

RESEARCH ARTICLE

Hospitalisations before and after entry into a residential aged care facility: An interrupted time series analysis

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Abstract

Objective: Hospitalisations are an important indicator of safety and quality of care in residential aged care facilities (RACFs). This study aimed to investigate changes in hospital use 12 months before and 12 months after RACF entry using routinely collected data from 25 Australian RACFs.

Methods: This was a retrospective longitudinal cohort study using linked aged care provider and hospital record data. The sample comprised 1029 residents living in an aged care facility between July 2014 and December 2019 who had stayed a minimum of 12 months in an RACF. The outcome measures were *all-cause hospitalisations* and *fall-related hospitalisations*. We applied an interrupted time series analysis using segmented regression to examine changes in both outcome measures over time. Stratified analyses were conducted by gender and dementia status.

Results: The rate of *all-cause hospitalisations* increased dramatically over the 12 months before RACF entry, from 97 per 1000 residents per month 12 months prior to RACF admission to 303 per 1000 residents at the second month prior to RACF entry. *All-cause hospitalisations* then decreased considerably to 55 per 1000 residents upon RACF admission and stabilised across the next 12 months. Such trajectories were also observed in *fall-related hospitalisations* and were consistent for gender and dementia status.

Conclusions: In this study, hospitalisation rates decreased significantly after RACF entry, and such reductions were maintained for residents who stayed for 12 months in RACFs. Multiple hospital admissions are likely to precipitate entry into RACF. Additional investigation of how community-based services can be successful in reducing the escalating hospitalisations is needed.

KEYWORDS

ageing, dementia, health services for the aged, hospitals, hospitalisation, outcome assessment, quality indicators

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1 | INTRODUCTION

The number of older adults living in residential aged care facilities (RACFs) (i.e. nursing homes, care homes or long-term care facilities) has been increasing dramatically globally.¹ Between 2009 and 2019, the number of people living in RACFs in 23 Organisation for Economic Co-operation and Development (OECD) member states increased by 25% to 3.83 million.¹ During this period, Australia saw a 10% increase in permanent residents in RACFs,¹ with more than 238,000 older adults residing in RACFs in 2020.² The rising number of older adults living in RACFs attracts widespread concern about how to provide sufficient, high-quality and financially sustainable services for this growing subpopulation to improve their well-being and quality of life.^{3–5}

Hospital utilisation is an important indicator to measure and monitor the safety and quality of aged care services delivered in RACFs and community settings, as many hospitalisations are potentially avoidable with appropriate care.⁶ Residents in RACFs are frequently hospitalised due to multimorbidity and polypharmacy associated with declines in physical and cognitive function.^{7,8} The proportion of residents hospitalised in RACFs, according to a systematic review based on studies from the United States, Canada, China and four European countries, ranged from 6.8% to 45.7% for various time periods of follow-up.⁹ Hospitalisation is costly (e.g. \geq USD 6700 per hospitalisation per resident in the United States¹⁰ and \geq AUD 5700 in Australia)¹¹ and exposes RACF residents to an increased risk of a number of adverse events, including falls, functional decline, delirium, iatrogenesis and malnutrition.^{7,8,12–14} Further, a large proportion of hospitalisation visits by RACF residents are considered inappropriate, with up to 77% of hospitalisations potentially preventable.¹⁵

While hospitalisation is an important indicator to evaluate the quality of aged care services delivered in RACFs,⁶ most previous studies have focussed on reporting the overall hospitalisation rate by age- and gender-based on cross-sectional data.⁹ However, investigations into longitudinal changes of hospitalisation rates among RACF residents, particularly before and after admission into RACFs, are important to determine the short-term and long-term benefit of service provisions such as residential aged care services. A handful of studies have demonstrated considerable differences in hospital use before and after RACF admission, with the rate of hospitalisation increasing significantly in the period immediately prior to RACF admission, and reducing immediately after entry into RACFs.^{16–20}

In Australia, approximately 37% of RACF residents are hospitalised annually (1.25 hospitalisations per person-year),²¹ with the most common causes being falls and infections.²¹ There is some evidence that the rates of

Practice Impact

Our study demonstrates that entry into residential aged care facilities (RACFs) significantly reduced and helped to stabilise escalating hospital admissions from older adults in the community. Timely and appropriate entry into RACF would likely result in a cost-benefit from the perspective of the health system. Understanding the contributing and protective factors from community-based services behind the increase in hospitalisation preceding RACF entry is critical in avoiding preventable hospital admissions.

fall- (2003–2012) or infection-related (2013–2016) hospitalisations for older people in RACFs have increased during the past few years.^{22,23} A study published in 2022 based on data from three Australian states from 2013 to 2016 reported a considerable decrease in the proportion of individuals hospitalised after RACF entry.²⁰ However, previous studies have failed to shine a light on the changes in fall-related hospitalisation and/or dementia and gender-specific trends.

