JOURNAL OF NURSING SCHOLARSHIP

Care Complexity Individual Factors Associated With Hospital Readmission: A Retrospective Cohort Study

Jordi Adamuz, PhD, MSN, RN[1], Maribel González-Samartino, PhD, MSN, RN[2], Emilio Jiménez-Martínez, RN[3], Marta Tapia-Pérez, RN[4], María-Magdalena López-Jiménez, RN[5], María-José Ruiz-Martínez, RN[6], Hugo Rodríguez-Fernández, RN[7], Pilar Delgado-Hito, PhD, MSN, RN[8], & Maria-Eulàlia Juvé-Udina, PhD, MSN, RN[9]

1 Research nurse, Information Systems Department Support, Hospital Universitari de Bellvitge, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat and Associate Professor, University of Barcelona Medicine and Health Science School, Department of Nursing, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain
2 Nurse supervisor, Information Systems Department Support, Hospital Universitari de Bellvitge, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat and Associate professor, University of Barcelona Medicine and Health Science School, Department of Nursing, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain
3 Advanced Practice Nurse, Infectious Disease Department, Hospital Universitari de Bellvitge, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain
4 Advanced Practice Nurse, Information Systems Department Support, Hospital Universitari de Bellvitge, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain
5 Advanced Practice Nurse, Information Systems Department Support, Hospital Universitari de Bellvitge, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain
6 Advanced Practice Nurse, Information Systems Department Support, Hospital Universitari de Bellvitge, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain
7 Nurse, Information Systems Department Support, Hospital Universitari de Bellvitge, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain
8 Nurse Director, University of Barcelona Medicine and Health Science School, Department of Nursing, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain
9 Associate Professor, University of Barcelona Medicine and Health Science School, Department of Nursing, Institut d'Investigació Biomèdica de Bellvitge (IDIBELL), L'Hospitalet de Llobregat (Barcelona), Spain

Key words
Care complexity, hospital readmission, patient discharge, risk factors

Correspondence
Dr. Jordi Adamuz, Information Systems Department Support, Hospital Universitari de Bellvitge - IDIBELL. Feixa Llarga s/n, 08907, L'Hospitalet de Llobregat (Barcelona), Spain.
E-mail: jadamuz@bellvitgehospital.cat

Accepted February 15, 2018

doi: 10.1111/jnu.12393

Abstract

Purpose: To determine the frequency of care complexity individual factors documented in the nursing assessment and to identify the risk factors associated with hospital readmission within 30 days of hospital discharge.
Design: Observational analysis of a retrospective cohort at a 700-bed university hospital in Barcelona, Spain. A total of 16,925 adult patient admissions to a ward or intermediate care units were evaluated from January to December 2016. Most patients were admitted due to cardiocirculatory and respiratory disorders (29.3%), musculoskeletal and nervous system disorders (21.8%), digestive and hepatobiliary conditions (17.9%), and kidney or urinary disorders (11.2%).
Methods: Readmission was defined as rehospitalization for any reason within 30 days of discharge. Patients who required hospital readmission were compared with those who did not. The individual factors of care complexity included five domains (developmental, mental-cognitive, psycho-emotional, sociocultural, and comorbidity or complications) and were reviewed using the electronic nursing assessment records. Multivariate logistic analysis was performed to determine factors associated with readmission.
Findings: A total of 1,052 patients (6.4%) were readmitted within 30 days of hospital discharge. Care complexity individual factors from the comorbidity or complications domain were found to be the most frequently e-charted (88.3%). Care complexity individual factors from developmental (33.2%), psycho-emotional (13.2%), mental-cognitive (7.2%), and sociocultural

(0.7%) domains were less frequently documented. Independent factors associated with hospital readmission were old age (≥75 years), duration of first hospitalization, admission to a nonsurgical ward, major chronic disease, hemodynamic instability, immunosuppression, and relative weight of diagnosis-related group.

Conclusions: A substantial number of patients required readmission within 30 days after discharge. The most frequent care complexity individual factors recorded in the nursing assessment at index admission were related to comorbidity or complications, developmental, and psycho-emotional domains. Strategies related to transition of care that include clinical characteristics and comorbidity or complications factors should be a priority at hospital discharge and after leaving hospital, but other factors related to developmental and psycho-emotional domains could have an important effect on the use of healthcare resources.

Clinical Relevance: Nurses should identify patients with comorbidity or complications, developmental, and psycho-emotional complexity factors during the index admission in order to be able to implement an effective discharge process of care.

Hospital readmission is considered one of the more undesirable postdischarge events by patients, providers, and health systems, both due to its impact on the costs of care and the disruption it causes to the lives of patients and families (Feigenbaum et al., 2012; Kim & Flanders, 2013). Recent studies found that almost one in five patients were rehospitalized within 30 days of the index discharge (Jencks, Williams, & Coleman, 2009; Medicare Payment Advisory Commission, 2007).

Although many readmissions are unanticipated, recent studies that evaluated the preventability of hospital readmissions found that rates ranged widely, from 5% to 79%, with a median of 27% being considered avoidable (van Galen et al., 2017; van Walraven, Bennett, Jennings, Austin, & Forster, 2011). Therefore, identifying the risk factors associated with readmissions may help to predict subsequent admission and to prepare the transition of care. Several risk factors associated with hospital readmission have been identified, such as age, male sex, multiple chronic conditions, previous hospital admission, length of index hospitalization, functional disability, and biomarkers (Kirby, Dennis, Jayasinghe, & Harris, 2010; Rasmussen, Ravn, Molsted, Tarnow, & Rosthøj, 2017). Other potential nonmedical risk factors that play a role in early hospital readmission include living alone, educational level, socioeconomic status, and staying in a nursing home in the past 6 months (Iloabuchi, Mi, Tu, & Counsell, 2014; Ohta, Mola, Rosenfeld, & Ford, 2016). Although much effort has been made to identify individual factors associated with readmission, studies examining hospital readmissions have only explored administrative data related to clinical status, clinical care, and patient characteristics, most often in the context of single conditions such as pneumonia, congestive heart failure, or chronic obstructive pulmonary disease (Adamuz et al., 2011; Feigenbaum et al., 2012).

Limited research has addressed the broader health, functional, and psychosocial problems that may contribute to hospital readmission (Iloabuchi et al., 2014). Other studies concluded that factors related to care during the index stay, the discharge process, and follow-up care could potentially prevent readmission (Feigenbaum et al., 2012). Consequently, assessing the complexity of care during admission would help providers address specific barriers during hospitalization and prepare the patient and family members for hospital discharge. The study of care complexity revealed that there are many meanings attributed to this term and that it is frequently used as a synonym for care intensity or nursing workload (Guarinoni, Motta, Petrucci, & Lancia, 2014). Complex patients, often burdened by multiple chronic conditions and psychosocial issues, have more frequent interactions with healthcare systems and are at higher risk for poor health outcomes and avoidable acute utilization (Hong et al., 2015). Patients can be complex not only due to multiple co-occurring medical conditions, but also due to their socioeconomic, cultural, behavioral, and environmental circumstances, although the latter sources of complexity have not received much attention. In this context, the Vector Model of Complexity defines the determinants of complexity along axes representing major determinants of health (Safford, Allison, & Kiefe, 2015). Juvé-Udina et al. (2010) also identified care complexity individual factors among inpatients categorized

into five domains: developmental, mental-cognitive, psycho-emotional, sociocultural, and comorbidity or complications. In their study on the five complexity axes described in Safford's Vector Model of Complexity, four were coincident with care complexity individual factors (Juvé-Udina et al., 2010). Other researchers evaluated this model using a predictive tool for emergency department visits, hospital utilization, and 30-day readmission rates and concluded that more work will be needed to reliably identify at-risk patients based on psychosocial, biological, and environmental circumstances (Safford, 2015).

A variety of factors may be associated with readmission and may help identify patients who are at high risk for readmission, but prior studies did not incorporate the broader health, functional, and psychosocial problems that are registered in nursing records. This study of a large retrospective cohort of hospitalized adult patients aimed to determine the frequency of care complexity individual factors recorded in the nursing assessment and to identify the risk factors associated with hospital readmission within 30 days of discharge.

Methods

Setting and Study Design

A retrospective cohort study was carried out in a 700-bed university hospital for adults in Barcelona, Spain. The hospital serves an area of 1,100,000 inhabitants and admits approximately 24,000 patients per year. All patients >17 years of age with a completed nursing assessment form who were admitted to a ward or intermediate care unit from January 1, 2016, to December 31, 2016, were recruited retrospectively and followed up. Patients who died during index hospitalization were not included. Patients admitted to outpatient surgical wards, major ambulatory surgery units, and psychiatric wards were also excluded because these settings use a different nursing assessment tool. We counted no more than one readmission for each discharge.

For this study, patients were classified into the following two groups: those who required hospital readmission for any reason within 30 days of hospital discharge and those who did not.

This study was evaluated and approved by the research ethics committee of the Hospital Universitari de Bellvitge (reference 267/16). Ethical standards related to anonymity and data confidentiality (access to records, data encryption, and archiving of information) were complied with throughout the entire research process.

Data Collection

Data regarding the demographic characteristics, age, gender, unit of admission, length of hospital stay, major diagnostic categories, comorbidities, relative weight of the diagnosis-related group (DRG), circumstances of discharge (home, transfer to another center, voluntary discharge, death), and hospital readmission for any reason within 30 days of hospital discharge were collected from the administrative data systems basic minimum data set (BMDS) collected at hospital discharge by the Catalan Health Service (Institut Català de la Salut).

All procedures and diagnoses were coded using the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM, 4th ed.). For every main diagnosis, major diagnostic categories were assigned. These major diagnostic categories are 25 mutually exclusive categories into which all possible principal diagnoses fall. The comorbidities were identified using ICD-9-CM codes in any primary or secondary diagnosis field (Ministerio de Sanidad, Servicios Sociales e Igualdad, 2015; Zapatero et al., 2012). In addition, the DRG included estimators of resource consumption and costs, known as relative weights. The DRG system attributes a relative weight to each DRG based on its cost, with the value of 1 representing the mean global cost. In Spain, these weights and costs are derived from information on hospital care costs obtained by the hospital accounting systems (Ministerio de Sanidad, Servicios Sociales e Igualdad, 2015; Montes-Santiago et al., 2013).

Adult inpatient units were defined as nursing wards caring for patients over 18 years old. Medical wards were defined as those admitting patients for health conditions that required medical diagnostic or therapeutic interventions and patients requiring short-term continuity of care at home. Surgical wards were defined as those admitting patients for health conditions that required any surgical procedure, including all surgical specialties and organ transplants.

Care complexity individual factors are a set of characteristics related to different health axes that have the potential to cause an increase in difficulty in the process of care delivery and a boost in healthcare utilization (Juvé-Udina et al., 2010). Care complexity individual factors can be divided into five domains: (a) developmental, (b) mental-cognitive, (c) psycho-emotional, (d) sociocultural, and (e) comorbidity or complications. Each is structured into factors and specifications. The specifications of care complexity individual factors were related to nursing assessment elements based on the Architecture, Terminology, Interface, Knowledge (ATIC terminology; Juvé-Udina, 2012) and organized at the macro level onto the Virginia Henderson model of care

needs, as recorded in the electronic charts. The electronic health record (EHR) system runs the software Gacela Care® (Oesía, Madrid, Spain) integrated into the platform SAP® (Systems, Applications & Products, Waldorff, Germany). All data were collected from a review of the patients' EHRs.

The developmental domain contained four factors: (a) cultural shock (spiritual distress); (b) lack of caregiver support; (c) old age (≥75 years old); and (d) adolescence (13–19 years old). The mental-cognitive domain included four factors: (a) agitation; (b) consciousness disorders (confusion, disorientation); (c) impaired cognitive functions (intellectual disability, amnesia); and (d) perception of reality disorders (delirium, hallucinations). The psycho-emotional domain included four factors: (a) aggressive behavior, (b) fear, (c) anxiety, and (d) impaired adaptation (disruptive behavior, hopelessness, or surrender). The sociocultural domain included two factors: (a) language barriers and (b) social exclusion (extreme poverty). Finally, the comorbidity or complications domain contained 15 factors: (a) major chronic disease; (b) hemodynamic instability (intensive control of vital signs or state of shock); (c) high risk for hemorrhage (coagulation disorders, thrombocytopenia); (d) communication disorders (aphasia, dysphasia, laryngectomy); (e) mixed incontinence; (f) vascular fragility (capillary fragility); (g) functional impotence; (h) dyskinesia (involuntary muscle movements); (i) extreme weight (low weight, obesity); (j) dehydration (skin turgor); (k) edema; (l) uncontrolled pain (verbal numerical rating scale greater than three points); (m) transmissible infections (isolation measures); (n) immunosuppression; and (o) anatomical and functional disorders (amputation, deformities, joint stiffness).

Data Analyses

Retrieved data were entered on an Excel spreadsheet (Microsoft Excel, Redmond, VA, USA) and reviewed to identify potential processing errors and to control for inconsistencies. Statistical analysis was performed using the SPSS software package version 18.0 (SPSS, Chicago, IL, USA).

Depending on the properties of the data, percentage frequencies, median, and interquartile range were calculated for description. Significant differences between groups were detected using the chi-square test for categorical variables. For continuous variables we used Student's *t* test or the Mann-Whitney *U* test, depending on the results of the Kolmogorov-Smirnov normality test. The logistic regression model of factors potentially associated with rehospitalization within 30 days of hospital discharge included all the significant variables in the univariate analysis ($p < .05$; if there was a plausible relationship with the dependent outcome variable, in order to avoid spurious associations), as well as all clinically important variables. All potential explanatory variables included in the multivariate analyses were subjected to a correlation matrix for analysis of collinearity. We restricted the number of variables included in the multivariable model following the rule that there should be at least five to nine events per variable (Vittinghoff & McCulloch, 2007). The goodness-of-fit of the logistic model was evaluated using the Hosmer-Lomeshow test. The results of the multivariate analyses were reported as odds ratios and 95% confidence intervals. The individual risk in cases with more than one risk factor was assessed by means of chi-squared analysis for linear trends. Probability values of less than .05 were considered statistically significant. All reported *p* values are two-tailed.

Results

During the study period, 16,925 adult patients were admitted to surgical or medical wards. Four hundred forty-three patients died during the index hospitalization. Of the 16,482 patients discharged from the hospital, 1,052 (6.4%) were readmitted within 30 days of hospital discharge. Most were admitted due to cardiocirculatory and respiratory disorders (29.3%), musculoskeletal and nervous system disorders (21.8%), digestive and hepatobiliary conditions (17.9%), and kidney or urinary disorders (11.2%).

Patient Characteristics

The demographic features and the main clinical characteristics at the index hospital admission of patients who were readmitted within 30 days of hospital discharge and those who were not readmitted are compared in **Table 1**. The frequency of patients who required admission to the intensive care unit during the index admission and continuity of care in another center after discharge was similar between groups. However, patients who were readmitted were more often male, older (≥75 years), and admitted to a medical ward. Regarding comorbidities, patients who required hospital readmission within 30 days of hospital discharge more often had an underlying disease (mainly chronic respiratory disease, chronic heart disease, liver disease, renal disease, cancer, or immunosuppression). Similarly, they had a longer hospital stay and higher relative weight of the DRG at the index admission.

The major diagnostic category during the index admission for patients who required rehospitalization within 30 days of hospital discharge tended to involve the respiratory system, hepatobiliary system and pancreas,

Table 1. Main Clinical Characteristics of Adult Patients According to Hospital Readmission Within 30 Days of Discharge

	Hospital readmission ($n = 1,052$)		Nonreadmission ($n = 15,430$)		
Characteristic	*n*	% or IQR	*n*	% or IQR	*p* value
Demographic characteristics					
Median years of age	70	58–79	68	55–77	<.001
Age ≥75 years	390	37.1	4,769	30.9	<.001
Male sex	652	62	9,056	58.7	.038
Continuity of care (other centre)	93	8.8	1,509	9.8	.333
Medical ward	575	54.7	7,869	51	.022
ICU admission	77	7.3	1,004	6.5	.303
Underlying disease	630	59.9	6,903	44.7	<.001
Chronic respiratory disease	134	12.7	1,392	9	<.001
Chronic heart disease	158	15	1,813	11.7	.002
Chronic liver disease	82	7.8	792	5.1	<.001
Chronic renal disease	197	18.7	1,963	12.7	<.001
Neurodegenerative disease	15	1.4	146	0.9	.141
Cancer	229	21.8	2,597	16.8	<.001
Immunosuppression	20	1.9	176	1.1	.038
Duration (median days) of first hospitalization	8	4–14	7	4–12	<.001
Relative median weight of diagnosis-related group	1.1	0.8–2	1.09	0.7–1.8	.005
Major diagnostic category					
01-Diseases & Disorders of the Nervous System	94	8.9	1,776	11.5	.011
02-Diseases & Disorders of the Eye	1	0.1	96	0.6	.021
03-Diseases & Disorders of the Ear, Nose, Mouth & Throat	33	3.1	494	3.2	.990
04-Diseases & Disorders of the Respiratory System	130	12.4	1,594	10.3	.04
05-Diseases & Disorders of the Circulatory System	191	18.2	2,912	18.9	.594
06-Diseases & Disorders of the Digestive System	121	11.5	1,618	10.5	.300
07-Diseases & Disorders of the Hepatobiliary System & Pancreas	107	10.2	1,103	7.1	<.001
08-Diseases & Disorders of the Musculoskeletal System & Connective Tissue	52	4.9	1,663	10.8	<.001
09-Diseases & Disorders of the Skin, Subcutaneous Tissue & Breast	25	2.4	395	2.6	.829
10-Endocrine, Nutritional & Metabolic Diseases & Disorders	16	1.5	335	2.2	.189
11-Diseases & Disorders of the Kidney & Urinary Tract	176	16.7	1,675	10.9	<.001
12-Diseases & Disorders of the Male Reproductive System	17	1.6	315	2	.423
13-Diseases & Disorders of the Female Reproductive System	7	0.7	202	1.3	.085
14-Pregnancy, Childbirth & the Puerperium	0	0	7	0	1
15-Newborns & Other Neonates with Conditions Originating in Perinatal Period	0	0	0	0	—
16-Diseases & Disorders of Blood, Blood Forming Organs, Immunologic Disorders	11	1	89	0.6	.064
17-Myeloproliferative Diseases & Disorders, Poorly Differentiated Neoplasms	17	1.6	128	0.8	.015
18-Infectious & Parasitic Diseases, Systemic or Unspecified Sites	28	2.7	423	2.7	.989
19-Mental Diseases & Disorders	3	0.3	33	0.2	.499
20-Alcohol/Drug Use & Alcohol/Drug Induced Organic Mental Disorders	0	0	10	0.1	1
21-Injuries, Poisonings & Toxic Effects of Drugs	12	1.1	244	1.6	.304
22-Burns	0	0	0	0	—
23-Factors Influencing Health Status & Other Contacts with Health Services	4	0.4	200	1.3	.006
24-Multiple Significant Trauma	5	0.5	32	0.2	.084
25-Human Immunodeficiency Virus Infections	2	0.2	83	0.5	.177

Note. IQR = interquartile range; ICU = intensive care unit.

kidney and urinary tract, myeloproliferative diseases and disorders, or poorly differentiated neoplasms. In patients who did not require readmission, the major diagnostic category tended to involve the nervous system, eyes, musculoskeletal system, connective tissue diseases and disorders, or factors influencing health status or other contact with health services. There was no significant difference between groups regarding the other major diagnostic categories.

Care Complexity Individual Factors

Figure 1 shows the domains recorded in the nursing assessment data for all admissions. The main

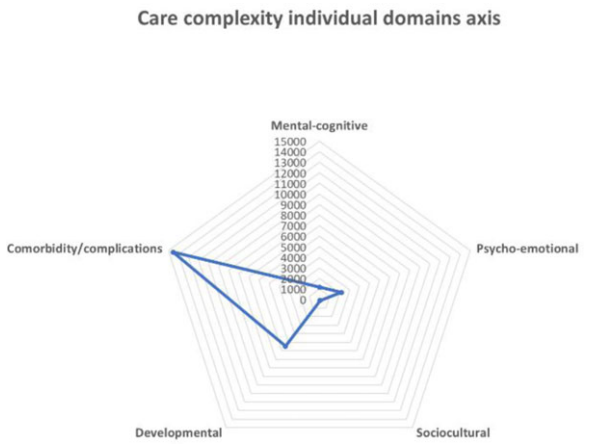

Figure 1. Care complexity individual domains of all episodes in admitted patients (axis diagram).

domains were comorbidity or complications, developmental, and psycho-emotional. Mental-cognitive and sociocultural domains were less frequently recorded. Regarding comorbidity or complications, hemodynamic instability, major chronic disease, and uncontrolled pain were the most frequent care complexity individual factors identified in the nursing assessment data. In the developmental domain, the most frequently recorded care complexity factors were old age (≤75 years) and lack of caregiver support. Fear, anxiety, and aggressive behavior were the care complexity individual factors most frequently recorded in the psycho-emotional domain. In the mental-cognitive and sociocultural domains, the most frequently recorded care complexity factors were consciousness disorders and language barriers, respectively (**Table 2**).

Among the 16,482 patients undergoing analysis in this study, 3,584 (21.7%) had one complexity factor, 8,069 (49%) had between two and three, and 3,441 (20.9%) had four or more complexity factors recorded in the nursing assessment data at the index admission.

Table 3 shows the care complexity individual factors for patients readmitted to hospital within 30 days of discharge. Patients who required readmission more often had psycho-emotional, developmental, and comorbidity or complications domains recorded in the nursing assessment data. Regarding psycho-emotional domains, impaired adaptation was more frequently registered in patients who required readmission. In the developmental domain, old age (≥75 years) was more frequently identified in patients who required rehospitalization. Finally, patients who required readmission more often had comorbidity or complications, major chronic disease, hemodynamic instability, vascular fragility, transmissible infection, or immunosuppression.

Hospitalization within 30 days of hospital discharge was more frequently identified in patients with at least one complexity factor recorded in the nursing assessment. Among the 1,052 patients readmitted within 30 days of hospital discharge, 181 (17.2%) had one, 560 (53.3%) had between two and three, and 271 (25.8%) had four or more care complexity individual factors. The frequency of rehospitalization increased with increasing number of care complexity individual factors and reached >13% with at least seven risk factors (chi-squared for trend, $p < .001$).

Risk Factors Associated With Hospital Readmission Within 30 Days of Discharge

The results of the multivariate logistic regression analysis for all factors potentially associated with readmission within 30 days of hospital discharge are summarized in **Table 4**. After adjustment for confounders, old age (≥75 years), duration of first hospitalization, admission to a nonsurgical ward, major chronic disease, and relative weight of the DRG at index admission were associated with rehospitalization. The goodness-of-fit of the model was 0.30.

A multivariate logistic regression of the care complexity individual factors associated with readmission within 30 days of hospital discharge was also performed (**Table 5**). After adjustment for confounders, old age (≥75 years), major chronic disease, hemodynamic instability, and immunosuppression were shown to be independent factors associated with hospital readmissions. The goodness-of-fit of the model was 0.42.

Discussion

In this retrospective study of a large cohort of hospitalized patients, we found that a substantial number of patients required readmission within 30 days after discharge. The main care complexity individual factors recorded in the nursing assessment at index admission were related to the comorbidity or complications, developmental, and psycho-emotional domains. The risk factors independently associated with rehospitalization were old age (≥75 years), duration of first hospitalization, admission to a nonsurgical ward, major chronic disease, hemodynamic instability, immunosuppression, and relative weight of the DRG.

In the present study, 1,052 patients (6.4%) were readmitted within 30 days after hospital admission. Our findings are consistent with previous reports that found a similar frequency of hospital readmission (Jencks et al., 2009; Kim & Flanders, 2013; Medicare Payment Advisory Commission, 2007). However, most of these studies

evaluated hospital readmission within 30 days of hospital discharge in the context of single conditions.

This is the first study evaluating the frequency of care complexity individual factors recorded in the nursing charts and including broader health, functional, and psychosocial problems to identify the risk factors associated with hospital readmission within 30 days of discharge. The major care complexity individual factors were related to the comorbidity or complications, developmental, and psycho-emotional domains. We found a high frequency of major chronic disease (46%) and old age (≥75 years; 31%) in hospitalized patients. Previous studies also identified major chronic disease and old age as the major complexity individual factors in hospitalized patients (García-Pérez et al., 2011). Of interest, other care complexity factors such as hemodynamic instability, uncontrolled pain, anatomical and functional disorders, extreme weight, mixed incontinence, and communication disorders were commonly recorded in the nursing assessment. Importantly, there are other nonmedical conditions that have not received much attention but contribute to care complexity, such as socioeconomic, cultural, behavioral, and environmental circumstances (Safford, 2015). Our study also found that a substantial number of hospitalized patients had demonstrated fear or anxiety, aggressive behavior, consciousness disorders, impaired adaptation, lack of caregiver support, and perception of reality disorders.

After adjustment for potential confounders in the multivariate analysis, we found that old age (≥75 years), major chronic disease, duration of first hospitalization, admission to a nonsurgical ward, hemodynamic instability, immunosuppression, and relative weight of the DRG were independent factors associated with hospital readmission. In this regard, the aging of the population in most countries increases the demand on social and healthcare services (García-Pérez et al., 2011). Similarly, the elderly have a higher risk for becoming frail, having more comorbidities, and receiving polypharmacy with increasing age and becoming higher risks for adverse outcomes such as hospital readmission or long-term care (Gobbens, van Assen, Luijkx, & Schols, 2012). Our findings were also consistent with previous studies showing that length of hospital stay is associated with hospital readmission (Rasmussen et al., 2017). Admission to medical wards; respiratory, hepatobiliary, kidney, and urinary system tract disorders; or myeloproliferative disorders as the major diagnostic category at index admission were also associated with hospital readmission. Patients who are hospitalized in medical wards are usually senior citizens who are suffering from chronic diseases with associated comorbidity. Therefore, these patients are frequently functionally dependent, are cognitively impaired, and take multiple forms of medication that could potentially increase the risk for readmission (Zapatero et al., 2012). Furthermore, we found that patients who were readmitted had a higher relative weight of the DRG at index admission. Previous studies have also shown that a higher DRG weight increased the risk for postoperative incidents and readmission (Paez et al., 2007).

This study also showed that hemodynamic instability and immunosuppression were independents factors associated with hospital readmission. These are care complexity individual factors related to the comorbidity or complications domain. Hemodynamic instability was defined as the intensive control of vital signs or state of shock during the index admission (Juvé-Udina et al.,

Table 2. Care complexity individual factors and domains of all episodes in admitted patients

	No=16,482	
Domain/Complexity factor	No.	(%) or IQR
Comorbidity/complications	14,549	(88.3)
Hemodynamic instability	10,732	(65.1)
Major chronic disease	7,533	(45.7)
Uncontrolled pain	5,311	(32.2)
Anatomical and functional disorders	1,556	(9.4)
Extreme weight	1,273	(7.7)
Mixed incontinence	890	(5.4)
Communication disorders	807	(4.9)
Transmissible infection	791	(4.8)
Functional impotence	479	(2.9)
High risk of hemorrhage	439	(2.7)
Edema	243	(1.5)
Vascular fragility	236	(1.4)
Immunosuppression	196	(1.2)
Dyskinesias	85	(0.5)
Dehydration	2	(0)
Developmental	5.469	(33.2)
Old age (≥75 years)	5,159	(31.3)
Lack of caregiver support	441	(2.7)
Adolescence (10–19 years)	55	(0.3)
Cultural shock	41	(0.2)
Psycho-emotional	2,173	(13.2)
Fear/anxiety	1,494	(9,1)
Impaired adaptation	895	(5.4)
Aggressive behavior	60	(0.4)
Mental-cognitive	1,182	(7.2)
Consciousness disorders	915	(5.6)
Perception of reality disorders	334	(2)
Agitation	170	(1)
Impaired cognitive functions	39	(0.2)
Sociocultural	121	(0.7)
Language barriers	106	(0.6)
Social rejection	15	(0.1)
Care individual complexity factors, median (IQR)	2	(1–3)

Note. IQR, interquartile range.

Table 3. Care Complexity Individual Factors of Adult Patients According to Hospital Readmission Within 30 Days of Discharge

	Hospital readmission ($n = 1,052$)		Nonreadmission ($n = 15,430$)		
Domain/complexity factor	*n*	% or IQR	*n*	% or IQR	*p* value
Mental-cognitive	87	8.3	1,095	7.1	.086
Agitation	12	1.1	158	1	.638
Consciousness disorders	68	6.5	847	5.5	.184
Impaired cognitive functions	4	0.4	35	0.2	.312
Perception of reality disorders	23	2.2	311	2	.663
Psycho-emotional	158	15	2,015	13.1	.038
Aggressive behavior	2	0.2	58	0.4	.591
Fear/anxiety	104	9.9	1,390	9	.346
Impaired adaptation	70	6.7	825	5.3	.041
Sociocultural	6	0.6	115	0.7	.707
Language barriers	4	0.4	102	0.7	.421
Social rejection	2	0.2	13	0.1	.248
Developmental	406	38.6	5,063	32.8	<.001
Cultural shock	2	0.2	39	0.3	1
Lack of caregiver support	31	2.9	410	2.7	.561
Old age (≥75 years)	390	37.1	4,769	30.9	<.001
Adolescence (10–19 years)	0	0	55	0.4	.049
Comorbidity/complications	975	92.7	13,574	88	<.001
Major chronic disease	630	59.9	6,903	44.7	<.001
Hemodynamic instability	726	69	10,006	64.8	.006
High-risk for haemorrhage	32	3	407	2.6	.432
Communication disorders	54	5.1	753	4.9	.718
Mixed incontinence	64	6.1	826	5.4	.324
Vascular fragility	24	2.3	212	1.4	.012
Functional impotence	29	2.8	450	2.9	.840
Dyskinesias	7	0.7	78	0.5	.499
Extreme weight	91	8.7	1,182	7.7	.256
Dehydration	0	0	2	0	1
Edema	16	1.5	227	1.5	.909
Uncontrolled pain	349	33.2	4,962	32.2	.496
Transmissible infection	62	5.9	729	4.7	.05
Immunosuppression	20	1.9	176	1.1	.026
Anatomical and functional disorders	94	8.9	1,462	9.5	.620
Median care complexity individual factors	3	2–4	2	1–3	<.001
One care complexity individual factor	181	17.2	3,403	22.1	<.001
Two or three care complexity individual factors	560	53.2	7,509	48.7	.005
Four or more care complexity individual factors	271	25.8	3,170	20.5	<.001

Note. IQR = interquartile range.

2010). Previous studies stated that measurement of vital signs is crucial for early detection of acute deterioration and patient surveillance (Stevenson, Israelsson, Nilsson, Petersson, & Bath, 2016). Therefore, patients with hemodynamic instability recorded in the nursing assessment had probably experienced adverse events during the index admission and needed a longer hospital stay. Likewise, immunosuppressed patients have a higher risk for complications such as infections. Other studies identified immunodeficiency as an independent variable associated with readmission to intensive care units (Woldhek, Rijkenberg, Bosman, & van der Voort, 2017). It is also a leading cause of hospital readmission among patients at skilled nursing facilities (Ouslander, Diaz, Hain, & Tappen, 2011).

The univariate analysis found that vascular fragility, transmissible infection, and impaired adaptation were correlated with readmission. However, these factors were not found to be independent predictors of 30-day hospital readmission after controlling for confounding factors. Vascular and skin fragility in the elderly is common and needs to be more closely monitored to prevent complications (Farage, Miller, Berardesca, & Maibach, 2009). Patients in isolation measures also have a risk for infection that can be associated with adverse events (Kim & Flanders, 2013), while impaired

Table 4. Multivariate Analysis of All Significant Factors Associated With Hospital Readmission Within 30 Days of Discharge

Factor	Odds ratio	95% Confidence interval	*p* value
Male sex	1.11	0.97–1.27	.11
Old age (≥75 years)	1.17	1.02–1.33	.02
Duration of first hospitalization (days)	1.01	1.00–1.01	.002
Medical ward	1.22	1.06–1.40	.007
ICU admission	0.88	0.66–1.17	.38
Major chronic disease	1.73	1.52–1.96	<.001
Hemodynamic instability	1.10	0.96–1.27	.17
Vascular fragility	1.34	0.87–2.07	.18
Transmissible infection	0.92	0.74–1.31	.92
Impaired adaptation	1.12	0.86–1.45	.39
Relative weight of DRG	1.05	1.00–1.09	.03

Note. ICU = intensive care unit; DRG = diagnosis-related group.

Table 5. Multivariate Analysis of Complexity Factors Associated With Hospital Readmission Within 30 Days of Discharge

Factor	Odds ratio	95% Confidence interval	*p* value
Major chronic disease	1.77	1.55–2.01	<.001
Hemodynamic instability	1.16	1.01–1.32	.04
High risk for haemorrhage	1.13	0.78–1.63	.53
Mixed incontinence	0.97	0.74–1.28	.84
Vascular fragility	1.41	0.91–2.19	.123
Functional impotence	0.86	0.58–1.27	.44
Dyskinesias	1.19	0.54–2.61	.67
Extreme weigh	1.04	0.83–1.31	.74
Transmissible infection	1.18	0.89–1.54	.24
Immunosuppression	1.67	1.04–2.67	.03
Consciousness disorders	1.07	0.80–1.42	.65
Impaired cognitive functions	1.82	0.64–5.19	.27
Perception of reality disorders	0.97	0.62–1.54	.91
Aggressive behavior	0.45	0.11–1.89	.28
Fear/anxiety	1.07	0.86–1.33	.57
Language barriers	0.63	0.23–1.71	.36
Social rejection	2.01	0.43–9.30	.37
Cultural shock	0.51	0.12–2.18	.37
Lack of caregiver support	0.94	0.63–1.40	.77
Impaired adaptation	1.18	0.89–1.56	.24
Old age (≥75 years)	1.18	1.03–1.35	.02

adaptation, dysfunctional attitudes, hopelessness, or surrender may affect the patients' recovery, generate feelings of exclusion, frustration, or loss of control, and negatively impact overall health outcomes (Finke, Light, & Kitko, 2008; Juvé-Udina et al., 2014). In this regard, future research should evaluate the impact of psychosocial factors and specific interventions on health outcomes.

In light of these findings, it should be noted that previous research has shown that patients are made complex not only by multiple co-occurring medical conditions, but also by socioeconomic, cultural, behavioral, and environmental circumstances, although the latter sources of complexity have not received similar attention (Safford et al., 2007). Determining the influence of all care complexity individual factors on health outcomes, such as hospital readmission, is necessary. Care during the index stay, discharge process, and follow-up care were identified as important factors associated with readmission (Feigenbaum et al., 2012). Thus, care complexity individual factors might be associated with an increase in healthcare utilization and a high risk for hospital readmission (Hong et al., 2015; Juvé-Udina et al., 2010). The present study highlights a number of points that should be acknowledged during transition of care. Based on these results, nurses should identify patients with comorbidity or complications, developmental, and psycho-emotional complexity factors during the index admission in order to be able to implement an effective discharge process of care. As well as specific information relating to the management of known signs or symptoms, an appropriate discharge process and outpatient follow-up care are necessary in transition of care. Other care complexity individual factors at index admission such as emotional needs, developmental factors, and complications during hospitalization may play an important role in healthcare outcomes. Discharge planning should also include an early assessment of the anticipated patient care requirements that involves the patient, his or her family, and caregivers. Overall our study found that the frequency of hospital readmission increased with increasing number of risk factors and reached >13% with at least seven risk factors. These findings may help to identify and stratify the risk for hospital readmission.

The strengths of this study are its retrospective design and the large number of patients included. In addition, comprehensive care complexity individual factors and clinical data were collected, and the research was conducted using a standardized protocol. We included other factors that are likely contributors to readmission, such as physiological instability, mental-cognitive, and sociocultural factors. However, there are some limitations that should be acknowledged. The study was conducted at a single center, and our findings should be validated by other studies. Furthermore, information about care complexity individual factors and clinical data were obtained by reviewing electronic records that used ATIC terminology and the administrative data systems BMDS of the Catalan Health Service at hospital discharge. Information about all variables included in the nursing assessment is usually collected as soon as the patient is admitted to the

nursing unit, and must be re-evaluated during hospitalization according to the patient's needs. Although there were no missing data, we relied on administrative data, which might have included coding errors. We did not consider other factors that could contribute to readmission, such as previous admission, Charlson's comorbidity index, and laboratory parameters. On the other hand, male sex was associated with hospital readmission in the univariate analysis. In this regard, male sex also was associated with more comorbidity; however, gender was not found to be an independent predictor of 30-day hospital readmission.

Conclusions

A substantial number of patients required readmission within 30 days after discharge. The main care complexity individual factors recorded in the nursing assessment at index admission were related to the comorbidity or complications, developmental, and psycho-emotional domains. The risk factors independently associated with rehospitalization were old age (≥75 years), duration of first hospitalization, admission to a nonsurgical ward, major chronic disease, hemodynamic instability, immunosuppression, and relative weight of the DRG. Strategies related to transition of care that include clinical characteristics and comorbidity or complications factors should be a priority at hospital discharge and after leaving hospital, but other factors related to developmental and psycho-emotional domains could have an important effect on the use of healthcare resources.

Clinical Resources

- International Council of Nurses. Fact sheets on nursing and health informatics. http://www.icn.ch/images/stories/documents/publications/fact_sheets/15b_FS-Nursing_Informatics.pdf
- The Joint Commission. Transitions of care. https://www.jointcommission.org/toc.aspx
- World Health Organization. Transitions of care. Technical series on safer primary care. http://apps.who.int/iris/bitstream/10665/252272/1/9789241511599-eng.pdf

Acknowledgments

This work was supported by the Departament de Salut de la Generalitat de Catalunya, Pla estratègic de recerca i innovació en salut (PERIS) 2016–2020 (SLT002/16/00085), Catalunya, Spain. Dr. Adamuz is the recipient of a research grant from the PERIS.

References

Adamuz, J., Viasus, D., Campreciós-Rodríguez, P., Cañavate-Jurado, O., Jiménez-Martínez, E., Isla, P., … Carratalà, J. (2011). A prospective cohort study of healthcare visits and rehospitalizations after discharge of patients with community-acquired pneumonia. *Respirology*, *16*(7), 1119–1126.

Farage, M. A., Miller, K. W., Berardesca, E., & Maibach, H. I. (2009). Clinical implications of aging skin: Cutaneous disorders in the elderly. *American Journal of Clinical Dermatology*, *10*(2), 73–86.

Feigenbaum, P., Neuwirth, E., Trowbridge, L., Teplitsky, S., Barnes, C. A., Fireman, E., … Bellows, J. (2012). Factors contributing to all-cause 30-day readmissions: A structured case series across 18 hospitals. *Medical Care*, *50*(7), 599–605.

Finke, E. H., Light, J., & Kitko, L. (2008). A systematic review of the effectiveness of nurse communication with patients with complex care communication needs with a focus on the use of augmentative and alternative communication. *Journal of Clinical Nursing*, *17*(16), 2102–2115.

García-Pérez, L., Linertová, R., Lorenzo-Riera, A., Vázquez-Díaz, J. R., Duque-González, B., & Sarría-Santamera, A. (2011). Risk factors for hospital readmissions in elderly patients: A systematic review. *QJM: An International Journal of Medicine*, *104*(8), 639–651.

Gobbens, R. J., van Assen, M. A., Luijkx, K. G., & Schols, J. M. (2012). The predictive validity of the Tilburg Frailty Indicator: Disability, health care utilization, and quality of life in a population at risk. *Gerontologist*, *52*(5), 619–631.

Guarinoni, M. G., Motta, P. C., Petrucci, C., & Lancia, L. (2014). Complexity of care: A concept analysis. *Annali di Igiene*, *26*(3), 226–236.

Hong, C. S., Atlas, S. J., Ashburner, J. M., Chang, Y., He, W., Ferris, T. G., & Grant, R. W. (2015). Evaluating a model to predict primary care physician–defined complexity in a large academic primary care practice–based research network. *Journal of General Internal Medicine*, *30*(12), 1741–1747.

Iloabuchi, T. C., Mi, D., Tu, W., & Counsell, S. R. (2014). Risk factors for early hospital readmission in low-income elderly adults. *Journal of the American Geriatrics Society*, *62*(3), 489–494.

Jencks, S. F., Williams, M. V., & Coleman, E. A. (2009). Re-hospitalizations among patients in the Medicare fee-for-service program. *New England Journal of Medicine*, *360*(14), 1418–1428.

Juvé-Udina, M. E. (2012). A nursing interface terminology. Evaluation of face validity. *Open Journal of Nursing*, *2*(3), 196–203.

Juvé-Udina, M. E., Matud, C., Farrero, S., Jiménez, H., Rodríguez, E., Martínez, M., … Mesalles-Morredes, M. (2010). Intensity of nursing care: Workloads or individual complexity? *Metas de Enfermería*, *13*(8), 6–14.

Juvé-Udina, M. E., Pérez, E. Z., Padrés, N. F., Samartino, M. G., García, M. R., Creus, M. C., … Calvo, C. M. (2014). Basic nursing care: Retrospective evaluation of communication and psychosocial interventions documented by nurses in the acute care setting. *Journal of Nursing Scholarship*, *46*(1), 65–72.

Kim, C. S., & Flanders, S. A. (2013). In the clinic: Transitions of care. *Annals of Internal Medicine*, *5*(158, 5 Pt. 1), ITC3-1.

Kirby, S. E., Dennis, S. M., Jayasinghe, U. W., & Harris, M. F. (2010). Patient related factors in frequent readmissions: The influence of condition, access to services and patient choice. *BMC Health Service Research*, *10*(1), 216.

Medicare Payment Advisory Commission. (2007). Payment policy for inpatient readmissions. In *June 2007 report to the Congress: Promoting greater efficiency in Medicare* (pp. 103–120). Washington, DC: Author.

Ministerio de Sanidad, Servicios Sociales e Igualdad. (2015). (*Registro de altas. ICMBD: Indicadores y ejes de análisis del CMBD. Madrid: Aplicación para el análisis y explotación del registro de altas hospitalarias*). Retrieved from http://icmbd.es/login-success.do

Montes-Santiago, J., Rodil, V., Formiga, F., Cepeda, J.M., Urrutia, A., & Working Group on Heart Failure and Atrial Fibrillation of the Spanish Society of Internal Medicine. (2013). Features and costs of patients admitted for cardiac arrhythmias in Spain. *Revista Clínica Española*, *213*(5), 235–239.

Ohta, B., Mola, A., Rosenfeld, P., & Ford, S. (2016). Early discharge planning and improved care transitions: Pre-admission assessment for readmission risk in an elective orthopedic and cardiovascular surgical population. *International Journal of Integrated Care*, *16*(2), 1–10.

Ouslander, J. G., Diaz, S., Hain, D., & Tappen, R. (2011). Frequency and diagnoses associated with 7- and 30-day readmission of skilled nursing facility patients to a nonteaching community hospital. *Journal of the American Medical Directors Association*, *12*(3), 195–203.

Paez, A., Redondo, E., Linares, A., Rios, E., Vallejo, J., & Sanchez-Castilla, M. (2007). Adverse events and readmissions after day-case urological surgery. *International Brazilian Journal of Urology*, *33*(3), 330–338.

Rasmussen, M. G., Ravn, P., Molsted, S., Tarnow, L., & Rosthøj, S. (2017). Readmission to hospital of medical patients—A cohort study. *European Journal of Internal Medicine*, *46*, 19–24.

Safford, M. M. (2015). The complexity of complex patients. *Journal of General Internal Medicine*, *30*(12), 1724–1725.

Safford, M. M., Allison, J. J., & Kiefe, C. I. (2007). Patient complexity: More than comorbidity. The vector model of complexity. *Journal of General Internal Medicine*, *22*(3), 382–390.

Stevenson, J. E., Israelsson, J., Nilsson, G. C., Petersson, G. I., & Bath, P. A. (2016). Recording signs of deterioration in acute patients: The documentation of vital signs within electronic health records in patients who suffered in-hospital cardiac arrest. *Health Informatics Journal*, *22*(1), 21–33.

van Galen, L. S., Brabrand, M., Cooksley, T., van de Ven, P. M., Merten, H., So, R. K., … Safer@home consortium. (2017). Patients' and providers' perceptions of the preventability of hospital readmission: A prospective, observational study in four European countries. *BMJ Quality & Safety*, *26*, 958–969. https://www.org.10.1136/bmjqs-2017-006645

van Walraven, C., Bennett, C., Jennings, A., Austin, P. C., & Forster, A. J. (2011). Proportion of hospital readmissions deemed avoidable: A systematic review. *Canadian Medical Association Journal*, *183*(7), E391–E402.

Vittinghoff, E., & McCulloch, C. E. (2007). Relaxing the rule of ten events per variable in logistic and Cox regression. *American Journal of Epidemiology*, *165*(6), 710–718.

Woldhek, A. L., Rijkenberg, S., Bosman, R. J., & van der Voort, P. H. (2017). Readmission of ICU patients: A quality indicator? *Journal of Critical Care*, *38*, 328–334.

Zapatero, A., Barba, R., Marco, J., Hinojosa, J., Plaza, S., Losa, J. E., & Canora, J. (2012). