Archives of Gerontology and Geriatrics 94 (2021) 104350

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Risk factors of readmission after geriatric hospital care: An interRAI-based cohort study in Finland

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ARTICLE INFO

Keywords:
Risk factors
Readmission
Aged
Community-dwelling
Geriatric hospital care
Hospitalisation

ABSTRACT

Purpose: To identify risk factors for readmission after geriatric hospital care.
Methods: A retrospective cohort study of 1,167 community-dwelling patients aged ≥70 years who were hospitalised in two geriatric hospitals and discharged to their homes over a three-year period. We combined the results of the interRAI-post acute care instrument (interRAI-PAC) with hospital discharge records. Factors associated with readmissions within 90 days following discharge were analysed using logistic regression analysis.
Results: The patients' mean age was 84.5 (SD 6.2) years, and 71% (n = 827) were women. The 90-day readmission rate was 29.5%. The risk factors associated with readmission in the univariate analysis were as follows: age, admission from home vs. acute care hospital, Alzheimer's disease, unsteady gait, fatigue, unstable conditions, Activities of Daily Living Hierarchy Scale (ADLH) score, Cognitive Performance Scale (CPS) score, body mass index (BMI), frailty index, bowel incontinence, hearing difficulties, and poor self-rated health. In the multivariable analysis, age of ≥90 years, ADLH ≥1, unsteady gait, BMI <25 or ≥30 kg/m 2 , and frailty remained as risk factors for readmission. Surgical operation during the treatment period was associated with a lower readmission risk.
Conclusions and implications: InterRAI-PAC performed upon admission to geriatric hospitals revealed patient-related risk factors for readmission. Based on the identified risk factors, we recommend that the patient's functional ability, activities of daily living (ADL) needs, and individual factors underlying ADL disability, as well as nutritional and mobility problems should be carefully addressed and managed during hospitalization to diminish the risk for readmission.

1. Introduction

Hospital readmission shortly after discharge is a common adverse outcome of hospitalization among older patients (Pedersen et al., 2017). Approximately 15% of patients discharged from acute care (Pedersen et al., 2017) and 11—23% of patients discharged from post-acute care or rehabilitation settings are admitted to hospital within 30 days of discharge (Hoyer et al., 2013; Hughes & Witham, 2018; Ottenbacher et al., 2014).

The reasons for readmissions are multifactorial (Pedersen et al., 2017). According to a systematic review, the main risk factors associated with a higher risk for hospital readmission after a stay in an acute care hospital are related to socio-demographic determinants (e.g. higher age and male sex), and impaired health state (e.g. poor overall condition, functional disability, geriatric syndromes, and frailty) (Pedersen et al., 2017). The factors associated with hospital admission shortly after a stay in post-acute care or rehabilitation settings include delirium (Miu et al., 2016), congestive heart failure (Flanagan et al., 2018), dependencies in mobility, self-care and cognition at discharge (Hoyer et al., 2013; Middleton et al., 2016; Middleton et al., 2018), possible depression, chronic obstructive pulmonary disease (COPD), and unstable or acute conditions (Sinn et al., 2016). Meanwhile, higher gait speed (Peel et al., 2014) and optimism about rehabilitation are protective against readmission (Sinn et al., 2016). About a quarter of readmitted patients are readmitted with the same condition that they had for their initial admission (Hughes & Witham, 2018).

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https://doi.org/10.1016/j.archger.2021.104350
Received 30 September 2020; Received in revised form 2 January 2021; Accepted 18 January 2021
Available online 20 January 2021

Geriatric syndromes are common multifactorial clinical conditions in older hospitalised patients (Buurman et al., 2011; Inouye et al., 2007), and they increase the risk for readmission and other adverse hospital outcomes (Espallargues et al., 2008). In patients with geriatric syndromes, recovery after acute illness or trauma is usually prolonged. As the length of stay in acute hospitals is short, patients are often transferred to post-acute care settings (Bowles et al., 2009). In Finland, post-acute care is organised in hospital settings.

There are a few studies concerning risk factors of readmissions following discharge from post-acute care or rehabilitation settings and from acute geriatric units, but there are no studies about risk factors after other kind of geriatric care. In previous studies, follow-up has been limited to 30 days of discharge. This study explored risk factors of readmissions to any hospitals after geriatric hospital care among mixed patient populations; including patients with subacute, post-acute and rehabilitation care needs. Especially, this study aimed to clarify how comprehensive geriatric assessment (CGA), based on the interRAI Post-Acute Care instrument (interRAI-PAC), can be used to identify patients in a mixed patient population of community-dwelling older adults with increased risk for such readmissions.

2. Methods

2.1. Setting and materials

This retrospective cohort study was conducted among community-dwelling older patients who were hospitalised in two geriatric hospitals and discharged to their own homes. The hospitals (230 and 190 beds) are situated in the city of Tampere (population 232,000, of which 11% are ≥70 years old) in western Finland. These hospitals offered post-acute care and rehabilitation to older patients who were first hospitalised in acute care hospitals. Furthermore, home care clients could be referred directly from home to these hospitals when they needed temporary hospital care or rehabilitation without the need for a higher level of acute care.

The materials of this study consisted of two routinely collected health databases: 1) interRAI-PAC assessments and 2) hospital discharge records of these two geriatric hospitals. The use of interRAI-PAC was started in February 2013 in one hospital and gradually in the other hospital. All the wards in both hospitals had started to use interRAI-PAC by the beginning of 2016. The hospital discharge records contained information on the place the patient was admitted from, dates of

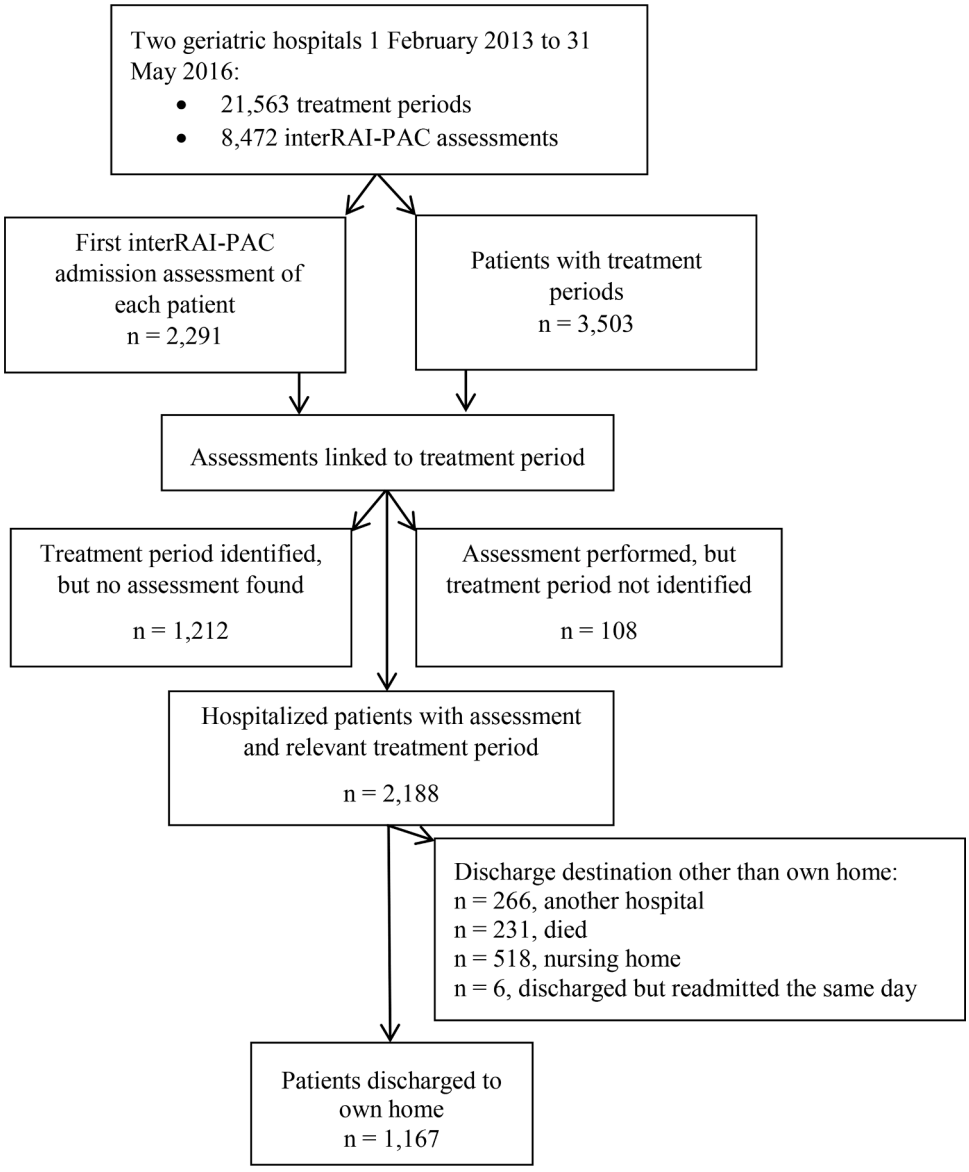

Fig. 1. Formation of materials.

admission and discharge, and discharge diagnoses and destination.

The results of the interRAI-PAC assessments were linked to the mandatory hospital discharge records of these two geriatric hospitals. The formation of materials is shown in Fig. 1. First, interRAI-PAC assessments of patients aged ≥70 years that had been performed during the study period from 1 February 2013 to 31 May 2016 in geriatric hospitals were considered. From all the assessments performed in these hospitals (n = 8472), we included all patients' first admission assessment. There were 2291 such assessments. Second, the discharge records of these hospitals from the same time period were collected, including 21,826 treatment periods of 3503 patients. Third, the interRAI assessments were linked to the hospital discharge records using social security numbers, resulting in 2188 matches, or patients with both the assessment and corresponding hospital discharge records. Only patients who were discharged back to their own homes were included, because our purpose was to obtain evidence on the risk factors for hospital admission following the stay in geriatric hospitals in community-dwelling older adults. The excluded patients were those 1) who were transferred to an acute care hospital during their stay in the geriatric hospital, 2) who died during hospitalization, 3) who were discharged to a nursing home or long-term care facility, or 4) who were discharged but returned to the hospital on the same day. Thus, 1167 patients were included in the analysis (Fig. 1).

Finally, dates of new hospital admissions in the Tampere region and possible dates of death for one year after discharge were noted. Dates of death were based on comprehensive national records of death certificates.

2.2. InterRAI-PAC variables and scales

The interRAI-PAC was designed to be used as a CGA tool in post-acute and rehabilitation settings (Gray et al., 2009). It consists of about 150 variables and contains information, for example, on the patient's home care, chronic diseases, functional ability, number of symptoms, and body mass index (BMI). According to the guidance, the interRAI admission assessment should be performed by trained nurses within a few days of the patient's admission to the ward. During the assessment, these nurses interview the patient and family members, observe the patient, and review the medical records. Single variables are combined to compose validated scales (Gray et al., 2009) that generate knowledge on the patients' functioning in different domains. For example, the Cognitive Performance Scale (CPS) describes the cognitive status of the patient (Morris et al., 2016); the Activities of Daily Living Hierarchy Scale (ADLH) measures functional ability (Morris et al., 1999); the Depression Rating Scale (DRS) is based on existing symptoms of depression (Burrows et al., 2000); the Changes in Health, End-stage disease, and Signs and Symptoms Scale (CHESS) is a summary measure designed to identify individuals at high risk for a clinically significant decline in health status (Hirdes et al., 2003; Hirdes et al., 2014) the Aggressive Behaviour Scale (ABS) measures the severity of behavioural symptoms (Perlman & Hirdes 2008); and the Pain Scale measures the frequency and severity of pain. (Fries et al., 2001). Generally, increasing scores describe a worsening state of health.

The interRAI-PAC variables evaluated as possible risk factors for readmission included the baseline characteristics of the patients (e.g. age, sex, living place, home-care services, and chronic diseases), BMI, the frailty index, the scales that assess functioning in different domains (CPS, ADLH, DRS, CHESS, ABS, and the Pain Scale), primary mode of locomotion, walking speed, and information about falls, hearing, vision, self-rated health, specific symptoms, continence, and rehabilitation potential.

BMI was classified as 1) the healthiest range for older adults (25—29.9 kg/m^2) and 2) outside the healthiest range (<25 or ≥30 kg/m2) according to previous findings of the relation between BMI and health outcomes among older persons (Heiat et al., 2001; Porter Starr & Bales 2015; Winter et al., 2014; Woolley et al., 2019). The Frailty Index is not included in the interRAI-PAC, but it can be calculated from the database according to the standard procedure for selecting individual deficits (Searle et al., 2008). In our study, the Frailty Index was calculated from the interRAI-PAC, as described previously (Kerminen et al., 2020).

2.3. Outcome measure

The primary outcome was the all-cause readmissions of patients within 90 days following discharge from the geriatric hospitals. Time for hospital admission was determined as the difference between the date of discharge and that of the first hospital admission of the patient. Hospital admission data were obtained from the hospital discharge records of Tampere, and they included data from the secondary care hospital and geriatric hospitals.

2.4. Statistical analyses

Patient characteristics were described using frequencies and percentages. We created the survival curve for readmissions using the Kaplan—Meier estimator. Associations of the risk factors with readmission were analysed using binary logistic regression. Variables selected for regression analysis included demographic variables from hospital discharge records and clinical, functional, and social variables from the interRAI-PAC.

In the first step, all variables included in the univariate analysis, except for the Frailty Index, were included in the multivariable analysis using the enter method. The Frailty Index was not included because it consists of the other included variables. In the second step, the following supplementary analyses were performed. First, only age, sex, and the Frailty Index were entered into the multivariable model. Second, patients were divided into three Frailty Index groups for performing the original multivariable analysis: <0.2 (robust), 0.2—0.4 (pre-frail), and >0.4 (frail).

The results were presented as odds ratios (ORs) with 95% confidence intervals (CIs). Data management and analysis were performed using IBM SPSS Statistics 25.0.

2.5. Ethics

Retrospective register-based studies are not considered medical research by Finnish legislation (Medical research act 9.4.1999/4881999), and as such, ethics committee approval was not required. Our research plan was institutionally reviewed. We obtained permission to use hospital discharge records and the interRAI-PAC assessments from the city administration of Tampere (decision by the Director of Hospital Services, given on 30 August 2016). Retrospectively collected health register data could be used for this study with permission from the register owner without the participants' informed consent, based on current national legislation (Act on the publicity of official documents 21.5.1999/6211999; Data protection act 5.12.2018/10502018 and European Union General Data Protection Regulation: General data protection regulation (GDPR), recital 1572018).

3. Results

3.1. Basic characteristics of the patients

The cohort included 1167 patients with a mean age (SD) of 84.5 (6.2) years; 71% (n = 827) were women (Table 1). Of the patients, 37% (n = 436) were diagnosed with a memory disorder, 70% used assistive devices while walking, 6% needed help in all basic activities of daily living (BADLs), and 33% were independent in BADLs. Of the patients, 60% were admitted from home and 40% from hospital wards. Within the past 90 days before admission to geriatric hospitals, 60% had experienced a

Table 1
Baseline characteristics of the patients ($n = 1167$).

	n	%
Female	827	70.9
Age (years)		
70–79.9	275	23.6
80–89.9	666	57.1
≥90	226	19.4
Age (years), mean (SD)	84.5	(6.2)
Living arrangement prior to admission		
Alone	765	65.6
With somebody	402	34.4
Home-care services		
No	443	38.0
Yes	723	62.0
Chronic diseases		
Alzheimer's disease	341	29.2
Other memory disorder	95	8.1
Alzheimer's disease and other memory disorder	25	2.1
Congestive heart failure	354	30.3
Coronary heart disease	298	25.5
Diabetes	296	25.4
Cancer	150	12.9
Depression	107	9.2
Stroke	106	9.1
Chronic obstructive pulmonary disease	74	6.3
Parkinson's disease	33	2.8
Independent in Activities of Daily Living		
Bathing	251	21.5
Personal hygiene	438	37.5
Dressing	498	42.3
Toilet use	631	54.1
Transfer toilet	722	61.9
Walking	719	61.6
Bed mobility	863	74.0
Eating	1043	89.4
Primary mode of locomotion		
Walking	983	84.2
Wheelchair or bedridden	184	15.8
Falls		
No falls in the last 3 months	601	51.5
Fall(s) 1 to 3 months ago	130	11.1
Fall(s) in last month	436	37.4
Smokes tobacco daily	46	3.9
BMI, kg/m^2*		
<18.5	80	6.9
18.5–24.9	500	42.8
25–29.9	336	28.8
≥30	240	20.6
BMI, kg/m^2*, mean (SD)	25.8	(5.6)
Admitted from		
Home	694	59.5
Hospital ward	473	40.5
Operated on during hospital stay	151	12.9
Ten most common main discharge diagnoses codes (ICD-10)		
Diseases of the circulatory system (I)	284	24.4
Diseases of the nervous system (G)	187	16.0
Injury, poisoning and certain other consequences of external causes (S or T)	146	12.5
Mental and behavioural disorders (F)	138	11.8
Diseases of the musculoskeletal system and connective tissue (M)	86	7.4
Diseases of the genitourinary system (N)†	71	6.1
Neoplasms or diseases of the blood (C or D)	59	5.0
Symptoms and signs, not elsewhere classified (R)	56	4.8
Endocrine, nutritional and metabolic diseases (E)	43	3.7
Diseases of the respiratory system (J)	35	3.0
Duration of hospital stay		
1—30 days	971	83.2
>30 days	196	16.8

* $n = 1156$, BMI missing $n = 11$.
† Urinary tract infections 77%.

decline in ADL performance. The median length of the stay in the geriatric hospital was 26 days (interquartile range, 15—48 days), and 196 patients (17%) were hospitalized for ≥30 days. The most common reasons for the hospital stay were diseases of the circulatory system, diseases of the nervous system, injuries, mental and behavioural disorders, and diseases of the musculoskeletal system and connective tissue (Table 1). Of interRAI assessments, 64% and 85% had been performed within seven and 14 days upon the patient's admission to the ward, respectively.

3.2. Readmissions after discharge from geriatric hospitals

The 90-day readmission rate was 29.5% ($n = 344$), accounting for 57% of the (first) readmissions that occurred during the year after discharge (Fig. 2). One-third ($n = 197$) of yearly readmissions occurred in the first 30 days after discharge (the 30-day hospital admission rate was 6.9%). There were no clinically significant differences in patient characteristics among patients readmitted within 30 days of discharge ($n = 197$) between those readmitted in 31 to 90 days of discharge ($n = 147$). Meanwhile, the 90-day mortality rate was 4.3% ($n = 50$).