This study aimed to conduct a time series analysis of hospitalisation and fall-related hospitalisation before and after RACFs admission in Australia using a large dynamic, observational data set. Fall-related hospitalisations are included given that falls are the leading cause of hospitalisation in Australian RACFs, accounting for 15% of overnight inpatient hospitalisation,²¹ and can have severe clinical consequences for older adults.²⁴ A secondary aim was to examine the changes in hospitalisation rate by resident gender and dementia status. The differences in hospitalisation by dementia status in RACFs are of interest since dementia is generally the most prevalent disease in RACFs²⁵ and older adults with dementia tend to experience a higher probability of hospital admissions and create greater difficulties in management plans in general hospitals²⁶; therefore, the trajectories of hospitalisation before and after RACF admission might exhibit distinctive patterns by dementia status.

2 | METHODS

2.1 | Study design and settings

We conducted an interrupted time series-design study utilising a large routinely collected aged care data set from 25 RACFs administered by a large not-for-profit aged care provider in New South Wales, Australia. Interrupted time

series design is a type of quasi-experimental design enabling the evaluation of immediate impact and slope associated with an intervention while controlling for secular trend in the rate of an outcome of interest.²⁷ We linked the RACF resident data to the state hospitalisation data set to investigate residents' use of hospitals over time. The cohort consisted of residents who entered the RACFs from 1 July 2014 to 31 December 2019.

2.2 | Participants

We used data relating to permanent residents aged 65 years and older.²⁸ Respite residents, interim care residents and those discharged on the same day of admission were excluded from the study. Residents who had hospital admissions for dialysis (International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification [ICD-10-AM] codes Z49.1) and those who were in RACFs for less than 1 year were also excluded to ensure the follow-up time was consistent.

2.3 | Data sources

Data were sourced from the aged care provider's clinical and care management information systems. The de-identified data included residents' profiles including age, gender, entry and departure date, health conditions (free text documenting the health conditions including dementia, depression, mood and affective disorders, cognitive impairment, anxiety and stress-related disorders, cerebrovascular accident, diabetes mellitus, visual impairment, delirium and Parkinson's disease) and admission type (i.e. permanent, respite or interim care). These data were linked through the Centre for Health Record Linkage (CHeReL) to the Admitted Patient Data Collection (APDC), which contains data on residents' hospitalisation history (e.g. admission date, discharge date, principal and secondary diagnoses and other diagnoses). We calculated the updated version of the Charlson Comorbidity Index scores using ICD-10-AM codes.²⁹

2.4 | Outcome measures

Outcome measures assessed were as follows: (1) number of *all-cause hospitalisations* defined as hospitalisations for any reason, including falls and (2) *fall-related hospitalisation* defined as hospitalisations with any principal or secondary diagnosis of a fall (i.e. ICD-10-AM code W00-W19). Both outcomes were measured monthly 1 year before and 1 year after entry to an RACF. Sensitivity analysis

was conducted across three other time points including 3 months, 6 months and 2 years with all time points demonstrating the same trend; due to sample size 1 year was chosen.

