ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2021;102:1524-32

ORIGINAL RESEARCH

Risk Factors of Readmissions in Geriatric Rehabilitation Patients: RESORT

Ching S. Wan, PhD,[a] Esmee M. Reijnierse, PhD,[a,b] Andrea B. Maier, MD, PhD[a,b,c,d]

From the [a]Department of Medicine and Aged Care, @AgeMelbourne, The Royal Melbourne Hospital, The University of Melbourne, Parkville, Victoria, Australia; [b]Department of Human Movement Sciences, @AgeAmsterdam, Faculty of Behavioural and Movement Sciences, Amsterdam Movement Sciences, Vrije Universiteit, Amsterdam, The Netherlands; [c]Healthy Longevity Translational Research Program, Yong Loo Lin School of Medicine, National University of Singapore, Singapore; and [d]Centre for Healthy Longevity, @AgeSingapore, National University Health System, Singapore.

Abstract

Objective: To evaluate the risk factors associated with 30- and 90-day hospital readmissions in geriatric rehabilitation inpatients.

Design: Observational, prospective longitudinal inception cohort.

Setting: Tertiary hospital in Victoria, Australia.

Participants: Geriatric rehabilitation inpatients of the REStORing Health of Acutely Unwell AdulTs (RESORT) cohort evalutated by a comprehensive geriatric assessment including potential readmission risk factors (ie, demographic, social support, lifestyle, functional performance, quality of life, morbidity, length of stay in an acute ward). Of 693 inpatients, 11 died during geriatric rehabilitation. The mean age of the remaining 682 inpatients was 82.2±7.8 years, and 56.7% were women.

Interventions: Not applicable.

Main Outcome Measures: Thirty- and 90-day readmissions after discharge from geriatric inpatient rehabilitation.

Results: The 30- and 90-day unplanned all-cause readmission rates were 11.6% and 25.2%, respectively. Risk factors for 30- and 90-day readmissions were as follows: did not receive tertiary education, lower quality of life, higher Charlson Comorbidity Index and Cumulative Illness Rating Scale (CIRS) scores, and a higher number of medications used in the univariable models. Formal care was associated with increased risk for 90-day readmissions. In multivariable models, CIRS score was a significant risk factor for 30-day readmissions, whereas high fear of falling and CIRS score were significant risk factors for 90-day readmissions.

Conclusions: High fear of falling and CIRS score were independent risk factors for readmission in geriatric rehabilitation inpatients. These variables should be included in hospital readmission risk prediction model developments for geriatric rehabilitation inpatients.

Archives of Physical Medicine and Rehabilitation 2021;102:1524-32

Unplanned hospital readmissions and mortality rates are quality of care indicators.[1] Given the steady rise of hospital readmissions by at least 20% in high-income countries over the past decade,[2] as well as the tremendous associated costs,[3] reducing hospital readmissions has become a priority for hospital policymakers.[4] One in 4 readmissions is deemed avoidable.[5] Hospital readmission risk prediction models, combined with targeted interventions preventing readmissions, help to reallocate public health resources and provide improved clinical outcomes for patients.[6,7] Risk prediction models often use hospital administrative data, which include patient demographics, principal diagnosis, urgency of the previous admission, length of stay, previous admission history, and blood biochemistry results.[8,9] However, a prediction model has inconsistent predictive performance between different health care settings.[9] In addition, the existing validated prediction models are targeted to either general medical or disease-specific inpatients,[7,10] and the models have low sensitivity and specificity when applied to geriatric inpatients.[11]

Geriatric rehabilitation inpatients have a higher risk of readmission compared with acute inpatients owing to their complex health conditions, a decline in functional capacity, and associated

Disclosures: none.

https://doi.org/10.1016/j.apmr.2021.01.082

higher health care needs.[12-14] Limited evidence on evaluating and improving geriatric rehabilitation interventions to avoid readmissions is available.[12] Investigating risk factors of readmissions and identifying high-risk geriatric rehabilitation inpatients upon admission who need tailored case management and transitional care after discharge improve patient-centered care and reduce potentially preventable readmissions.[15] Among geriatric rehabilitation inpatients, malnutrition,[16] functional status,[17] polypharmacy,[17] and multimorbidity[18] are associated with hospital readmission. However, the association between other patient characteristics, such as social factors, lifestyle, quality of life, and readmissions, is unknown. The identification of aforementioned risk factors for readmissions may provide insights into developing risk prediction models in this population.[18] This study aimed to identify risk factors associated with the risk of 30- and 90-day hospital readmissions in geriatric rehabilitation inpatients.

Methods

Study design

REStORing Health of Acutely Unwell AdulTs (RESORT) is an ongoing observational, longitudinal inception cohort from October 16, 2017 onwards using a comprehensive geriatric assessment (CGA) to investigate the characteristics and health outcomes of inpatients recruited from geriatric rehabilitation wards at the Royal Melbourne Hospital. Older and frailer adults tending to have multimorbidity who require multidisciplinary rehabilitation care for recovery after acute episodes of ill-health are transferred to geriatric rehabilitation wards. CGA is a multidimensional, interdisciplinary diagnostic process to determine health characteristics and develop relevant coordinated intervention or follow-up.[19] The study was approved by the Melbourne Health Human Research Ethics Committee (reference no: HREC/17/MH/103) and followed national and international ethical guidelines according to the Declaration of Helsinki.[20] Written informed consent was obtained by either the patient or a nominated proxy. Patients were excluded if they were receiving palliative care at admission, incapable of providing informed consent without a nominated proxy, or transferring to acute care prior to consenting to the study.

This study used data of 693 geriatric rehabilitation inpatients of the first wave from October 16, 2017 until August 31, 2018 after excluding patients (n = 152, 15.3%) who met the exclusion criteria. Patients who died during their hospital stay in geriatric rehabilitation wards (n = 11) were excluded from the data analysis, leaving 682 patients for the present study. Patients were assessed using the CGA within 48 hours of admission to the geriatric rehabilitation wards by physicians, nurses, physiotherapists, occupational therapists, and dietitians on social characteristics, nutrition status, physical and functional capacity, morbidity, and cognition using standardized assessment tools. The CGA also included patient surveys consisting of brief, primarily closed-ended questions to collect demographics, social support, quality of life, and lifestyle information completed by patients, caregivers, or health professionals. Potential risk factors for readmissions were grouped into 7 domains: demographics, social support, lifestyle, functional performance, quality of life, morbidity (including cognition), and index admission.

List of abbreviations:

ADL	**activities of daily living**
AUC	**area under the receiver operating characteristic curve**
CCI	**Charlson Comorbidity Index**
CFS	**Clinical Frailty Scale**
CGA	**comprehensive geriatric assessment**
CI	**confidence interval**
CIRS	**Cumulative Illness Rating Scale**
IADL	**instrumental activities of daily living**
IQR	**interquartile range**
OR	**odds ratio**
RESORT	**REStORing Health of Acutely Unwell AdulTs**

Demographics

Age and sex were collected from medical records. Country of birth, ethnicity, and highest level of education data were collected from surveys. Patients with tertiary education were defined as those having pursued beyond the secondary school level, including college education.

Social support

Whether patients were institutionalized before admission and received services from the council or other organizations (formal care) were collected from surveys. The question on whether patients had caregivers (informal care) in the Brief Abuse Screen for the Elderly[21] questionnaire was completed by physicians. Caregivers were defined as unremunerated individuals providing needed care regularly.[21]

Lifestyle

Current smoking status and alcohol consumption over the past year were collected from surveys. Trained nurses completed the Malnutrition Screening Tool.[22] Patients who scored more than 2 were at risk of malnutrition. Body mass index was calculated by anthropometric measurements completed by trained nurses.

Functional performance

Patients' walking ability, history of having at least 1 fall over the past year before hospital admission, and fear of falling 1 month before hospital admission were collected from surveys. Frailty was assessed by physicians using the Clinical Frailty Scale (CFS),[23] ranging from 1-9, with greater scores indicating a higher level of frailty. Trained occupational therapists assessed functional independence status using activities of daily living (ADL)[24] and instrumental activities of daily living (IADL).[25] ADL and IADL scores ranged from 0-6 and 0-8, respectively, with higher scores indicating higher levels of independence for both scales. A physical functioning assessment was performed by trained physiotherapists using the Short Physical Performance Battery.[26] It included assessments on balance maintenance with eyes open, a timed 4-meter walk, and a timed sit-to-stand test. It ranged from 0-12, with higher scores demonstrating higher levels of lower extremity functioning.

Quality of life

Patients were asked to rate their health status from 0 (worst imaginable health) to 100 (best imaginable health) using the

Table 1 Characteristics of geriatric rehabilitation inpatients at admission

Characteristics	No. of Patients (n)	Value
Demographics		
Age (y), mean ± SD	682	82.2±7.8
Women	682	387 (56.7)
White	677	603 (89.1)
Australian-born	679	297 (43.7)
Tertiary education	510	59 (11.6)
Social support		
Institutionalized	682	24 (3.5)
Informal care*	569	348 (61.2)
Formal care†	649	360 (55.5)
Lifestyle		
Current smoking	601	39 (6.5)
Alcohol use over the past year	546	282 (51.6)
Risk of malnutrition (MST)	672	83 (12.4)
BMI (kg/m^2), mean ± SD	654	27.3±6.5
Functional performance		
Ability to walk with or without a walking aid	679	494 (72.8)
Fall history over the past year	669	443 (66.2)
High fear of falling 1 mo before admission, n (%)	476	86 (18.1)
Clinical Frailty Scale score, median (IQR)	605	6 (5-6)
ADL score, median (IQR)	663	2 (1-3)
IADL score, median (IQR)	664	1 (0-1)
SPPB score, median (IQR)	647	1 (0-4)
Quality of life		
EuroQoL-VAS score, median (IQR)	419	50 (35-70)
Morbidity		
CCI score, median (IQR)	682	2 (1-4)
CIRS score, median (IQR)	682	11 (8-15)
CIRS no. of systems affected, median (IQR)	682	6 (5-8)
CIRS severity index, median (IQR)	682	1.9 (1.6-2.2)
Cognitive impairment	682	435 (63.8)
Anxiety, HADS	431	82 (19.0)
Depression, HADS	444	100 (22.5)
No. of medications, median (IQR)	682	10 (7-13)
Index admission		
LOS in acute ward, d, median (IQR)	682	7.0 (4.0-11.0)
LOS in rehabilitation ward, d, median (IQR)	682	20.0 (14.0-30.0)
Readmission		
30-d readmission	682	79 (11.6)
90-d readmission	682	172 (25.2)

NOTE. Data in are presented in numbers of patients and percentages unless stated otherwise.