Among the ten most common main discharge diagnosis codes (Table 2), the hospital readmission rate was the highest among patients with diseases of the genitourinary system (42.3%), followed by symptoms and signs not elsewhere classified (35.7%), diseases of the musculoskeletal system and connective tissue (32.6%), and neoplasms or diseases of the blood (32.2%).

3.3. Univariate and multivariable analyses

The risk factors associated with the 90-day readmission in the univariate analysis were as follows: age of ≥90 years, admission from home vs. acute care hospital, Alzheimer's disease, unsteady gait, fatigue, unstable conditions, ADLH score of ≥1, requiring assistance in eating, CPS score of ≥1, BMI of <25 or ≥30 kg/m^2, Frailty Index of ≥0.20, bowel incontinence, hearing difficulties, and poor self-rated health (Table 2). Undergoing a surgical operation during the treatment period was associated with a lower risk for readmission.

In the multivariable analysis, age of ≥90 years, ADLH score of ≥1, BMI of <25 or ≥30 kg/m^2, and unsteady gait remained as independent risk factors for 90-day readmission (Table 2). When only age, gender, and the Frailty Index were entered into the multivariable model, both age and Frailty Index associated with readmission. When the multivariable model was repeated separately for patients with Frailty Indexes <0.2, 0.2—0.4, and >0.4, the ORs for age and BMI were similar to those of the original model, albeit not to a statistically significant degree because of the wider Cls. In addition, we observed a tendency towards a greater risk for readmission in patients with ADL disability and patients with a Frailty Index of >0.4 (Appendix).

4. Discussion

In this retrospective cohort study, nearly one third of the older patients discharged from geriatric hospitals were admitted to hospital within 90 days of discharge. The independent risk factors associated with readmissions were ADL disability, age of ≥90 years, unsteady gait, and low or high BMI.

The 30 and 90-day readmission rates were 16.9% and 29.5%, respectively. The 30-day readmission rate was comparable to that in previous studies among older patients discharged from post-acute care and rehabilitation settings (Hoyer et al., 2013; Hughes & Witham 2018; Ottenbacher et al., 2014). Meanwhile, no studies have examined 90-day hospital admission rates. Consistent with the literature (Burke et al., 2015), our study found that the readmission risk was the highest soon after discharge: although one-third of yearly readmissions occurred within 30 days, readmissions continued to cumulate rapidly and over half of them occurred within 90 days.

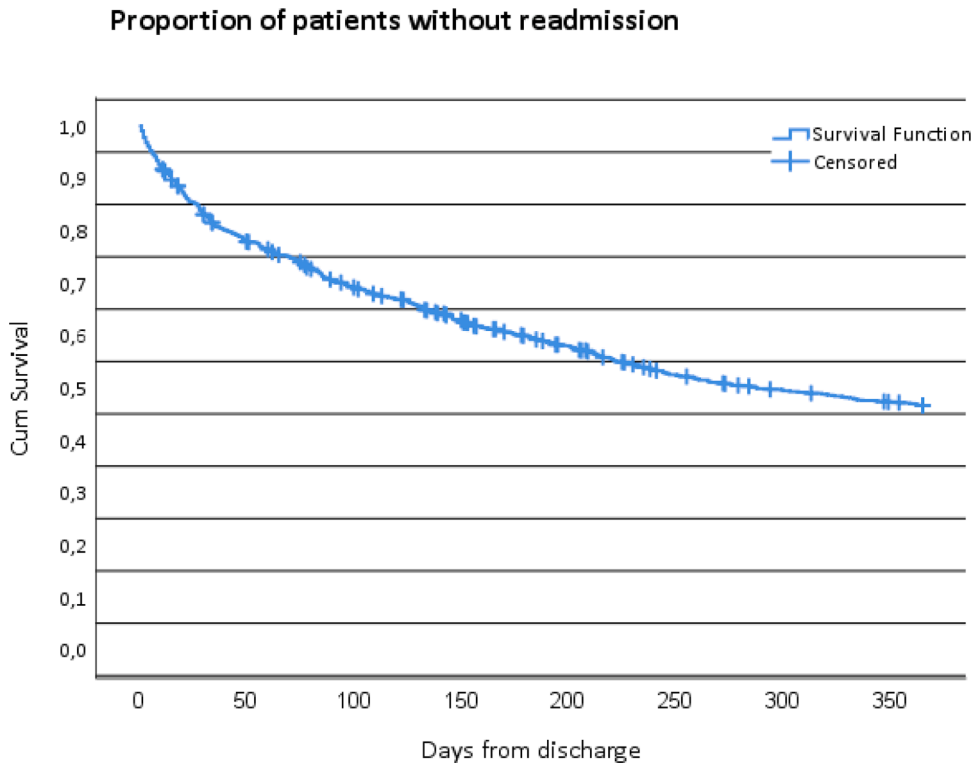

Fig. 2. Kaplan—Meier curve showing one-year readmissions after discharge from a geriatric hospital among 1167 community-dwelling older patients.

Our results showed that the strongest independent risk factor for readmission was ADL disability upon admission to hospital. This finding coincided with previous reports on the risk factors for 30-day readmission after a treatment period in post-acute care or inpatient rehabilitation settings (Hoyer et al., 2013; Middleton et al., 2018, Middleton et al., 2016; Ottenbacher et al., 2014). ADL disability and increasing age could remain as risk factors beyond the previously studied period of 30 days following discharge. Furthermore, age was an independent risk factor regardless of frailty status.

The finding that low or high BMI ($<$25 or $\geq$30 kg/m^2) could predict readmission corroborates the position of Woolley et al., who suggested that the healthiest BMI with fewer adverse outcomes in older hospitalized patients is $\geq$25 kg/m^2 (Woolley et al., 2019). Low BMI may be related to malnutrition, which has been associated with the 30-day readmission risk (Hudson et al., 2018). In addition, obesity has been found to be a risk factor for readmission among persons aged $\geq$85 years receiving post-acute care in nursing home facilities (Cai et al., 2019).