2.5 | Statistical analysis

Descriptive statistics were used to describe the characteristics of the cohort and their hospital admissions before and after RACF entry. Differences in characteristics of hospitalisation from 12 months before and 12 months after RACF entry were tested using McNemar's chi-squared test and Wilcoxon rank-sum test depending on the nature of the variable. For both outcome measures, we conducted segmented regression analysis to examine the changes in outcomes over time. Segmented regression is a commonly utilised method in an interrupted time series design to evaluate the immediate impact and slope associated with an intervention. In this study, our outcome of interest was hospitalisation rate (with hospitalisation data aggregated at monthly level due to sample size), and the time of a resident's entry into an RACF was considered as the intervention time point. Using segmented regression enabled us to investigate whether the changes in the two outcomes before and after RACF entry reach a statistically significant level. This was conducted using the STATA *xtitsa* module as a single group analysis; for the distribution the negative binomial was used and for the link function identity was used. To identify autocorrelation in the regression model, we used Newey–West standard errors³⁰ with lag terms applied to the regression model where needed. The segmented regression looked at two time periods: (1) 12 months before entry into RAC and (2) 12 months after entry into RAC. The segmented regression compared the baseline level of hospitalisations rate at the 12 months prior to entry into RAC, change in the monthly hospitalisation rate in the 12 months before RAC, the immediate change in hospitalisation rate in the first month after entry into RAC and change in monthly hospitalisations rate in the 12 months after entry into RAC. Stratified analysis was conducted by gender and dementia status to examine differences among these subpopulations. Tests were two-tailed with $p < .05$. All analysis was undertaken using Stata version 17 (StataCorp LP).

2.6 | Ethics

The study received ethics approval by the New South Wales Population and Health Service Research Ethics Committee (2020_ETH00166) and from the Macquarie University Human Research Ethics Committee (52019614412614).

3 | RESULTS

3.1 | Participants

A total of 1029 residents were included in our analysis (Figure 1). Of all residents, 58% ($n=602$) had at least one hospitalisation during the observed study period (i.e. 12 months before or 12 months after entry into RACFs). Approximately two-thirds were female (66%), and the median age at entry of RACFs was 87 years (interquartile range [IQR], 81–91). The most common health condition among the residents was dementia (60%), followed by depression, mood and affective disorders (45%) and cognitive impairment (40%) (Table S1). Table S1 highlights the differences between residents who were included in the

cohort (i.e. length of stay in RACF greater than 365 days) and resident excluded from the cohort due to length of stay in RACF less than 365 days.

3.2 | All-cause hospitalisations

Table 1 shows the characteristics of *all-cause hospitalisations* in the 12 months before and 12 months after RACF entry. Patterns of *all-cause hospitalisations* significantly changed over the 24-month study period. Of the total 2531 hospital admissions recorded, 1906 were reported in the year before RACF admission with the remaining 625 occurring during the first-year residence in residential care, showing a considerable decrease in residents' hospital