Abbreviations: BMI, body mass index; EuroQoL-VAS, EuroQol visual analog scale; HADS, Hospital Anxiety and Depression Scale; LOS, length of stay; MST, Malnutrition Screening Tool; SPPB, Short Physical Performance Battery.

* Informal care indicates that patients had caregivers.

† Formal care indicates that patients received services from the council or other organizations.

EuroQoL[27] visual analog scale in surveys. Patients with visual impairment were asked verbally to rate their health status.

Morbidity

Physicians assessed morbidity using the Charlson Comorbidity Index (CCI)[28] and the Cumulative Illness Rating Scale (CIRS).[29] CCI and CIRS scores ranged from 0-37 and 0-56, respectively. CIRS scores at admission were presented as total scores, the total number of organ systems endorsed, and severity index (total score/total number of systems endorsed). The number of medications at admission to geriatric rehabilitation wards was extracted from the medical records.

Cognitive impairment was defined as a dementia diagnosis captured by the CCI, CIRS, or medical records, a score on the Standardized Mini-Mental State Examination of less than 24 points,[30] Montreal Cognitive Assessment less than 26 points,[31] or Rowland Universal Dementia Scale less than 23 points.[32] Cognitive testing was completed by physicians. Hospital Anxiety and Depression Scale[33] in surveys was used to assess anxiety (≥11 points indicating anxiety symptoms) and depressive symptoms (≥11 points indicating depression symptoms).

Index admission

The length of stay during the acute admission before being admitted to geriatric rehabilitation and the length of stay during geriatric rehabilitation were collected from medical records.

Readmission

Information on whether patients had all-cause unplanned 30- and 90-day hospital readmissions to the Royal Melbourne Hospital were obtained from the hospital administrative system. Questions on whether they had hospital readmissions to other hospitals within 90 days after discharged were asked during a follow-up phone call with the patient or caregiver. Planned admissions after discharge were excluded, which included elective admissions for follow-up surgical or medical treatments, such as scheduled dialysis or chemotherapy.

Statistical analysis

Descriptive variables were presented as numbers and percentages, means and SDs or as medians and interquartile ranges (IQR). We compared categorical variables using Pearson or Fisher exact tests and continuous variables using Student *t* tests or Mann-Whitney *U* tests as appropriate. We performed Levene's test of homogeneity of variances as part of the continuous variable comparison statistical tests.

The linearity between continuous variables and readmissions were checked, and univariable logistic regression analyses were performed to identify associations, odds ratios (ORs), and 95% confidence intervals (CIs) between potential risk factors and readmissions. Multivariable logistic regression analyses were performed using the variables with $P<.10$ from the univariable logistic regression analysis to identify risk factors for readmissions. We checked multicollinearity within each domain using variance inflation factors and chi-square test for significant continuous and categorical variables, respectively.[34] Variance inflation factors higher than 3 or a P value below 0.05 in chi-square tests were considered as having multicollinearity. For variables that were found to have multicollinearity, the variable

Table 2 Characteristics of geriatric rehabilitation inpatients with and without all-cause unplanned 30- and 90-day readmissions in univariable logistic regression

