospital and healthcare-related factors utilisation shown were in the year prior to residential aged care facility entry.
GP, general practitioners; MBS, Medicare Benefits Schedule; RAC, residential aged care.

causes (International Statistical Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM) S00-T98 codes), of which 7.8% were for fractures of subcapital section of femur (ICD-10-AM S72.03) and 6.7% for fracture of intertrochanteric session of the femur (ICD-10-AM S72.11); 15.8% were for diseases of the respiratory system (ICD-10-AM J00-J99), of which 33.6% were due to pneumonia unspecified (ICD-10-AM J18.9), and 18.7% due to pneumonitis due to food and vomit (ICD-10-AM J69.0); and 13.4% for diseases of the circulatory system (ICD-10-AM I00-I99), of which 32.9% were due to congestive heart failure (ICD-10-AM I50.0) and 7.9% for acute subendocardial myocardial infarction (ICD-10-AM I21.4). The three most common groups of diagnosis leading to ED presentations included: 27.9% for symptoms, signs and abnormal clinical findings (ICD-10-AM R00-R99), of which 23.5% was for tendency to fall (ICD-10-AM R29.6), 9.5% for chest pain, unspecified (ICD-10-AM R07.4), and 8.3% for syncope and collapse (ICD-10-AM R55); 18.8% for injury, poisoning and certain other consequences of external causes (ICD-10-AM S00-T98), of which 9.6% were for fracture of neck of femur (ICD-10-AM S72.00)




| | Harrell's C-index | |
|---|---|---|
| | Hospitalisation within 90 days | ED presentation within 90 days |
| In-sample 10-fold cross-validation | | |
| Using quintile groups | 0.658 (95% CI 0.654-0.661) | 0.648 (95% CI 0.644-0.651) |
| Using prediction scores | 0.667 (95% CI 0.663-0.671) | 0.657 (95% CI 0.653-0.660) |
| Out-of-sample validation | | |
| Using quintile groups | 0.655 (95% CI 0.648-0.662) | 0.647 (95% CI 0.641-0.654) |
| Using prediction scores | 0.664 (95% CI 0.657-0.672) | 0.655 (95% CI 0.648-0.662) |

**Figure 1** Cumulative incidence plots (after entry into a residential aged care facility) using quintiles of risk predictions for: (A) unplanned hospitalisation from in-sample 10-fold cross-validation; (B) emergency department presentation from in-sample 10-fold cross-validation; (C) unplanned hospitalisation from out-of-sample validation and (D) emergency department presentation from out-of-sample validation. The groups of quintiles of predicted risk, from lowest to highest, are coloured: black (lowest, first quintile)), red (second quintile), green (third quintile), blue (fourth quintile) and light blue (highest, fifth quintile).
**ED=Emergency department.**

and 7.1% for fracture of other parts of neck of femur (ICD-10-AM S72.08); and 11.9% for diseases of the respiratory system (ICD-10-AM J00-J99), of which 18.7% were for pneumonia unspecified (ICD-10-AM J18.9), and 18.0% for unspecified acute lower respiratory infection (ICD-10-AM J22). See online supplemental table 5 for full reasons for first hospitalisations and ED presentations for the cohort.

### Predictors of 90-day unplanned hospitalisation and ED presentations after care entry

There were 34 predictors of unplanned hospitalisations and 34 predictors of ED presentations identified. Of the predictors identified, 27 were common to both outcomes and 7 were unique to each. The model estimating risk of unplanned hospitalisation and ED presentation out-of-sample Harrell's C-index was 0.664 (95% CI 0.657 to 0.672) and 0.655 (95% CI 0.648 to 0.662), respectively (figure 1; online supplemental figure S2 for the receiver operator characteristic curve).

Common predictors associated with a higher risk of unplanned hospitalisation and ED presentation included (see table 3 for risk estimates and functional forms): being a man, being younger (after the age of 90), having history of delirium, higher ADL needs, higher behavioural needs, higher complex care needs, having entered the facility in 2013 compared with 2015, history, number and recency of hospitalisations and ED presentations in the year prior to entry, number of regularGP and GP urgent after hours attendances in the year prior, exposure to a high sedative load from medications dispensed in the 6 months prior to care entry, and the use of proton pump inhibitors (PPIs), sulfonamides diuretics (ie, furosemide, bumetanide), beta blockers, vitamin K antagonists (warfarin), organic nitrates, inhaled adrenergics in combination with corticosteroids or other drugs (ie, short-acting or long-acting beta2 agonist and corticosteroid combination products) and inhaled anticholinergics. Common factors associated with a lower risk of unplanned hospitalisations and ED presentations included: history of incontinence, no complex care needs compared with lower care needs, being from the state of VIC compared with NSW, entering a government funded facility compared with a non-profit, and anticholinesterases use in the 6 months prior to care entry.

Predictors of higher risk of unplanned hospitalisation only included: facility being in a major city or outer regional compared with inner regional areas, facility entry year 2016, use of systemic glucocorticoids and preparations inhibiting uric acid production (ie, allopurinol, febuxostat) in the 6 months prior to entry into RACF. Factors associated with a lower risk of unplanned hospitalisation only included: living with dementia and facility in SA compared with NSW.

Predictors of a higher risk of ED presentation only included: facility located in a major city compared with inner regional, number of medications individuals had dispensed in the last 6 months, and number of urgent after-hours attendances in the year prior to care entry. Factors associated with a lower risk of ED presentation only included: facility not in a major city in SA compared with inner city NSW, use of HMG CoA reductase inhibitors (statins) and use of two or more health services in RACFs in the year prior to permanent care entry.

## DISCUSSION

In this large cohort study of new residents of 1967 RACFs between 2013 and 2017, we determined that 18.0% of individuals had an unplanned hospitalisation and 22.6% had an ED presentation within 90 days of entering care. We also identified 27 factors, including potentially modifiable ones such as exposure to high medication sedative load, that are common predictors of both unplanned hospitalisations and ED presentation and an additional 7 that are unique to each of the outcomes examined. We have demonstrated that moderately well performing risk predictions tools for whether an individual will get

**Table 3** Predictors of unplanned hospitalisation and emergency department presentations within 90 days of entry into a residential aged care facility

| Factors* | Hospitalisation within 90 days | | ED presentation within 90 days | |
|---|---|---|---|---|
| | sHR (95% CI) | P value | sHR (95% CI) | P value |
| Individual factors | | | | |
| Men vs women | 1.23 (1.21 to 1.27) | <0.001 | 1.24 (1.21 to 1.27) | <0.001 |
| Age, per 10 years increment, only for age ≥90 year | 0.81 (0.75 to 0.89) | <0.001 | 0.84 (0.78 to 0.91) | <0.001 |
| Dementia | 0.96 (0.93 to 0.99) | 0.011 | – | – |
| History of delirium | 1.14 (1.08 to 1.20) | <0.001 | 1.12 (1.07 to 1.18) | <0.001 |
| Incontinence | 0.94 (0.91 to 0.97) | <0.001 | 0.94 (0.92 to 0.97) | <0.001 |
| ADL needs: medium vs low | 1.13 (1.08 to 1.18) | <0.001 | 1.15 (1.11 to 1.19) | <0.001 |
| ADL needs: high vs low | 1.41 (1.35 to 1.47) | <0.001 | 1.37 (1.32 to 1.43) | <0.001 |
| Behavioural needs: high vs low | 1.06 (1.03 to 1.09) | <0.001 | 1.11 (1.08 to 1.14) | <0.001 |
| Complex healthcare needs: none vs low | 0.76 (0.70 to 0.82) | <0.001 | 0.80 (0.76 to 0.86) | <0.001 |
| Complex healthcare needs: high vs low | 1.20 (1.17 to 1.24) | <0.001 | 1.14 (1.11 to 1.18) | <0.001 |
| Facility factors | | | | |
| Major city vs inner regional areas | 1.36 (1.31 to 1.41) | <0.001 | – | – |
| Major city, NSW or VIC only | – | – | 1.21 (1.17 to 1.25) | <0.001 |
| Outer regional and remote vs inner regional areas | 1.20 (1.12 to 1.28) | <0.001 | – | – |
| State: SA vs NSW | 0.88 (0.85 to 0.92) | <0.001 | – | – |
| State: SA, major city only vs NSW, inner regional areas | – | – | 1.08 (1.03 to 1.14) | 0.001 |
| State: SA, not major city vs NSW, inner regional areas | – | – | 0.53 (0.47 to 0.58) | <0.001 |
| State: VIC vs NSW | 0.82 (0.79 to 0.84) | <0.001 | 0.81 (0.79 to 0.84) | <0.001 |
| Government funded vs non-profit facility | 0.78 (0.72 to 0.85) | <0.001 | 0.69 (0.64 to 0.74) | <0.001 |
| System factors | | | | |
| Year: 2013 vs 2015 | 1.07 (1.03 to 1.11) | <0.001 | 1.11 (1.08 to 1.15) | <0.001 |
| Year: 2016 vs 2015 | 0.93 (0.90 to 0.97) | <0.001 | – | – |
| Medication factors† | | | | |
| No of medications ($\log_2$(N-6) for n>6) | – | – | 1.05 (1.03 to 1.06) | <0.001 |
| Sedative load (truncated to 4) | 1.03 (1.02 to 1.04) | <0.001 | 1.02 (1.01 to 1.03) | <0.001 |
| Vitamin K antagonists (warfarin) | 1.14 (1.10 to 1.19) | <0.001 | 1.15 (1.10 to 1.19) | <0.001 |
| Organic nitrates | 1.18 (1.13 to 1.24) | <0.001 | 1.16 (1.10 to 1.20) | <0.001 |
| Enzyme 3-hydroxy-3-methylglutaryl coenzyme (HMG CoA) reductase inhibitors (statins) | – | – | 0.95 (0.92 to 0.97) | <0.001 |
| Sulfonamide diuretics, plain | 1.13 (1.09 to 1.16) | <0.001 | 1.06 (1.03 to 1.09) | <0.001 |
| Beta blocking agents, selective | 1.07 (1.04 to 1.11) | <0.001 | 1.05 (1.02 to 1.09) | <0.001 |
| Inhaled adrenergics in combination with corticosteroids or other drugs, excluding anticholinergics | 1.08 (1.03 to 1.13) | 0.001 | 1.04 (1.00 to 1.09) | 0.059 |
| Inhaled anticholinergics | 1.13 (1.07 to 1.19) | <0.001 | 1.09 (1.04 to 1.14) | <0.001 |
| Systemic glucocorticoids | 1.10 (1.06 to 1.15) | <0.001 | – | – |
| Proton pump inhibitors | 1.08 (1.05 to 1.11) | <0.001 | 1.04 (1.01 to 1.07) | <0.001 |
| Anticholinesterases | 0.88 (0.83 to 0.93) | <0.001 | 0.89 (0.86 to 0.94) | <0.001 |
| Preparations inhibiting uric acid production | 1.11 (1.06 to 1.18) | <0.001 | – | – |
| Healthcare factors‡ | | | | |
| No unplanned hospitalisations ($\log_2$(n+1), N truncated to 20) | 1.31 (1.28 to 1.34) | <0.001 | 1.28 (1.25 to 1.30) | <0.001 |
| Unplanned hospitalisations (30 days prior) | 1.18 (1.13 to 1.23) | <0.001 | 1.14 (1.10 to 1.18) | <0.001 |
| No potentially preventable hospitalisations (truncated to 3) | 1.06 (1.04 to 1.09) | <0.001 | 1.05 (1.03 to 1.08) | <0.001 |
| Unplanned ED presentations (30 days prior) | 1.11 (1.07 to 1.15) | <0.001 | 1.17 (1.13 to 1.21) | <0.001 |

Continued

Table 3 Continued

| Factors* | Hospitalisation within 90 days | | ED presentation within 90 days | |
|---|---|---|---|---|
| | sHR (95% CI) | P value | sHR (95% CI) | P value |
| No of GP Attendances ($log_2$(n+1), N truncated to 20) | 1.07 (1.05 to 1.08) | <0.001 | 1.06 (1.05 to 1.08) | <0.001 |
| Two or more services for patients in RACFs | – | – | 0.94 (0.92 to 0.97) | <0.001 |
| No urgent after-hours attendances (truncated to 3) | – | – | 1.03 (1.02 to 1.05) | <0.001 |
| No GP urgent after-hours attendances (truncated to 3 (hosp) or $log_2$(n+1), N truncated to 10 (ED)) | 1.04 (1.03 to 1.06) | <0.001 | 1.06 (1.04 to 1.07) | <0.001 |