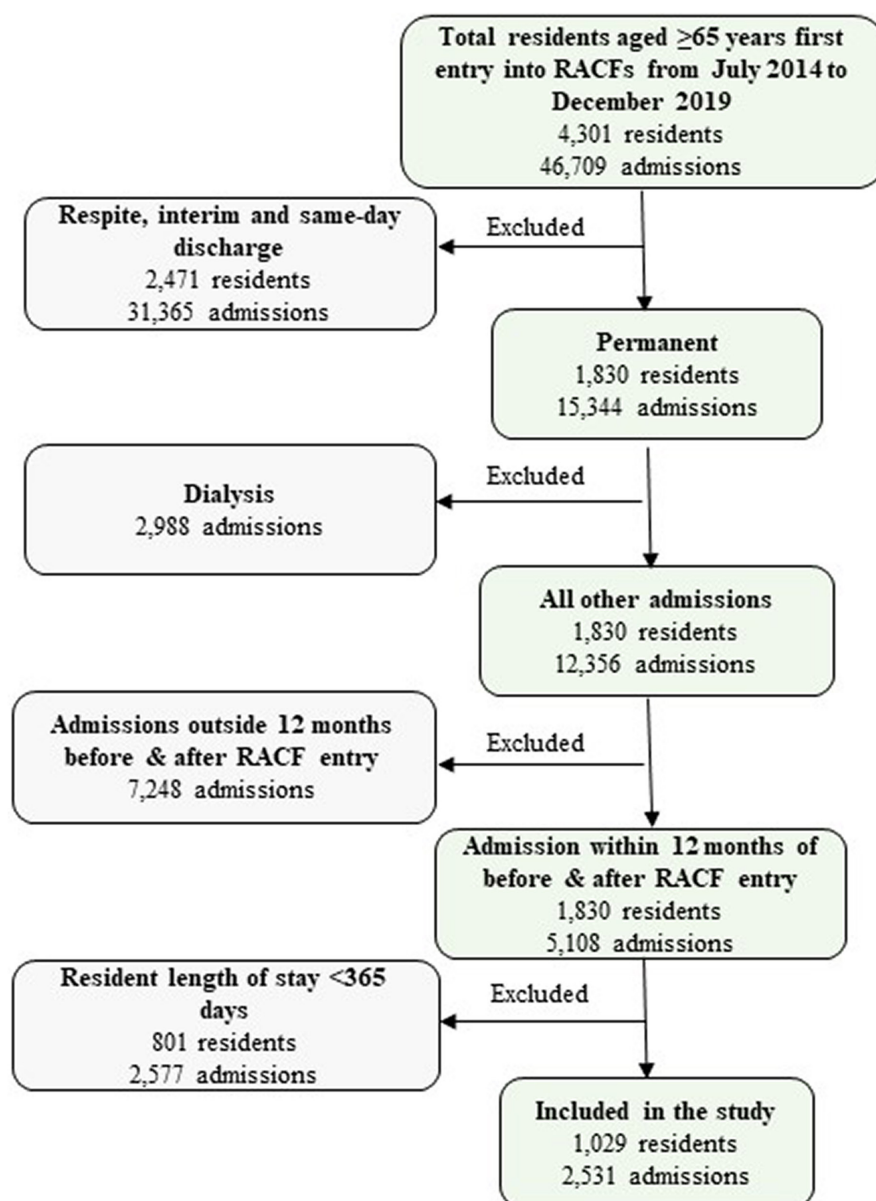


FIGURE 1 Resident selection flow chart.

TABLE 1 Characteristics of RACF residents and their hospitalisations in the 12 months before and 12 months after RACF entry.

	Before	After	p-Value
Hospital stay characteristics			
Number of admissions	1906	625	
Hospital length of stay (days)			
Median (IQR)	5.22 (0.24–16.85)	2.44 (0.37–6.60)	<0.001
Mean (SD)	11.66 (16.36)	5.44 (9.89)	
Fall-related hospital admission, n (%)	520 (27)	130 (20.80)	0.001
Characteristics of residents at time of entry to an RACF with at least 1 hospitalisation			
No. of residents	550	299	
Gender, n (%)			
Male	206 (37)	118 (39.46)	0.565
Female	344 (63)	181 (60.54)	
Charlson Comorbidity Index			
Median (IQR)	1 (0–2)	2 (1–3)	0.320
Mean (SD)	1.46 (1.61)	1.93 (1.53)	
Selected health status, n (%)			
Dementia	314 (57)	162 (54.18)	0.414
Depression, mood and affective disorders	271 (49)	153 (51.17)	0.597
Cognitive impairment	227 (41)	118 (39.46)	0.608
Anxiety- and stress-related disorders	208 (38)	105 (35.12)	0.436
Cerebrovascular accident	151 (27)	89 (29.77)	0.475
Diabetes mellitus	132 (24)	77 (27.75)	0.571
Visual impairment	115 (21)	63 (21.07)	0.956
Delirium	76 (14)	39 (13.04)	0.753
Parkinson's disease	54 (10)	24 (8.03)	0.388

TABLE 2 Segmented regression output of the impact of RACF admission on *all-cause hospitalisations*.

	Estimated <i>all-cause hospitalisation rate</i> (per 1000 residents, 95% CI)	p-Value
Use at baseline ^a	83 (59 to 107)	<0.001
Trend before RACF entry ^b	14 (10 to 17)	<0.001
Change at RACF entry ^c	–185 (–212 to –158)	<0.001
Change in monthly trend after RACF entry compared to before ^d	–15 (–18 to –11)	<0.001
Trend after RACF entry ^e	–2 (–2 to –1)	0.11

^aAll-cause hospitalisation rate per 1000 residents in the first month of the before compared to after.

^bThe slope of the linear regression line (i.e. the monthly rate of change in all-cause hospitalisations) in the before RACF period.

^cThe immediate change in all-cause hospitalisation in the first month of RACF period (i.e. the first month after entry) compared to the last month prior to entry.

^dThe slope of the linear regression line (i.e. the monthly rate of change in all-cause hospitalisations) after entry in RACF compared to before entry in RACFs.

^eThe slope of the linear regression line (i.e., the monthly rate of change in all-cause hospitalisations rates per 1000 residents) after entry into RACFs.

use after RACF admission. There was also a significant decrease in hospital length of stay and fall-related hospitalisations after RACF admission.

There were no significant differences in the characteristics of residents hospitalised before and after entry into

RACFs (Table 1). For residents admitted to hospitals, the median length of hospital stay decreased from 5.22 days (before admission to RACFs) to 2.44 days (after admission to RACFs), while the proportion of *fall-related hospitalisations* decreased from 27% to 21%. However, the causes

of hospitalisation changed slightly (Table S2). The most frequent reason for hospitalisation in the 12 months before RACF entry was ICD10-AM codes Z00-Z99 (factors influencing health status and contact with health services, 20%), followed by ICD10-AM codes S00-T98 (injury, poisoning and certain other consequences of external causes, 17%) compared to the 12 months after entry into RACFs, which was ICD10-AM codes S00-T98 (injury, poisoning and certain other consequences of external causes, 20%), followed by ICD10-AM codes R00-R99 (symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, 14%) (Table S2).

Figure S1 (below) shows the monthly trend of *all-cause hospitalisations* over the study period. The rate of *all-cause hospitalisations* exhibited an overall upward trend as participants approached entry into an RACF, increasing from 97 hospital admissions per 1000 residents per month 12 months prior to RACF entry, to 303 per 1000 residents 2 months prior to RACF entry. Hospitalisations then decreased to 55 per 1000 residents upon entry to RACFs and stabilised over the next 12 months (Figure S1 and Table S3). Thus, residents experienced an 82% reduction in hospitalisations upon entry into RACFs compared to the period 2 months prior to entry. A similar pattern of the decrease was observed for the average length of stay of *all-cause hospitalisations* (Figure S2).

The results from the segmented regression analysis are presented in Figure 2 and Table 2. It confirms the results above that hospitalisation rates significantly increased each month by 14 per 1000 residents in the 12 months

leading up to entry into RACFs and significantly reduced upon entry into RACFs by 185 per 1000 residents. Additionally, this reduction was maintained across the 12 months after RACF admission.

3.3 | Fall-related hospitalisations

There were 650 *fall-related hospitalisations* recorded across the 24 months from the 1029 residents. This comprised of 520 hospitalisations before and 130 hospitalisations after RACF entry. The changes in the average *fall-related hospitalisations* by month followed the same pattern as for *all-cause hospitalisations* (Figure S3), with *fall-related hospitalisations* reaching 113 per 1000 residents 2 months prior to RACF entry and then dramatically decreasing to 16 per 1000 residents upon entry to RACFs.

The results of segmented regression estimate a rate of nine *fall-related hospitalisations* per 1000 residents at baseline. This increased statistically every month prior to RACF entry by seven per 1000 residents. In the first month of entry into RACFs, there was a significant decrease by 70 per 1000 residents (95% CI:57–84) average monthly. This represented a statistically significant decrease in the monthly trend relative to before entry into RACFs to seven *fall-related hospitalisations* per 1000 residents per month. However, there was no significant change in trends in *fall-related hospitalisations* after entry into RACFs ($p=0.572$) (Table S4; and Figure 3).

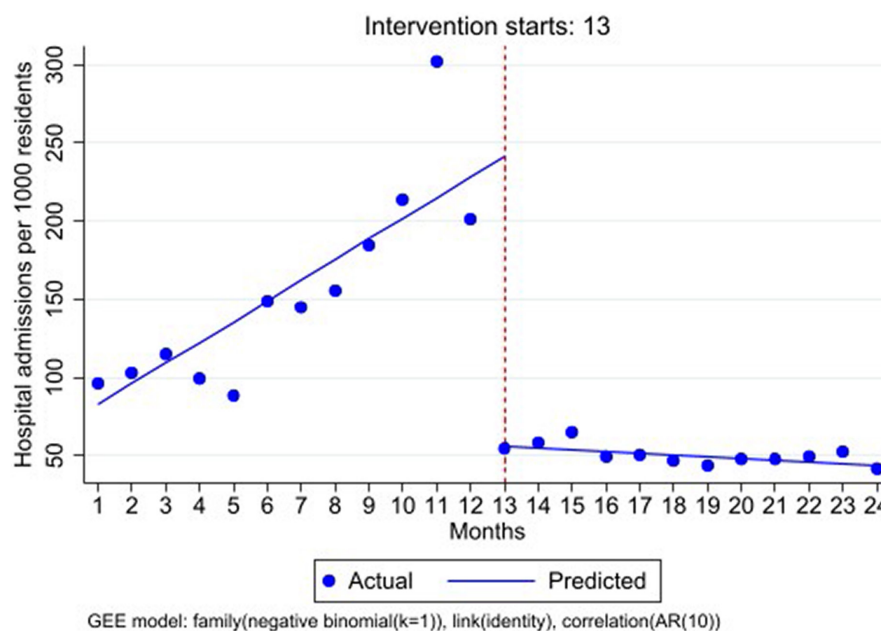


FIGURE 2 Trends in monthly *all-cause hospitalisations* per 1000 residents in the 12 months before and after entry into RACFs with the dotted line indicating the time of RACF admission.