Several patient-related factors were associated with readmission in the univariate analyses, but their effects were attenuated or lessened after accounting for individual covariates. Studies regarding the association of cognitive impairment with readmission have generated contradictory results (Burke et al., 2015; Callahan et al., 2015). Poor self-rated health has been shown to be a risk factor for hospitalization among home-care clients (Rönneikkö et al., 2017), and it increases hospital services use among community-dwelling adults (Isaac et al., 2015; Tamayo-Fonseca et al., 2015). However, previous studies about readmissions are absent.

The association between bowel incontinence and readmission has not previously been reported, although it is a known risk factor for unplanned hospitalization among home-care clients (Rönneikkö et al., 2017), and is related to mortality in older people (Jamieson et al., 2017). Likewise, hearing difficulties with perceived problems in communication increase the risk for readmission in older patients (Chang et al., 2018). Surgical operation during the treatment period was associated with a lower risk for readmission. The mechanism for this is unclear, but it may be related to patient selection for elective surgery.

In our study, the Frailty Index was associated with readmission in the univariate analysis and also after adjustments for age and sex. The likelihood of experiencing readmission was 1.5-fold in pre-frail and nearly 2-fold in frail patients, compared with those with a Frailty Index of $<$0.20. Frailty has been shown to be associated with early readmissions in older medical (Kahlon et al., 2015) and surgical patients (Stern et al., 2018; Wahl et al., 2016). In our previous study among the same patient cohort as used in this study, the Frailty Index is shown to be associated with prolonged hospital stay and in-hospital mortality, but its predictive ability is similar to that of ADL disability measured by the ADLH scale (Kerminen et al., 2020).

Knowledge of the risk factors for readmission following discharge from geriatric hospitals have several implications in clinical practice. First, the early detection during hospitalization of individual factors that predispose patients to readmission may aid in avoiding such admissions after discharge. Discharge planning, including a plan for post-discharge services and rehabilitation, has already been shown to reduce readmissions and increase the satisfaction of patients and healthcare professionals (Goncalves-Bradley et al., 2016). Functional impairment is a strong risk factor for readmission, and the greatest risk is among patients who develop a new ADL deficit during the hospital stay (Depalma et al., 2013) and are discharged with an unmet need for an ADL disability (Arbaje et al., 2008; Depalma et al., 2013). Therefore, functional ability and ADL needs, as well as the factors underlying the ADL disability of the patient, should be carefully addressed and managed during hospitalization. It is especially important to identify modifiable conditions, such as unsteady gait and nutritional problems. Second, our study demonstrated that interRAI-PAC can be used as a tool for CGA, or the evaluation of the patient's medical, psychological, cognitive, and functional state to identify factors that may contribute to ADL disability, gait instability, and nutritional problems. Information gathered in CGA forms the basis of individually designed treatment, rehabilitation, and follow-up (Ellis et al., 2017). The present results highlighted the importance of systematic assessment, as many of the identified risk

Table 2
Association of patient factors with the 90-day hospital admission following discharge from geriatric hospitals providing primary care.

	Patients	Readmissions	Univariate		Multivariable	
	n	n (%)	OR	95% CI	OR	95% CI
Age (years)						
70—79.9	275	70 (25.5)	1		1	
80—89.9	666	192 (28.8)	1.19	0.86—1.63	1.24	0.86—1.77
≥90	226	82 (36.3)	1.67	1.14—2.45	1.94	1.22—3.08
Sex						
Men	340	99 (29.1)	1		1	
Women	827	245 (29.6)	1.03	0.78—1.35	1.03	0.77—1.37
Living arrangement prior to admission						
Alone	765	220 (28.8)	1		1	
With somebody	402	124 (30.8)	1.11	0.85—1.44	1.03	0.77—1.37
Admitted from						
Hospital	473	119 (25.2)	1		1	
Home	694	225 (32.4)	1.43	1.10—1.85	1.34	0.99—1.84
Operated on the same treatment period	151	27 (17.9)	0.48	0.31—0.74	0.54	0.32—0.91
Primary mode of locomotion						
Walking	983	290 (29.5)	1		1	
Wheelchair or bedridden	184	54 (29.3)	0.99	0.70—1.40	1.11	0.70—2.30
Walking speed						
>0.80 m/s	77	23 (29.9)	1		1	
0.80—0.14 m/s	787	236 (30.0)	1.01	0.60—1.68	0.85	0.47—1.54
<0.14 m/s or patient was not able to perform the test	303	85 (28.1)	0.92	0.53—1.58	0.67	0.33—1.35
Rehabilitation potential						
Patient is optimistic	1057	310 (29.3)	1.03	0.58—1.84	1.27	0.70—2.30
Care professionals are optimistic	1108	327 (29.5)	0.93	0.61—1.42	0.96	0.43—2.14
Worsening of ADL performance	817	249 (30.5)	1.18	0.89—1.56	1.14	0.77—1.67
Symptoms						
Dizziness	497	148 (29.8)	1.03	0.80—1.32	0.91	0.69—1.20
Unsteady gait	298	223 (31.9)	1.35	1.04—1.75	1.40	1.01—1.94
Constipation	198	67 (33.8)	1.28	0.92—1.77	1.27	0.89—1.82
Sleeping problems	265	87 (32.8)	1.23	0.91—1.65	1.33	0.96—1.85
Dyspnoea	206	65 (31.6)	1.13	0.81—1.56	1.13	0.72—1.78
Fatigue	169	65 (38.5)	1.61	1.15—2.26	1.23	0.82—1.93
Dysphagia	63	18 (28.6)	0.96	0.54—1.67	0.65	0.33—1.28
Weight loss	71	24 (33.8)	1.24	0.75—2.06	1.41	0.74—2.69
Disease diagnoses						
Alzheimer's disease	366	123 (33.6)	1.33	1.02—1.73	1.20	0.86—1.67
Another memory disorder	120	41 (34.2)	1.27	0.85—1.90	1.33	0.86—2.06
Stroke	106	32 (30.2)	1.04	0.67—1.60	0.96	0.59—1.56
Coronary artery disease	298	80 (26.8)	0.84	0.63—1.13	0.85	0.62—1.18
Congestive heart failure	354	106 (29.9)	1.03	0.79—1.36	0.89	0.65—1.22
Chronic obstructive pulmonary disease	74	27 (36.5)	1.41	0.86—2.30	1.57	0.90—2.72
Depression	107	30 (28.0)	0.93	0.60—1.44	0.89	0.55—1.44
Cancer	150	45 (30.0)	1.03	0.71—1.50	1.28	0.84—1.95
Diabetes	296	88 (29.7)	1.02	0.76—1.35	1.12	0.82—1.54
Activities of daily living hierarchy scale						
0	379	85 (22.4)	1		1	1
1—2	455	148 (32.5)	1.67	1.22—2.28	1.62	1.12—2.34
3—4	263	84 (31.9)	1.62	1.14—2.31	1.67	1.04—2.71
5—6	70	27 (38.6)	2.17	1.27—3.72	2.52	1.17—5.43
Cognitive Performance Scale						
0	309	71 (23.0)	1		1	
1—2	643	199 (30.9)	1.50	1.10—2.06	1.22	0.84—1.78
3—4	153	49 (32.0)	1.58	1.03—2.43	1.05	0.51—1.89
5—6	62	25 (40.3)	2.27	1.28—4.02	1.51	0.67—3.39
Depression Rating Scale						
0—2	1010	294 (29.1)	1			
3—14	157	50 (31.8)	1.14	0.79—1.64	0.98	0.45—1.49
The Changes in Health, End-Stage Disease, Signs and Symptoms Scale						
0	276	75 (27.2)	1		1	
1	476	132 (27.7)	1.03	0.74—1.43	0.89	0.59—1.32
2	277	92 (33.2)	1.33	0.93—1.92	0.91	0.55—1.50
3	109	33 (30.3)	1.16	0.72—1.89	0.59	0.29—1.19
4	29	12 (41.4)	1.89	0.86—4.15	0.80	0.26—2.42
Pain Scale						
0	613	183 (29.9)	1		1	
1	330	105 (31.8)	1.10	0.82—1.46	1.10	0.80—1.52
2–4	224	56 (25.0)	0.78	0.55—1.11	0.67	0.45—1.01
Communicative Ability Scale						
0–1	853	234 (27.4)	1		1	
2–5	290	97 (3313)	1.33	1.00—1.77	1.02	0.71—1.47
6–8	24	13 (54.2)	3.13	1.38—7.08	2.36	0.83—6.71

(*continued on next page*)

Table 2 (*continued*)

	Patients	Readmissions	Univariate		Multivariable	
	n	n (%)	OR	95% CI	OR	95% CI
Requiring assistance in eating	124	48 (38.7)	1.59	1.08—2.34	*	
Aggressive Behaviour Scale	1167					
0	997	296 (29.7)	1		1	
1—14	170	48 (28.2)	0.93	0.65—1.34	0.62	0.40—0.95
Body Mass Index						
25—29.9	367	93 (25.3)	1		1	
<25 or ≥30	800	251 (31.4)	1.35	1.02—1.78	1.44	1.06—1.98
Frailty index/ 0.1 increment	1167	344 (29.5)	1.20	1.09—1.32	**	
Frailty index						
<0.20	362	84 (23.2)	1			
0.20—0.40	571	175 (30.6)	1.46	1.08—1.98		
>0.40	234	85 (36.3)	1.89	1.32—2.71		
Bladder continence						
Continent	540	146 (27.0)	1		1	
Occasionally or frequently incontinent	627	198 (31.6)	1.25	0.97—1.61	0.80	0.57—1.12
Bowel continence						
Continent	890	249 (28.0)	1		1	
Occasionally or frequently incontinent	277	95 (34.6)	1.34	1.01—1.79	0.99	0.67—1.44
Hearing						
Adequate	837	234 (27.3)	1		1	
Minimal difficulty	206	72 (35.0)	1.43	1.04—1.98	1.15	0.80—1.66
Moderate or severe difficulty	104	38 (36.5)	1.53	1.00—2.35	1.31	0.81—2.13
Vision						
Adequate	843	236 (28.0)	1		1	
Minimal difficulty	239	80 (33.5)	1.29	0.95—1.76	0.99	0.70—1.41
Moderate or severe difficulty	85	28 (32.9)	1.26	0.78—2.06	1.04	0.62—1.76
Foot problems	233	75 (32.2)	1.17	0.86—1.60	1.24	0.88—1.75
Falls						
No (in last month)	731	218 (29.8)	1		1	
Yes	436	126 (28.9)	0.96	0.74—1.24	0.86	0.64—1.16
Self-rated health						
Good	295	77 (26.1)	1		1	
Fair	614	174 (28.3)	1.12	0.82—1.53	1.08	0.76—1.53
Poor	158	56 (35.4)	1.55	1.03—2.36	1.36	0.81—2.27
Patient was unable to answer	100	37 (37.0)	1.66	1.03—2.69	1.14	0.64—2.02
Unstable conditions	735	233 (31.7)	1.34	1.03—1.75	1.12	0.68—1.82
Acute episode or flare-up	305	98 (32.1)	1.19	0.89—1.57	1.15	0.84—1.57
Duration of hospital stay						
1—30 days	971	286 (29.5)	1		1	
>30 days	196	58 (29.6)	1.01	0.72—1.41	1.12	0.75—1.67
Ten most common main discharge diagnosis codes (ICD-10)						
Diseases of the circulatory system (I)	284	82 (28.9)				
Diseases of the nervous system (G)	187	54 (28.9)				
Injury, poisoning and certain other consequences of external causes (S or T)	146	27 (18.5)				
Mental and behavioural disorders (F)	138	42 (30.4)				
Diseases of the musculoskeletal system and connective tissue (M)	86	28 (32.6)				
Diseases of the genitourinary system (N)	71	30 (42.3)				
Neoplasms or diseases of the blood (C or D)	59	19 (32.2)				
Symptoms and signs, not elsewhere classified (R)	56	20 (35.7)				
Endocrine, nutritional and metabolic diseases (E)	43	10 (23.3)				
Diseases of the respiratory system (J)	35	11 (31.4)				

* Not entered, because the variable is included in ADLH.
** Not entered, because the indec consists of the variables included in the multivariable analysis.

factors could be easily missed in routine clinical practice. However, CGA performed during the stay in a post-acute care hospital may or may not have an impact on readmissions. In the case of acute care, CGA has not been shown to reduce readmissions (Ellis et al., 2017). Finally, the present results suggested that information on ADL performance, cognition, frailty, and nutritional state is needed for appropriate case-mix adjustments when comparing readmission rates between different hospitals; ignoring these factors might lead to the inadvertent poor performance of units taking care of the most vulnerable patient groups. InterRAI could be potentially used for benchmarking purposes in geriatric hospitals, as is the practice in nursing homes (Hirdes et al., 2013).