*If functional form not specified in parenthesis following factor, factor was binary (yes vs no) or linear (per unit increment).
†See online supplemental table 3 for specific medications' Anatomical, Therapeutic and Chemical classification codes.
‡Unless specified look back period for variable ascertainment is for the year prior to entry into permanent RACF entry.
ADL, activities of daily living; CI, Confidence interval; ED, emergency department; GP, general practitioners; NSW, New South Wales; RACF, residential aged care facility; SA, South Australia; sHR, subdistribution hazard ratio; VIC, Victoria.

hospitalised or have an ED presentation can be derived from integrated aged care and healthcare information from the period around entry into RACF. Given the critical period that the transition time into RACF is for older individuals, this type of risk profiling for these common events can be valuable for aged care and healthcare providers to inform and implement individually tailored risk mitigation strategies.

Our analysis confirms that men, and individuals with a history of delirium, higher levels of ADL limitations, behavioural needs and complex healthcare conditions, which are known risk factors for RACFs' residents hospitalisations,[6 15 23–25] are also associated with unplanned hospitalisations shortly after entry into RACF in a national cohort of new aged care residents. Similar to other studies we have found the relationship of age and hospitalisations and ED presentation to be complex and in our case we found that only after an individual was 90 years old was an inverse association between age and risk of these events obvious.[6 15] We also determined that incontinence was associated with a lower risk of hospitalisation, which has been reported by O'Malley *et al* in a large study of 687 956 US nursing home residents.[24]

Given the high prevalence of polypharmacy among individuals in RACFs, it is not unexpected that several medication classes, including the summative indicator of sedative load, were found to be associated with hospitalisations and ED presentations. As previously described, potentially high sedative burden, puts individuals at a higher risk of certain hospitalisations, most commonly for falls.[26 27] The count of medications alone was also found to be a predictor of ED presentations, but not unplanned hospitalisations. Polypharmacy, a newly implemented national quality indicator in Australian RACFs,[28] has been associated with hospitalisations in a study of RACF residents[29] and is a flag for a need to examine appropriateness of medication use. Some of the associations identified likely reflect the most common reasons for hospitalisations and ED presentations, or individuals with more severe health conditions. For example, several cardiovascular (sulfonamide diuretics, beta blockers, warfarin, nitrates) and respiratory medications (inhaled short-acting or long-acting beta2 agonist and corticosteroid combination products, inhaled anticholinergics and systemic corticosteroids) were associated with unplanned hospitalisations and/or ED presentations and diseases of the respiratory and circulatory systems were among the most common reasons for these unplanned events. Individuals taking warfarin who experience a fall or injury may also be transferred to hospital due to concern about bleeding risk.[30] Individuals prescribed these medication classes could benefit from a medication review on entry to the RACF. Closer review of asthma and chronic obstructive pulmonary disease action plans, review of inhaler technique, staff training and flags for vaccinations in electronic medication management systems were recommended in a previous root cause analysis of infection-related hospitalisations from South Australian RACFs.[31] PPIs, which were dispensed to 45% of the cohort prior to RACF entry, were associated with both studied outcomes. PPI use has been associated with pneumonia, fractures and *Clostridioides difficile* infection.[32] There may be opportunities to deprescribe PPIs among residents who are treated for >8 weeks or 'step-down' treatment among high-dose users.[33] Further, we found anticholinesterases to be associated with a lower risk of both hospitalisation and ED presentations. In Australia, anticholinesterases are subsidised for managing cognitive symptoms of mild-to-moderate symptoms of Alzheimer's disease and are associated with adverse events such as sedation, dizziness and syncope.[34] Dementia was also found to be associated with a lower risk of hospitalisation, which was also identified by a large US study and reported to be associated with a lower risk of hospitalisation before death in a recent systematic review.[24 35] However, individuals with greater behavioural needs were more likely to be hospitalised which suggests dementia severity may impact hospitalisation decisions as well as recognition of changes to an individual's health status.

Both type of RACF and its geographical location were predictors of unplanned hospitalisations and ED presentations. Payer models for RACF are often reported to

be associated with quality of care provided and events such as hospitalisations.[36 37] However, this relationship is dependent on country-specific models for aged care delivery.[36 37] In line with Australian Royal Commission into Aged Care Quality and Safety reports,[38] which looked at more than 40 indicators of quality and safety of care, several of which were hospitalisations for specific health events, we found government run facilities were consistently associated with lower incidence of unplanned hospitalisations and ED presentations. Canada, which like Australia, has a largely government subsidised aged care sector with resident contributions, delivered in facilities that are mostly non-profit, followed by for profit and then government managed, has also found similar results regarding hospitalisations.[37] Differences in regionality were also reported by the Royal Commission, but with less consistency than for types of facility.[38] Also, state-based differences were observed, and are likely reflective of varying state-based policies, access to pathology or medical imaging at the RACF,[39] differences in private hospitals use for unplanned hospitalisations,[13] and differences in hospital avoidance strategies (eg, extended care paramedics, hospital avoidance programmes),[40 41] which are not captured in this analysis. Another factor we determined to contribute to the risk of unplanned hospitalisation and ED presentation was year of RACF entry, with the most recent years being less likely to be associated with hospitalisations. While it is possible that less hospitalisations are truly occurring in more recent years because of the numerous efforts to reduce hospitalisations in these high-risk individuals, it is also possible individuals may be hospitalised more often in private hospitals, which would therefore not be captured in our analysis and is an important consideration in the interpretation of these findings.

The strongest predictors of hospitalisation and ED presentation we identified included the history of hospitalisation in the 30 days prior as well as the number of hospitalisations in the year prior to RACF entry, which has also been reported by the international literature for both people living in RACFs and in the community.[24 36 42 43] We also identified other health service factors that contribute to the prediction of hospitalisations, including the number of regular and urgent after hour GP attendances in the year prior to RACF entry, which we have also reported in a cohort of older Australians at the point of their aged care eligibility assessment.[44] Similarly, other studies have suggested that frequency of primary care encounters alone can be associated with a higher incidence of hospitalisations and ED presentations, and that continuity and quality of primary care relationships could be potential drivers for reducing the occurrence of these events.[12] Finally, we identified access to in-residential aged care primary care attendances, evidenced by subsidised services for residential aged care settings only, to be associated with a 6% lower risk of ED presentations in those entering RACFs. We investigated how these individuals had claims for these events in the year prior to RACF entry and determined that they accessed residential respite care at RACF in the year prior, which a large proportion (about 53% of the current cohort) of individuals in Australia usually do before entering care permanently.

The risk profiling models presented have moderate predictive performance (Harrell C between 0.65 and 0.66), which is similar to risk profiling models we have created for these outcomes in individuals living in the community and recently assessed for aged care services eligibility.[44] Our estimates are also within the range of published predictive models of hospitalisations and ED presentations in older individuals in general, which have had predictive abilities from poor (0.53) to good (0.83) with few models achieving good predictive ability (ie, c>0.8).[42 43] Additionally, a recent study of an Australian risk profiling tool for RACF residents was published proposing risk factors for hospitalisations but did not provide its model predictive ability.[25]

Our study has several limitations. As 92% of emergency hospitalisations are reportedly captured in public hospitals in Australia, we expect an underestimation of the unplanned hospitalisation and ED encounters in our analysis, but we do not have any reasons to believe this would be differential by the factors analysed.[13] Our analysis focused on predictive models for the studied outcomes that provided interpretable estimates for the factors included, which likely resulted in lower performing models than more sophisticated machine learning models. We cannot infer causality from any of the relationships presented in our findings given the nature of the data and analysis performed and will consider our hypothesis generating findings in future analysis that support causal inference examination. Our integration of health and aged care datasets gives us a comprehensive history of individuals health profiles, care needs, history of health services and medication use, as well as aged care facility characteristics, but we are still limited to the content of these existing datasets, which do not have important more in-depth clinical content, psychosocial and well-being variables, or other potentially important predictors of the events studied. Finally, while a large number of Australians use residential respite care prior to entering permanent care,[45] and therefore, had prior experience with RACFs, we focused on the transition to permanent care in our analysis. To determine whether prior care in an RACF influenced the risk of the outcomes studied we examined the incidence of unplanned hospitalisation and ED presentations in individuals with some respite care the year prior to entry and found it to be similar to the overall cohort (17.3% vs 21.6%, respectively).

Our study provides a population-based estimate of the incidence and predictive factors for unplanned hospitalisations and ED encounters in most individuals who entered an RACF in three Australians states covering 68% of the Australians RACF residents over a 4-year period. Our findings are applicable to the rest of the Australian population and Western countries with similar aged care

sectors with similarly ageing populations. Our models all appropriately address competing risk of mortality after RACF entry, which obviously affect the likelihood of the studied events. We have also used models that can moderately well categorise individuals according to their risk of unplanned hospitalisations and ED presentation and provide insightful information about the factors that contribute to these risks, which can be used by clinicians and aged care providers in their care planning and risk mitigation strategies.

## CONCLUSIONS AND IMPLICATIONS

With over 70 000 individuals entering RACF permanently every year in Australia alone and significant time dedicated to care needs assessment and planning, this is a useful time to characterise those at most risk of ED presentations and unplanned hospitalisations, which are commonplace in individuals entering care. Identifying those at highest risk can inform better monitoring and surveillance, preparation of providers, carers and clinicians regarding their care, and target some of the potentially modifiable factors associated with these events.

**Author affiliations**
[1]Allied Health and Human Performance, University of South Australia, Adelaide, South Australia, Australia
[2]Registry of Senior Australians, South Australian Health and Medical Research Institute, Adelaide, South Australia, Australia
[3]South Australian Health and Medical Research Institute, Adelaide, South Australia, Australia
[4]Southern Adelaide Local Health Network, SA Health, Adelaide, South Australia, Australia
[5]College of Medicine and Public Health, Flinders University, Adelaide, South Australia, Australia
[6]Northern Adelaide Local Health Network, SA Health, Adelaide, South Australia, Australia
[7]Central Adelaide Local Health Network, SA Health, Adelaide, South Australia, Australia
[8]College of Nursing and Health Sciences, Flinders University, Adelaide, South Australia, Australia

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**Twitter** Maria C Inacio @mariacinacio and Janet K Sluggett @JanetSluggett

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**Contributors** The following authors made substantial contributions to conception and design: MCI, RNJ, GH and MC. Acquisition of data: MCI, SW and CW. Analysis and interpretation of data: MCI, RNJ, SW, JKS, JM, JF, AB, GH, MC, STAAR-SA Study Collaborators. The manuscript was drafted by MCI and RNJ and it was critically revised with input from SW, JKS, CW, JM, JF, AB, GH, MC, STAAR-SA Study Collaborators. MCI is the study guarantor and accepts full responsibility for the finished work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

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**ORCID iDs**
Maria C Inacio http://orcid.org/0000-0001-8261-2665
Maria Crotty http://orcid.org/0000-0002-2996-5135

## REFERENCES

1 Organisation for Economic Co-operation and Development. OECD STAT. long-term care resources and utilisation. long-term care recipients. Available: https://stats.oecd.org/Index.aspx?QueryId=30142
2 Khadka J, Lang C, Ratcliffe J, *et al*. Trends in the utilisation of aged care services in Australia, 2008-2016. *BMC Geriatr* 2019;19:213.
3 Australian Government. Department of health. 2019-20 report on the operation of the aged care act, 1997. Available: https://www.gen-agedcaredata.gov.au/resources/reports-and-publications/2020/november/2019%E2%80%9320-report-on-the-operation-of-the-aged-care-a
4 Australian Government. Australian Institute of Health and Welfare. Australia's health 2016. 2.1 How does Australia's health system work? Available: https://www.aihw.gov.au/getmedia/f2ae1191-bbf2-47b6-a9d4-1b2ca65553a1/ah16-2-1-how-does-australias-health-system-work.pdf.aspx
5 Inacio MC, Lang C, Bray SCE, *et al*. Health status and healthcare trends of individuals accessing Australian aged care programmes over a decade: the registry of senior Australians historical cohort. *Intern Med J* 2021;51:712–24.