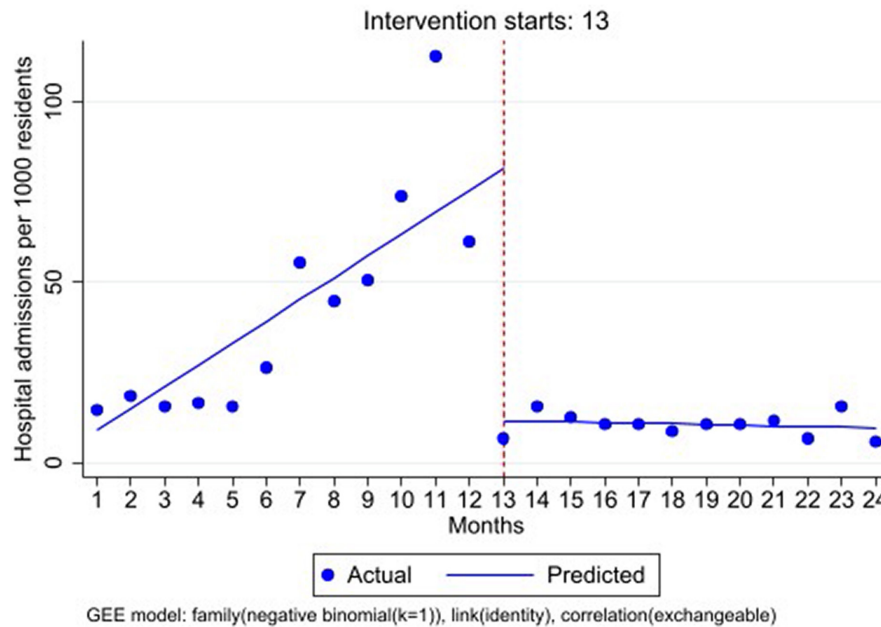


FIGURE 3 Trends in monthly fall-related hospitalisations in the 12 months before and after entry into RACFs with the dotted line indicating the time of RACF admission.

3.4 | Changes in hospitalisations by gender and dementia status

Stratified analysis by gender and dementia status produced similar trajectories, with the average number of hospital admissions increasing leading up to RACF entry and then dropping off (Figures S4 and S6). The segmented regression analysis demonstrated no differences in average monthly all-cause hospitalisation rates by gender or dementia status (Table S5, Figures S5 and S7).

4 | DISCUSSION

This study demonstrated a significant increase in hospital use over the 12 months leading up to entry into RACFs and a significant decrease in hospital admissions (by 82%) following RACF admission for residents that stayed for a minimum of 12 months in RACFs. In addition, the decrease in hospitalisation after RACF entry was maintained for the next 12 months, with an average hospitalisation rate lower than experienced 12 months prior to entry. This pattern of hospitalisation was also observed for fall-related hospitalisations. Overall, there were no differences in hospitalisation patterns by gender and dementia status.

The findings of a significant decline in hospitalisation after RACF entry mirror the results from the existing evidence reported in Germany,^{16,19} New Zealand¹⁷ and the United States³¹ and also from a recent study in Australia.²⁰ For example, a retrospective cohort study in Germany found that the hospitalisation rate quickly declined from

six hospitalisations per person-year during the 3 months immediately prior to RACF entry to 1.1 hospitalisations per person-year on entry to an RACF.¹⁶ Similarly, evidence from New Zealand demonstrated that the hospitalisation rate decreased from 1.49 hospitalisations per person-year during the 6 months immediately prior to RACF to 0.49 hospitalisations per person-year in the 6 months following RACF entry.¹⁷ A study in the United States also showed that the probability of hospitalisation declined by more than 70% after 90 days in an RACF and decreased by 7% with every extra year in residence.³¹ Our findings also align with a recent report from the Australian Royal Commission into Aged Care Quality and Safety reporting a lower level of hospital use among RACF residents (1256 hospital admissions per 1000 people) compared with the general Australian older population (1700 hospital admissions per 1000 people, age-adjusted).²¹ What this study adds to the existing literature is that the decline in hospital use after RACF entry appears to be universal and occurred regardless of type of hospitalisation, residents' gender and dementia status.