	30-Day Readmission					90-Day Readmission				
Patient Characteristics	No. of Patients (n)	No	No. of Patients (n)	Yes	OR (95% CI)	No. of Patients (n)	No	No. of Patients (n)	Yes	OR (95% CI)
Demographics										
Age at admission (y), mean ± SD	603	82.1±7.9	79	83.0±7.0	1.02 (0.99- 1.05)	510	82.2±8.0	172	82.2±7.4	1.00 (0.98- 1.02)
Women	603	341 (56.6)	79	46 (58.2)	1.07 (0.67- 1.72)	509	290 (57.0)	171	96 (56.1)	0.95 (0.67- 1.35)
White	598	535 (89.5)	79	68 (86.1)	0.76 (0.22- 2.66)	506	453 (89.5)	171	150 (87.7)	0.66 (0.26- 1.67)
Australian-born	600	272 (45.3)	79	25 (31.6)	0.56 (0.34- 0.92)*,†	507	232 (45.8)	172	65 (37.8)	0.72 (0.51- 1.03)*
Tertiary education	453	58 (12.8)	57	1 (1.8)	0.12 (0.02- 0.90)*,†	385	51 (13.2)	125	8 (6.4)	0.45 (0.21- 0.97)*,†
Social support										
Institutionalized	603	23 (3.8)	79	1 (1.3)	0.32 (0.04- 2.43)	510	17 (3.3)	172	7 (4.1)	1.23 (0.50- 3.02)
Informal care[†]	504	307 (60.9)	65	41 (63.1)	1.10 (0.64- 1.87)	431	257 (59.6)	138	91 (65.9)	1.31 (0.88- 1.96)
Formal care[§]	573	314 (54.8)	76	46 (60.5)	1.32 (0.80- 2.18)	486	260 (53.5)	163	100 (61.3)	1.39 (1.00-2.06)*,†
Lifestyle										
Smoking	529	35 (6.6)	72	4 (5.6)	0.94 (0.32- 2.80)	449	28 (6.2)	152	11 (7.2)	1.16 (0.55-2.42)
Alcohol use over the past year	482	254 (52.7)	64	28 (43.8)	0.70 (0.41- 1.18)	413	226 (54.7)	133	56 (42.1)	0.60 (0.41-0.89)*,†
Risk of malnutrition (MST)	593	68 (11.5)	79	15 (19.0)	1.86 (0.97-3.54)*	503	61 (12.1)	169	22 (13.0)	1.17 (0.68-2.01)
BMI (kg/m^2), mean ± SD	576	27.2±6.5	78	28.0±6.7	1.02 (0.98-1.05)	487	27.2±6.6	167	27.6±6.3	1.01 (0.98-1.04)
Functional performance										
Ability to walk	601	439 (73.0)	78	55 (70.5)	0.88 (0.53-1.48)	508	366 (72.0)	171	128 (74.9)	1.16 (0.78-1.72)
Fall history over the past year	591	393 (66.5)	78	50 (64.1)	0.90 (0.55-1.47)	500	329 (65.8)	169	114 (67.5)	1.08 (0.74-1.56)
High fear of falling 1 mo before admission	428	71 (16.6)	48	15 (31.3)	2.03 (0.97-4.25)*	366	55 (15.0)	110	31 (28.2)	2.51 (1.42-4.46)*,†
Clinical Frailty Scale score, median (IQR)	537	6 (5-6)	68	6 (5-7)	1.21 (0.98-1.50)*	458	6 (5-6)	147	6 (5-7)	1.18 (1.01-1.38)*,†
ADL score, median (IQR)	586	2 (1-3)	77	2 (1-3)	1.09 (0.95-1.26)	500	2 (1-3)	163	2 (1-3)	1.06 (0.95-1.18)
IADL score, median (IQR)	587	1 (0-1)	77	1 (0-1)	0.93 (0.76-1.15)	500	1 (0-1)	164	1 (0-1)	0.93 (0.80-1.08)
SPPB score, median (IQR)	569	1 (0-4)	78	2 (0-3)	0.99 (0.90-1.08)	485	1 (0-4)	162	1 (0-3)	0.97 (0.91-1.04)
Quality of life										
EuroQoL-VAS score, median (IQR)	372	55 (40-72)	47	50 (30-70)	0.99 (0.98-1.00)*,†	319	60 (40-75)	100	50 (30-70)	0.99 (0.98-1.00)*,†
Morbidity										
CCI score, median (IQR)	603	2 (1-4)	79	3 (2-5)	1.18 (1.08-1.28)*,†	510	2 (1-4)	172	3 (1-5)	1.14 (1.07-1.22)*,†
CIRS score, median (IQR)	603	11 (8-14)	79	13 (10-17)	1.08 (1.03-1.13)*,†	510	11 (8-14)	172	12 (9-15)	1.05 (1.02-1.09)*,†
CIRS no. of systems affected, median (IQR)	603	6 (5-8)	79	7 (6-8)	1.26 (1.12-1.41)*,†	510	6 (4-7)	172	7 (5-8)	1.16 (1.06-1.26)*,†
CIRS severity index, median (IQR)	603	1.9 (1.6-2.2)	79	1.9 (1.7-2.2)	0.83 (0.47-1.44)	510	1.9 (1.6-2.2)	172	1.9 (1.7-2.2)	0.95 (0.63-1.43)
Cognitive impairment	603	385 (63.8)	79	50 (63.3)	0.98 (0.60-1.59)	510	326 (63.9)	172	109 (63.4)	0.98 (0.68-1.40)
Anxiety, HADS	385	76 (19.7)	46	6 (13.0)	0.64 (0.26-1.60)	331	61 (18.4)	100	21 (21.0)	1.21 (0.68-2.13)
Depression, HADS	396	90 (22.7)	48	10 (20.8)	0.98 (0.46-2.11)	341	73 (21.4)	103	27 (26.2)	1.45 (0.85-2.46)
No. of medications, median (IQR)	603	9 (7-12)	79	10 (8-14)	1.07 (1.02-1.13)*,†	510	9 (7-12)	172	10 (8-14)	1.08 (1.04-1.12)*,†

(*continued on next page*)

Table 2 (*continued*)

Patient Characteristics	30-Day Readmission				90-Day Readmission			
	No. of Patients (n)	No	No. of Patients (n)	Yes	OR (95% CI)	No. of Patients (n)	No	No. of Patients (n)	Yes	OR (95% CI)
Index admission Acute length of stay, median (IQR), d	603	7.0 (4.0-11.0)	79	8.0 (3.0-16.0)	1.02 (1.00-1.04)*,†	510	7.0 (4.0-11.0)	172	7.0 (3.6-12.9)	1.01 (0.99-1.02)

NOTE. Data are presented in numbers of patients and percentages unless stated otherwise.

Abbreviations: BMI, body mass index; EuroQoL-VAS, EuroQoL visual analog scale; HADS, Hospital Anxiety and Depression Scale; MST, Malnutrition Screening Tool; SPPB, Short Physical Performance Battery.

* $P<.10$.

† $P<.05$.

‡ Informal care indicates that patients had caregivers.

§ Formal care indicates that patients received services from the council or other organizations.

with the lowest P value in univariable analysis was chosen. Given that different sections of the CGA were completed by specific health care professionals at different times, certain sections could have been missed at admission. Multiple imputation was performed in handling missing data before multivariable analysis if data were missing at random.[35] Missing value analysis using the Little's missing completely at random test and missing value patterns graph were used to determine whether the data were missing at random or not. A 2-tailed P value $>.05$ was considered a statistically significant independent risk factor for readmission in multivariable analysis. Sensitivity analysis was performed comparing independent risk factors of patients with complete data sets and patients with imputed missing data. The performance of the model including significant risk factors in multivariable analysis was assessed using analysis of area under the receiver operating characteristic curve (AUC) statistics. We conducted statistical analysis using the Statistical Package for Social Sciences (SPSS Statistics for Windows, version 25.0[a]).

Results

Patient characteristics

Table 1 shows the characteristics of 682 geriatric rehabilitation inpatients at admission. The mean age at admission was 82.2±7.8 years, and 56.7% (n=387) were women. Four percent of the patients were institutionalized and 61% had caregivers. Seventy-three percent of the patients were able to walk and 66.2% had experienced at least 1 fall within the year before admission. A median CCI score of 2 (IQR, 1-4) and a median of 6 (IQR, 5-8) systems were affected in CIRS. The median length of stay in acute wards before geriatric rehabilitation ward admission was 7.0 days (IQR, 4.0-11.0). The 30- and 90-day all-cause readmissions rates were 11.6% and 25.2% respectively. Among patients who had 90-day readmissions, 26 (15.1%) were identified outside the Royal Melbourne Hospital.

Risk factors for 30-day all-cause hospital readmissions

Table 2 shows the comparison of characteristics between patients with and without readmissions. Patients readmitted within 30 days after discharge were more likely to be non-Australian born, not have received tertiary education, have a lower self-rated quality of life, have higher CCI and CIRS scores, and have a higher number of medications used and longer length of acute hospital stay. Owing to the multicollinearity between CFS, CCI, CIRS, and number of medications (shown in appendix 1), CIRS score was only included in the multivariable analysis. Little's missing completely at random test and missing value pattern graph showed random arrangement of missing values across variables ($P=.541$), with more missing data from patient surveys. Multiple imputation was used to handle missing values. Multivariable analysis (table 3) found CIRS to be a significant risk factor for 30-day readmissions (OR, 1.06; 95% CI, 1.01-1.12), achieving an AUC of 0.61 (95% CI, 0.54-0.68). It was also significant in the multivariable analysis using only patients with complete data (appendix 2).

Risk factors for 90-day all-cause readmissions

Not receiving tertiary education; receiving formal care from councils or organizations; nonalcohol consumer; self-reported

Table 3 Risk factors for 30- and 90-day readmissions in geriatric rehabilitation inpatients in multivariable logistic regression

	30-Day Readmission (n = 682)		90-Day Readmission (n = 682)	
Patient Characteristics	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Demographics				
Australian-born	0.60 (0.35-1.03)	.063	0.81 (0.55-1.19)	.277
Tertiary education	0.22 (0.04-1.32)	.093	0.61 (0.29-1.26)	.174
Social support				
Formal care*	-	-	1.32 (0.91-1.91)	.147
Lifestyle				
Alcohol use over the past year	-	-	0.75 (0.49-1.13)	.161
Risk of malnutrition (MST)	1.57 (0.78-3.16)	.209	-	-
Functional performance				
High fear of falling 1 mo prior admission	1.67 (0.84-3.32)	.140	1.86 (1.11-3.10)	.018†
Quality of life				
EuroQoL-VAS, score	0.99 (0.98-1.01)	.651	0.99 (0.98-1.01)	.616
Morbidity				
CIRS, score	1.06 (1.01-1.12)	.025†	1.05 (1.01-1.09)	.012†
Index admission				
Length of stay in acute ward, d	1.02 (0.99-1.04)	.121	-	-

Abbreviations: EuroQoL-VAS, EuroQol visual analog scale; MST, Malnutrition Screening Tool.

* Formal care indicates that patients received services from the council or other organizations.

† $P < .05$.

high fear of falling; lower self-rated quality of life; higher scores in CFS, CCI, and CIRS; and higher number of medications used were risk factors for 90-day readmissions. Significant risk factors for 90-day readmissions were self-reported high fear of falling (OR, 1.86; 95% CI, 1.11-3.10) and CIRS (OR, 1.05; 95% CI, 1.01-1.09) score using multivariable analysis after multiple imputation, achieving an AUC of 0.62 (95% CI, 0.56-0.68). It was similar to multivariable analysis using only patients with complete data (see appendix 2).

Discussion

Lower self-rated quality of life and higher CCI, CIRS, and number of medications used were associated with increased risk for 30- and 90-day readmissions in the univariable analysis. Formal care was associated with increased risk for 90-day readmissions. In multivariable analysis, CIRS score was a significant risk factor for both 30- and 90-day readmissions; self-reported high fear of falling was significantly associated with 90-day readmissions.

Our finding that receiving formal care was a risk factor for 90-day readmissions is consistent with a recently published study among geriatric inpatients demonstrating a positive relationship between receipt of help or home health services postdischarge and 30-day readmissions.[36] Requiring a strong social support network can be an indicator for complex health needs and consequent risk of readmissions.[37,38] Accessibility to appropriate and timely support services reduces the risk of readmission.[39,40]

ADL and IADL scores were not associated with readmissions, in contrast to earlier studies among acutely admitted geriatric inpatients.[36,41] However, fear of falling was a risk factor for 30- and 90-day readmissions. Fear of falling leads to physical inactivity and unmet daily functional needs postdischarge, resulting in the risk of dependence in daily activities[42] and increased readmission risks.[41] Therefore, self-perceived fear of falling assessment is important in identifying patients who are at risk of readmission.[43] Interventions aiming to reduce fear of falling, which include strategies such as medication reviews, home safety assessment, osteoporosis prevention, regular eye examination, weight-bearing exercise programs, and caregiver-targeted fall prevention education,[42,44] might enhance self-confidence and self-efficacy in falls prevention.