6 Hoffmann F, Allers K. Variations over time in the effects of age and sex on hospitalization rates before and after admission to a nursing home: a German cohort study. *Maturitas* 2017;102:50–5.
7 Boyd M, Broad JB, Zhang TX, *et al*. Hospitalisation of older people before and after long-term care entry in Auckland, New Zealand. *Age Ageing* 2016;45:558–63.
8 Hoffmann F, Allers K. Age and sex differences in hospitalisation of nursing home residents: a systematic review. *BMJ Open* 2016;6:e011912.
9 Hirdes JP, Heckman GA, Morinville A, *et al*. One way out? A multistate transition model of outcomes after nursing home admission. *J Am Med Dir Assoc* 2019;20:1425–31.
10 Welberry HJ, Jorm LR, Schaffer AL, *et al*. Psychotropic medicine prescribing and polypharmacy for people with dementia entering residential aged care: the influence of changing general practitioners. *Med J Aust* 2021;215:130–6.
11 Ferrah N, Ibrahim JE, Kipsaina C, *et al*. Death following recent admission into nursing home from community living: a systematic review into the transition process. *J Aging Health* 2018;30:584–604.
12 Haber SG, Wensky SG, McCall NT. Reducing inpatient hospital and emergency room utilization among nursing home residents. *J Aging Health* 2017;29:510–30.
13 Australian Institute of Health and Welfare. Admitted patient care 2017–18: Australian hospital statistics. health services series No. 90 Cat. no. HSE 225. AIHW. Available: https://www.aihw.gov.au/getmedia/df0abd15-5dd8-4a56-94fa-c9ab68690e18/aihw-hse-225.pdf.aspx?inline=true
14 Commonwealth of Australia. Royal Commission into aged care quality and safety. research paper 18: hospitalisations in Australian Aged Care: 2014/15-2018/19. Available: https://agedcare.royalcommission.gov.au/sites/default/files/2021-02/research-paper-18-hospitalisations-australian-aged-care.pdf
15 Brucksch A, Hoffmann F, Allers K. Age and sex differences in emergency department visits of nursing home residents: a systematic review. *BMC Geriatr* 2018;18:151.
16 Australian Commission on Safety and Quality in Health Care. Safety issues at transitions of care. Consulation report on pain points relating to clinical information systems https://www.safetyandquality.gov.au/sites/default/files/migrated/Safety-issues-at-transitions-of-care-consultation-report.pdf
17 Khadka J, Visvanathan R, Theou O, *et al*. Development and validation of a frailty index based on Australian aged care assessment program data. *Med J Aust* 2020;213:321–6.
18 Australian Bureau of Statistics. Census of population and housing: socio-economic indexes for areas (SEIFA), Australia, 2016. Available: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/2033.0.55.001Main+Features12016?OpenDocument
19 Hugo Centre for Migration and Population Research. Accessibility/Remoteness index of Australia plus (ARIA+) 2016. The University of Adelaide. Available: https://www.adelaide.edu.au/hugo-centre/services/aria
20 World Health Organization Collaborating Centre for Drug Statistics Methodology. ATC/DDD index, 2018. Available: https://www.whocc.no/atc_ddd_index/
21 Linjakumpu T, Hartikainen S, Klaukka T, *et al*. A model to classify the sedative load of drugs. *Int J Geriatr Psychiatry* 2003;18:542–4.
22 Hosmer D, Lemeshow S. *Applied survival analysis: regression modeling of time to event data*. New York, NY, USA: Wiley, 2008: 132–68.
23 Graverholt B, Riise T, Jamtvedt G, *et al*. Acute hospital admissions among nursing home residents: a population-based observational study. *BMC Health Serv Res* 2011;11:126.
24 O'Malley AJ, Caudry DJ, Grabowski DC. Predictors of nursing home residents' time to hospitalization. *Health Serv Res* 2011;46:82–104.
25 Ooi M, Lewis ET, Brisbane J, *et al*. Feasibility of using a risk assessment tool to predict Hospital transfers or death for older people in Australian residential aged care. A retrospective cohort study. *Healthcare* 2020;8 doi:10.3390/healthcare8030284