Although this study is unable to verify the reasons behind the changes in hospitalisation before and after RACF entry, escalating hospital use prior to RACF entry can be due to an increase in health care caused by rapid deteriorations in health conditions, which could make the home an unsafe environment for older people with increasing disability. Hence, the decline in hospital use after RACF entry might be plausibly explained by the increase in provision of aged care services provided by RACFs and stabilisation of the critical health scare. Many RACFs provide

a wide range of services to support residents' health outcomes and prevent health problems, including the around-the-clock presence of care staff, increased access to more rapid care in response to residents in need (e.g. through telephone or buzzer bells), close monitoring on medication administration, routinely run fall prevention programs and regularly organised social events. In addition, RACFs generally have plans and trained staff in place for emergency situations to provide essential life support (e.g. use of cardiopulmonary resuscitation) and access to hospital avoidance programs.³² In contrast, such quantity and level of services are generally not available for older adults in the community; therefore, frail older people who are self-managing in community settings may experience injuries and illnesses requiring frequent hospital admissions. Home care recipients generally receive a lower level of care support with reduced access to rapid responses in case of emergency compared with their counterparts residing in RACFs. Therefore, RACFs may better fulfill the demand for advanced aged care services from older adults who can no longer be appropriately cared for in a community setting, hence leading to a reduced use of hospital services. However, it would be important to conduct further studies to identify the difference in residents' level of appropriate home care prior to entry into RACFs. It is also of crucial importance to further analyse the barriers that hamper older people in need to be transferred to RACFs and the multilevel determinants that affect older people's decision to enter an RACF.

The results show that entry to RACFs is associated with reduced hospitalisations and hence shifts the economic trajectory associated with high levels of hospitalisation. This is particularly important for Australia where the hospitalisation rate among older adults have been gradually increasing over the past few years.²¹ However, whether the same outcome might be achieved with better support services provided to older people in the community remains unanswered. Our results suggest that more targeted strategies and support programs in the community such as easily accessible access to community nurses are required to reduce the risk of hospitalisation. Improved programs to effectively identify older adults who are frail and truly in need of entry into RACFs may be warranted and reduce the likelihood of the risks of multiple hospitalisations prior to RACF entry.

Future research should look at hospitalisations in tandem with other outcome indicators such as psychotropic use³³ and severe pressure injuries,³⁴ as these both increase after entry into RACFs and the decrease in hospitalisations might be due to the residents being less active and lying-in bed longer, particularly for fall-related hospitalisations. Our findings do not imply that the fall rate is

lower in RACFs compared to a community setting (i.e. the 'before' group). The incidence of falls could be higher in RACFs but could be managed at the RACF level without the need to be hospitalised.

The study had particular strengths in that it used a comprehensive data set of all residents who entered into RACFs over a 5.5-year period. Further, the study design enabled individual level data to be analysed using interrupted time series analysis, which is a powerful method to detect the effect of entry into RACFs on hospitalisation rates.

This study had some limitations. Our linked data only contained hospitalisations in public hospitals and admissions to private hospitals are not represented; hence, number of hospitalisations both before and after RACF entry may be underestimated. Additionally, the study only included data from one aged care service provider in a metropolitan city and thus may not be representative of other RACFs. However, some of the core findings are similar to other published studies, strengthening the likelihood of the generalisability of our results.

5 | CONCLUSIONS

Hospitalisations are a major concern for older adults as they can lead to negative outcomes and quality of life. This study showed for residents who stayed in an RACF for a minimum of 12 months, an immediate 82% reduction in monthly all-cause hospital admissions and 86% reduction in fall-related hospital admissions, and these reduced rates were sustained for the first 12 months after entry into RACFs irrespective of gender or dementia status. The results highlight the need for future research to investigate the contributing and protective factors from community-based services behind the increase in hospitalisation preceding, and perhaps precipitating, admission into RACFs to avoid preventable hospital admissions.

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CONFLICT OF INTEREST STATEMENT

No conflicts of interest declared.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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