Low quality of life was a risk factor for 30- and 90-day readmission, which is in line with previous literature, including geriatric inpatients[45] and older community-dwelling individuals.[46,47] Lower quality of life may indicate living with compromised health due to existing morbidities[48] and is therefore associated with readmissions.

The finding that comorbidities and polypharmacy were risk factors for readmissions concurs with existing literature showing an association between the number of comorbidities with medications prescribed and hospital readmissions in geriatric patients after discharge from the hospital.[39,49-55] The effect of comorbidities on readmission is linked to polypharmacy.[55] Polypharmacy is associated with the increased use of potentially inappropriate medications, increased likelihood of adverse drug reactions, lower adherence to therapeutics, and increased likelihood of making mistakes on complex medication regimens.[50,53,56,57] This medication-related harm is potentially preventable.[58]

Study limitations

This was a single-site study, which might limit generalizability to other hospitals. The prevalence of 30-day readmissions could have been underestimated because it only included readmissions to the Royal Melbourne Hospital. Reasons for subacute ward admission were not available for readmission rate stratification. Furthermore, the sample size of this study was relatively small to detect moderate risk factors. A small proportion of data were randomly missing, which enabled imputation. The data are based on a highly standardized collected comprehensive assessments performed by a trained multidisciplinary team in a highly relevant cohort of

geriatric rehabilitation inpatients. Exclusion criteria were limited. Ongoing recruitment within the RESORT cohort will enable validating readmission risk prediction models for geriatric rehabilitation inpatients.

Conclusions

In geriatric rehabilitation patients, the risk factors for both 30- and 90-day readmissions included non-Australian born; not receiving a tertiary education; self-reported high fear of falling; self-rated quality of life; CFS, CCI, and CIRS score; and the number of medications used. In multivariable analysis, CIRS score was the significant risk factor for both 30- and 90-day readmissions; self-reported high fear of falling was a risk factor for 90-day readmissions. The inclusion of these risk factors in future readmission risk prediction models among geriatric rehabilitation inpatients is recommended.

Supplier

a. SPSS Statistics for Windows, version 25.0; IBM Corp.

Keywords

Aged; Geriatrics; Patient readmission; Rehabilitation; Risk factors

Corresponding author

Andrea B. Maier, MD, PhD, Department of Medicine and Aged Care, @Age, Department of Human Movement Sciences, Faculty of Behavioural and Movement Sciences, VU University Amsterdam, Amsterdam Movement Sciences, van der Boechorststraat 7, 1081 BT, Amsterdam, The Netherlands. *E-mail address:* a.b.maier@vu.nl.

Acknowledgments

We thank the @AgeMelbourne team for the establishment of the RESORT database and Jade Mitchell (B.A.Sc.) for the discussion about risk factors of readmission in geriatric rehabilitation inpatients. This research was funded by an unrestricted grant of the University of Melbourne received by Prof. Andrea B. Maier and the Medical Research Future Fund (MRFF) provided by the Melbourne Academic Centre for Health (MACH).

Appendix 1 Multicollinearity analysis for multivariable logistic regression

	Multicollinearity		*P* Value (Univariate Logistic Regression)	
Patient Characteristics	Variance Inflation Factor	*P* Value (χ^2)	30-Day Readmission	90-Day Readmission
Demographics				
Australian-born	-	.176	.021*	.069
Tertiary education	-	.176	.014*	.038*
Morbidity/Functional performance				
Clinical Frailty Scale score	CCI: 1.368 CIRS: 4.209 CIRS no. of system affected: 3.876 No. of medications: 1.116	-	.083	.036*
CCI score	Clinical frailty scale: 1.086 CIRS:4.115 CIRS no of systems affected: 3.889 No. of medications: 1.105	-	.001*	.009*
CIRS score	Clinical frailty scale: 1.057 CCI: 1.301 CIRS no. of systems affected: 1.328 No. of medications: 1.104	-	<.0001*	<.0001*
CIRS no. of systems affected	Clinical Frailty Scale: 1.087 CCI: 1.373 CIRS: 1.482 No. of medications: 1.118	-	.003*	.001*
No. of medications	Clinical Frailty Scale: 1.089 CCI: 1.357 CIRS: 4.288 CIRS no. of systems affected: 3.893	-	.001*	.001*

* $p<0.05$.

Appendix 2 Risk factors for 30- and 90-day readmissions in geriatric rehabilitation inpatients with complete data

	30-Day Readmission (n=380)		90-Day Readmission (n=377)	
Patient Characteristics	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Demographics				
Australian-born	0.54 (0.25-1.17)	.119	0.66 (0.38-1.15)	.143
Tertiary education	0.73 (0.32-3.36)	.946	0.47 (0.17-1.26)	.132
Social support				
Formal care	-	-	1.06 (0.63-1.78)	.832
Lifestyle				
Alcohol use over the past year	-	-	0.68 (0.41-1.16)	.155
Risk of malnutrition (MST)	2.24 (0.83-6.03)	.109	-	-
Functional performance				
High fear of falling 1 mo prior to admission	2.32 (0.94-5.71)	.067	2.24 (1.13-4.44)	.020*
Quality of life				
EuroQoL-VAS score	0.99 (0.98-1.01)	.235	0.99 (0.98-1.01)	.300
Morbidity				
CIRS score	1.07 (0.99-1.15)	.068	1.07 (1.01-1.13)	.015*
Index admission				
Length of stay in acute ward, d	1.04 (1.01-1.08)	.020*	-	-

Abbreviation: EuroQoL-VAS, EuroQol visual analog scale.
* $P<.05$.