26 Seppala LJ, Wermelink AMAT, de Vries M, *et al*. Fall-Risk-Increasing drugs: a systematic review and meta-analysis: II. psychotropics. *J Am Med Dir Assoc* 2018;19:371.e11–371.e17.
27 Pharmaceutical Society of Australia. Medicine safety: aged care. Available: https://www.psa.org.au/wp-content/uploads/2020/02/Medicine-Safety-Aged-Care-WEB-RES1.pdf
28 Australian Government, Department of Health. National aged care mandatory quality indicator program (Qi program). manual 2.0-Part A- final draft. Available: https://www.health.gov.au/sites/default/files/documents/2021/04/national-aged-care-mandatory-quality-indicator-program-manual-national-aged-care-mandatory-quality-indicator-program-manual-2-0-part-a-final-draft.pdf [Accessed 30 Apr 2021].
29 Lalic S, Sluggett JK, Ilomäki J, *et al*. Polypharmacy and medication regimen complexity as risk factors for hospitalization among residents of long-term care facilities: a prospective cohort study. *J Am Med Dir Assoc* 2016;17:1067.e1–1067.e6.
30 Green L, Selleck L, Gibbons M, *et al*. Does the evidence justify routine transfer of residents of aged care facilities for CT scan after minor head trauma? *Intern Med J* 2020;50:1048–52.
31 Sluggett JK, Lalic S, Hosking SM, *et al*. Root cause analysis of fall-related hospitalisations among residents of aged care services. *Aging Clin Exp Res* 2020;32:1947–57.
32 Maes ML, Fixen DR, Linnebur SA. Adverse effects of proton-pump inhibitor use in older adults: a review of the evidence. *Ther Adv Drug Saf* 2017;8:273–97.
33 Sluggett JK, Hendrix I, Bell JS. Evidence-based deprescribing of proton pump inhibitors in long-term care. *Res Social Adm Pharm* 2018;14:124–6.
34 Kim DH, Brown RT, Ding EL, *et al*. Dementia medications and risk of falls, syncope, and related adverse events: meta-analysis of randomized controlled trials. *J Am Geriatr Soc* 2011;59:10.1111/j.1532-5415.2011.03450.x:1019–31.
35 Hoffmann F, Strautmann A, Allers K. Hospitalization at the end of life among nursing home residents with dementia: a systematic review. *BMC Palliat Care* 2019;18:77.
36 Grabowski DC, Stewart KA, Broderick SM, *et al*. Predictors of nursing home hospitalization: a review of the literature. *Med Care Res Rev* 2008;65:3–39.
37 Tanuseputro P, Chalifoux M, Bennett C, *et al*. Hospitalization and mortality rates in long-term care facilities: does for-profit status matter? *J Am Med Dir Assoc* 2015;16:874–83.
38 Commonwealth of Australia. Royal Commission into aged care quality and safety. research paper 15: residential care quality indicator profile. Available: https://agedcare.royalcommission.gov.au/publications/research-paper-15-residential-care-quality-indicator-profile
39 Inacio M, Jorissen RN, *et al*. The national spending and uptake of mobile radiology services in aged care facilities- an opportunity to improve access remains. *Int Med J* 2021.
40 Burkett EBD, Donovan R, Cranitch E, *et al*. Implementation tool-kit for residential aged care support services (RaSS). CARE-PACT and healthcare improvement unit, Queensland health. Available: https://clinicalexcellence.qld.gov.au/sites/default/files/2019-07/racf-implementation-toolkit.pdf
41 SA Ambulance Service. SA ambulance service fact sheet: extended care paramedics (ECPs).
42 Zhou H, Della PR, Roberts P, *et al*. Utility of models to predict 28-day or 30-day unplanned hospital readmissions: an updated systematic review. *BMJ Open* 2016;6:e011060.
43 Wallace E, Stuart E, Vaughan N, *et al*. Risk prediction models to predict emergency hospital admission in community-dwelling adults: a systematic review. *Med Care* 2014;52:751–65.
44 Inacio MC, Jorissen RN, Khadka J, *et al*. Predictors of short-term hospitalization and emergency department presentations in aged care. *J Am Geriatr Soc* 2021 doi:10.1111/jgs.17317
45 Harrison SL, Lang C, Whitehead C, *et al*. Residential Respite care use is associated with fewer overall days in residential aged care. *J Am Med Dir Assoc* 2020;21:653–9.