One strength of our study was the use of a regionally representative sample size of real-life patients. Analysis of 90-day readmissions extends earlier literature and ensured sufficient statistical power for multivariable analysis. Although our materials covered all interRAI-PAC assessments performed in Tampere, and although the patients represented an unselected population (in terms of insurance or social status), the current patient numbers are modest, from an international context. The results may not be fully generalisable to other health care systems. Besides, as Finnish health care system differs from other countries, these results should be interpreted with caution. Another source of uncertainty is related to the reasons for readmissions. We could not exclude planned readmissions from our study as our materials did not include reasons for readmissions. However, it is unlikely that there were many planned readmissions within 90 days of discharge in this patient population.

In addition, our materials did not include all patients who had a treatment period in the study hospitals during the study period, as the interRAI assessment was not performed for all patients. Among the possible reasons for missing assessments is that the introduction of interRAI-PAC was gradual in different wards. Meanwhile, hospital discharge records were collected for the same period from both

hospitals. Another reason may be related to the laboriousness of assessment in a busy clinical practice (Carpenter & Hirdes 2013), which may lead to a substantial number of missing assessments in clinical context (Wellens et al., 2011). As we concentrated on patient characteristics that may increase the readmission risk, this study did not consider all known risk factors associated with readmissions, such as organisational factors and healthcare utilization. Furthermore, we could not differentiate ADL disability caused by an acute illness from longer-lasting functional decline because the time frame in which ADL disability had developed could not be determined.

In addition, the hospital discharge database did not include readmissions to the hospital providing tertiary care. However, older patients living an area are usually hospitalised in a secondary rather than a tertiary care hospital or, at least, transferred from a tertiary to a secondary care hospital before discharge to their home. Finally, the kind of assessment, treatment, and support offered to the patients during their hospital stay could not be specified, as well as the way they could affect the rate of readmissions.

5. Conclusions

The interRAI-PAC assessment performed upon admission to geriatric hospitals revealed patient-related risk factors for readmissions: ADL disability, age, low or high BMI, unsteady gait, and frailty were independent risk factors. Based on the identified complex risk factors, we recommend that patients' assessments should be systematic and multidisciplinary. Functional ability, ADL needs, and individual factors underlying the ADL disability, as well as nutritional and mobility problems, should be carefully addressed and managed during hospitalization to avoid repeat hospital admissions.

Considering the heterogeneity of patients in geriatric care settings, future studies could pay attention to the effects of interventions that target patients at the highest risk of adverse outcomes. The use of both interRAI-PAC admission and discharge assessments would offer opportunities for this kind of study.

Declaration of Competing Interest

The study was financially supported by the Competitive State Research Financing and non-profit research funds. Funding bodies had no role in preparing, performing, or reporting this study. No other conflicts of interest exist.

Acknowledgements

The funder had no role in the study design, methods, data collection, analysis, interpretation of data, or preparation of the manuscript.

Appendix 1. Multivariable model in all patients and in Frailty Index groups

			Frailty Index					
	All patients		<0.2		0.2—0.4		>0.4	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age (years)								
70—79.9	1		1		1		1	
80—89.9	1.24	0.86—1.77	1.41	0.61–3.23	1.07	0.63–1.82	1.36	0.56–3.35
≥90	1.94	1.22—3.08	3.65	1.27–10.50	2.16	1.09–4.27	0.86	0.24–3.04
Sex								
Men	1		1		1			
Women	1.03	0.77—1.37	1.18	0.56–2.46	0.91	0.56–1.51	2.08	0.87–4.95
Living arrangement prior to admission								
Alone	1		1		1		1	
With somebody	1.03	0.77—1.37	1.72	0.89–3.31	0.68	0.44–1.05	1.62	0.71–3.67
Admitted from								
Hospital	1		1		1		1	
Home	1.34	0.99—1.84	0.89	0.43–1.84	1.17	0.75–1.82	2.76	1.19–6.41
Operated on the same treatment period	0.54		0.50	0.14–1.79	0.66	0.13–1.39	0.26	0.07–1.04
Primary mode of locomotion								
Walking	1		1		1		1	
Wheelchair or bedridden	1.11	0.70—2.30	3.85	0.81–18.39	0.96	0.46–2.01	1.10	0.40–3.04
Walking speed								
>0.80 m/s	1		1		1			
0.80—0.14 m/s	0.85	0.47—1.54	0.72	0.29–1.84	0.99	0.38–2.61		
<0.14 m/s or patient was not able to perform the test	0.67	0.33—1.35	0.42	0.11–1.57	0.74	0.24–2.31		
Rehabilitation potential								
Patient is optimistic	1.27	0.70—2.30	5.61	0.55–57.67	1.02	0.41–2.53	1.51	0.45–5.09
Care professionals are optimistic	0.96	0.43—2.14			1.23	0.34–4.48	0.57	0.12–2.69
Worsening of ADL performance	1.14		1.63	0.71–3.74	0.83	0.48–1.44	1.19	0.31–4.51
Symptoms								
Dizziness	0.91	0.69—1.20	0.99	0.50–1.98	0.99	0.66–1.48	0.89	0.41–1.84
Unsteady gait	1.40	1.01—1.94	2.26	1.11–4.58	1.34	0.85–2.13	2.13	0.56–8.17
Constipation	1.27	0.89—1.82	2.43	0.95–6.22	1.23	0.70–2.15	1.31	0.58–2.93
Sleeping problems	1.33	0.96—1.85	0.79	0.30–2.04	1.89	1.19–3.01	0.82	0.36–1.88
Dyspnoea	1.13	0.72—1.78	0.30	0.07–1.22	0.98	0..51–1.86	3.40	1.16–9.99
Fatigue	1.23	0.82—1.93	0.60	0.05–7.73	1.71	0.86–3.39	1.50	0.67–3.35
Dysphagia	0.65	0.33—1.28	3.60	0.40–32.14	0.89	0.32–2.44	0.44	0.13–1.46
Weight loss	1.41	0.74—2.69	0.54	0.09–3.49	2.10	0.82–5.41	1.06	0.25–4.45
Disease diagnoses								
Alzheimer's disease	1.20	0.86—1.67	0.85	0.35–2.04	1.22	0.74–1.99	2.05	0.94–4.46
Another memory disorder	1.33	0.86—2.06	1.63	0.51–5.19	1.23	0.62–2.44	2.68	1.02–7.00
Stroke	0.96	0.59—1.56	1.45	0.41–5.09	0.62	0.28–1.35	1.33	0.44–3.95
Coronary artery disease	0.85	0.62—1.18	1.41	0.67–2.98	0.77	0.47–1.25	0.61	0.27–1.41

(continued on next page)

(*continued*)

			Frailty Index					
	All patients		<0.2		0.2—0.4		>0.4	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Congestive heart failure	0.89	0.65—1.22	0.35	0.15–0.82	1.15	0.73–1.81	1.57	0.64–3.84
Chronic obstructive pulmonary disease	1.57	0.90—2.72	8.81	1.89–41.14	2.21	1.00–4.88	0.77	0.20–2.99
Depression	0.89	0.55—1.44	0.63	0.13–2.96	0.71	0.36–1.40	1.50	0.49–4.62
Cancer	1.28	0.84—1.95	1.96	0.76–5.03	0.93	0.49–1.78	2.30	0.76–6.99
Diabetes	1.12	0.82—1.54	1.76	0.86–3.61	0.94	0.59–1.49	1.23	0.53–2.88
Activities of daily living hierarchy scale								
0	1		1		1			
1—2	1.62	1.12—2.34	2.81	1.28–6.16	1.11	0.61–2.00		
3—4	1.67	1.04—2.71	0.66	0.03–13.33	1.21	0.56–2.53		
5—6	2.52	1.17—5.43			2.65	0.85–8.23		
Cognitive Performance Scale								
0	1		1		1		1	
1—2	1.22	0.84—1.78	1.79	0.87–3.70	1.25	0.70–2.24	1.51	0.13–18.31
3—4	1.05	0.51—1.89	4.12	0.39–43.89	0.76	0.30–1.87	1.69	0.13–22.77
5—6	1.51	0.67—3.39			1.02	0.25–4.20	3.72	0.23–59.45
Depression Rating Scale								
0—2	1		1		1		1	
3—14	0.98	0.45—1.49	0.33	0.07–1.66	1.26	0.68–2.34	0.86	0.35–2.10
The Changes in Health, End-Stage Disease, Signs and Symptoms Scale								
0	1		1		1		1	
1	0.89	0.59—1.32	0.75	0.33–1.70	0.90	0.49–1.64	0.99	0.26–3.79
2	0.91	0.55—1.50	2.37	0.59–9.42	0.93	0.46–1.90	0.72	0.17–3.10
3	0.59	0.29—1.19	1.84	0.12–29.36	0.68	0.24–1.94	0.32	0.05–1.83
4	0.80	0.26—2.42					0.53	0.05–6.12
Pain Scale								
0	1		1		1		1	
1	1.10	0.80—1.52	2.64	1.25–5.56	0.85	0.53–1.35	0.82	0.34–1.96
2–4	0.67	0.45—1.01	1.63	0.64–4.20	0.50	0.27–0.92	0.48	0.18–1.26
Communicative Ability Scale								
0–1	1		1		1		1	
2–5	1.02	0.71—1.47	1.35	0.41–4.40	0.95	0.56–1.62	1.61	0.70–3.70
6–8	2.36	0.83—6.71						
Aggressive Behaviour Scale								
0	1		1		1		1	
1—14	0.62	0.40—0.95	2.14	0.50–9.27	0.32	0.16–0.64	1.03	0.45–2.35
Body Mass Index								
25—29.9	1		1		1		1	
<25 or ≥30	1.44	1.06—1.98	1.50	0.75–3.00	1.36	0.84–2.19	1.34	0.58–3.14
Bladder continence								
Continent	1		1		1		1	
Occasionally or frequently incontinent	0.80	0.57—1.12	1.00	0.48–2.08	0.69	0.44–1.09	0.90	0.19–4.31
Bowel continence								
Continent	1		1		1		1	
Occasionally or frequently incontinent	0.99	0.67—1.44	0.39	0.09–1.76	1.16	0.66–2.04	0.90	0.39–2.07
Hearing								
Adequate	1		1		1		1	
Minimal difficulty	1.15	0.80—1.66	1.58	0.66–3.77	1.37	0.80–2.36	0.95	0.40–2.23
Moderate or severe difficulty	1.31	0.81—2.13	0.50	0.09–2.81	1.27	0.66–2.46	2.36	0.64–8.65
Vision								
Adequate	1		1		1		1	
Minimal difficulty	0.99	0.70—1.41	0.94	0.36–2.49	0.83	0.50–1.37	1.03	0.42–2.50
Moderate or severe difficulty	1.04	0.62—1.76	0.53	0.09–3.14	1.16	0.57–2.36	0.49	0.13–1.87
Foot problems	1.24	0.88—1.75	1.37	0.55–3.43	1.08	0.64–1.81	1.51	0.64–3.52
Falls								
No (in last month)	1		1		1		1	
Yes	0.86	0.64—1.16	0.61	0.29–1.25	0.88	0.57–1.34	0.89	0.43–1.85
Self-rated health								
Good	1		1		1		1	
Fair	1.08	0.76—1.53	0.77	0.39–1.55	0.99	0.59–1.66	5.34	1.47–19.38
Poor	1.36	0.81—2.27	2.03	0.53–7.77	1.10	0.51–2.36	3.10	0.69–14.02
Patient was unable to answer	1.14	0.64—2.02	0.50	0.09–2.90	1.23	0.52–2.90	2.75	0.58–13.09
Unstable conditions	1.12	0.68—1.82	1.50	0.95–2.38	1.50	0.95–2.38	1.50	0.51–4.39
Acute episode or flare-up	1.15	0.84—1.57	1.39	0.66–2.91	1.07	0.66–1.73	0,86	0.39–1.95
Duration of hospital stay								
1—30 days	1		1		1		1	
>30 days	1.12	0.75—1.67	0.19	0.04–1.04	1.65	0.92–2.96	1.29	0.53–3.11

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