References

1. Medicare Payment Advisory Commission. Measuring quality of care in Medicare 2014. Available at: http://www.medpac.gov/docs/default-source/reports/chapter-3-measuring-quality-of-care-in-medicare-june-2014-report-.pdf. Accessed December 23, 2019.
2. Hakim MA, Garden FL, Jennings MD, Dobler CC. Performance of the LACE index to predict 30-day hospital readmissions in patients with chronic obstructive pulmonary disease. Clin Epidemiol 2018;10:51-9.
3. Medicare Payment Advisory Commission. March 2018 report to congress: Medicare payment policy 2018. Available at: http://www.medpac.gov/docs/default-source/reports/mar18_medpac_entirereport_sec.pdf. Accessed December 23, 2019.
4. Busby J, Purdy S, Hollingworth W. A systematic review of the magnitude and cause of geographic variation in unplanned hospital admission rates and length of stay for ambulatory care sensitive conditions. BMC Health Serv Res 2015;15:1-15.
5. van Walraven C, Jennings A, Forster AJ. A meta-analysis of hospital 30-day avoidable readmission rates. J Eval Clin Pract 2012;18:1211-8.
6. Walsh C, Hripcsak G. The effects of data sources, cohort selection, and outcome definition on a predictive model of risk of thirty-day hospital readmissions. J Biomed Inform 2014;52:418-26.
7. Kansagara D, Englander H, Salanitro A, et al. Risk prediction models for hospital readmission: a systematic review. JAMA 2011;306:1688-98.
8. Fischer C, Lingsma HF, Marang-van de Mheen PJ, Kringos DS, Klazinga NS, Steyerberg EW. Is the readmission rate a valid quality indicator? A review of the evidence. PLoS One 2014;9:e112282.
9. Zhou H, Della PR, Roberts P, Goh L, Dhaliwal SS. Utility of models to predict 28-day or 30-day unplanned hospital readmissions: an updated systematic review. BMJ Open 2016;6:e011060.
10. Morgan DJ, Bame B, Zimand P, et al. Assessment of machine learning vs standard prediction rules for predicting hospital readmissions. JAMA Netw Open 2019;2:e190348.
11. Braes T, Moons P, Lipkens P, et al. Screening for risk of unplanned readmission in older patients admitted to hospital: predictive accuracy of three instruments. Aging Clin Exp Res 2010;22:345-51.
12. Davis J, Morgans A, Stewart J. Developing an Australian health and aged care research agenda: a systematic review of evidence at the subacute interface. Aust Health Rev 2016;40:420-7.
13. Berian JR, Mohanty S, Ko CY, Rosenthal RA, Robinson TN. Association of loss of independence with readmission and death after discharge in older patients after surgical procedures. JAMA Surg 2016;151:e161689.
14. Hughes JM, Freiermuth CE, Shepherd-Banigan M, et al. Emergency department interventions for older adults: a systematic review. J Am Geriatr Soc 2019;67:1516-25.
15. O'Conner K, Meng H, Marino V, Boaz TL. Individual and organizational factors associated with hospital readmission rates: evidence from a US national sample. J Appl Gerontol 2020;39:1153-8.
16. Charlton K, Nichols C, Bowden S, et al. Poor nutritional status of older subacute patients predicts clinical outcomes and mortality at 18 months of follow-up. Eur J Clin Nutr 2012;66:1224-8.
17. Morandi A, Bellelli G, Vasilevskis EE, et al. Predictors of rehospitalization among elderly patients admitted to a rehabilitation hospital: the role of polypharmacy, functional status, and length of stay. J Am Med Dir Assoc 2013;14:761-7.
18. Kumar A, Karmarkar AM, Graham JE, et al. Comorbidity indices versus function as potential predictors of 30-day readmission in older patients following postacute rehabilitation. J Gerontol A-Biol 2016;72:223-8.
19. Ellis G, Gardner M, Tsiachristas A, et al. Comprehensive geriatric assessment for older adults admitted to hospital. Cochrane Database Syst Rev 2017:CD006211.
20. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. J Am Med Assoc 2013;310:2191-4.
21. Reis M, Nahmiash D. Validation of the indicators of abuse (IOA) screen. Gerontologist 1998;38:471-80.
22. Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. Nutrition 1999;15:458-64.
23. Rockwood K, Song X, MacKnight C, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173:489-95.
24. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of illness in the aged: the index of ADL: a standardized measure of biological and psychosocial function. JAMA 1963;185:914-9.
25. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 1969;9:179-86.
26. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with

self-reported disability and prediction of mortality and nursing home admission. J Gerontol 1994;49:M85-94.
27. Herdman M, Gudex C, Lloyd A, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). Qual Life Res 2011;20:1727-36.
28. Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. J Clin Epidemiol 1994;47:1245-51.
29. Miller MD, Paradis CF, Houck PR, et al. Rating chronic medical illness burden in geropsychiatric practice and research: application of the Cumulative Illness Rating Scale. Psychiatry Res 1992;41:237-48.
30. Folstein M, Folstein S, McHugh P. "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189-98.
31. Nasreddine ZS, Phillips NA, Bédirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc 2005;53:695-9.
32. Storey JE, Rowland JT, Conforti DA, Dickson HG. The Rowland universal dementia assessment scale (RUDAS): a multicultural cognitive assessment scale. Int Psychogeriatr 2004;16:13-31.
33. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983;67:361-70.
34. Daoud JI. Multicollinearity and regression analysis. J Phys Conf Ser 2017;949:012009.
35. Jakobsen JC, Gluud C, Wetterslev J, Winkel P. When and how should multiple imputation be used for handling missing data in randomised clinical trials—a practical guide with flowcharts. BMC Med Res Methodol 2017;17:162.
36. Sieck C, Adams W, Burkhart L. Validation of the BOOST risk stratification tool as a predictor of unplanned 30-day readmission in elderly patients. Qual Manag Health Care 2019;28:96-102.
37. Chan B, Goldman LE, Sarkar U, et al. High perceived social support and hospital readmissions in an older multi-ethnic, limited English proficiency, safety-net population. BMC Health Serv Res 2019;19:334.
38. Brault MA, Brewster AL, Bradley EH, Keene D, Tan AX, Curry LA. Links between social environment and health care utilization and costs. J Gerontol Soc Work 2018;61:203-20.
39. Preyde M, Brassard K. Evidence-based risk factors for adverse health outcomes in older patients after discharge home and assessment tools: a systematic review. J Evid Based Soc Work 2011;8:445-68.
40. Gregorevic KJ, Lim WK, Peel NM, Martin RS, Hubbard RE. Are health assets associated with improved outcomes for hospitalised older adults? A systematic review. Arch Gerontol Geriat 2016;67:14-20.
41. DePalma G, Xu H, Covinsky KE, et al. Hospital readmission among older adults who return home with unmet need for ADL disability. Gerontologist 2012;53:454-61.
42. Greenberg MR, Nguyen MC, Stello B, et al. Mechanical falls: are patients willing to discuss their risk with a health care provider? J Emerg Med 2015;48:108-14.
43. Greenberg MR, Moore EC, Nguyen MC, et al. Perceived fall risk and functional decline: gender differences in patient's willingness to discuss fall risk, fall history, or to have a home safety evaluation. Yale J Biol Med 2016;89:261-7.
44. Ang SGM, O'Brien AP, Wilson A. Fall concern about older persons shifts to carers as changing health policy focuses on family, home-based care. Singap Med J 2018;59:9-11.
45. Andreasen J, Gobbens RJ, Eriksen HH, Overvad K. Health-related quality of life at hospital discharge as a predictor for 6-month unplanned readmission and all-cause mortality of acutely admitted older medical patients. Qual Life Res 2019;28:3015-24.
46. Tsai S-Y, Chi L-Y, Lee C-h, Chou P. Health-related quality of life as a predictor of mortality among community-dwelling older persons. Eur J Epidemiol 2007;22:19-26.
47. Cavrini G, Broccoli S, Puccini A, Zoli M. EQ-5D as a predictor of mortality and hospitalization in elderly people. Qual Life Res 2012;21:269-80.
48. Karampampa K, Frumento P, Ahlbom A, Modig K. Does a hospital admission in old age denote the beginning of life with a compromised health-related quality of life? A longitudinal study of men and women aged 65 years and above participating in the Stockholm Public Health Cohort. BMJ Open 2016;6:e010901.
49. Wimmer BC, Dent E, Bell JS, et al. Medication regimen complexity and unplanned hospital readmissions in older people. Ann Pharmacother 2014;48:1120-8.
50. Dias A, Teixeira-Lopes F, Miranda A, et al. Comorbidity burden assessment in older people admitted to a Portuguese University Hospital. Aging Clin Exp Res 2015;27:323-8.
51. Basnet S, Zhang M, Lesser M, et al. Thirty-day hospital readmission rate amongst older adults correlates with an increased number of medications, but not with Beers medications. Geriatr Gerontol Int 2018;18:1513-8.
52. Tanderup A, Lassen AT, Rosholm J-U, Ryg J. Disability and morbidity among older patients in the emergency department: a Danish population-based cohort study. BMJ Open 2018;8:e023803.
53. Fabbietti P, Di Stefano G, Moresi R, et al. Impact of potentially inappropriate medications and polypharmacy on 3-month readmission among older patients discharged from acute care hospital: a prospective study. Aging Clin Exp Res 2018;30:977-84.
54. Franchi C, Nobili A, Mari D, Tettamanti M, Djade CD, Pasina L, et al. Risk factors for hospital readmission of elderly patients. Eur J Intern Med 2013;24:45-51.
55. Aljishi M, Parekh K. Risk factors for general medicine readmissions and association with mortality. N Z Med J 2014;127:42-50.
56. Al Hamid A, Ghaleb M, Aljadhey H, Aslanpour Z. A systematic review of hospitalization resulting from medicine-related problems in adult patients. Br J Clin Pharmacol 2014;78:202-17.
57. Saedder EA, Lisby M, Nielsen LP, Bonnerup DK, Brock B. Number of drugs most frequently found to be independent risk factors for serious adverse reactions: a systematic literature review. Br J Clin Pharmacol 2015;80:808-17.
58. Parekh N, Ali K, Stevenson JM, et al. Incidence and cost of medication harm in older adults following hospital discharge: a multicentre prospective study in the UK. Br J Clin Pharmacol 2018;84:1789-97.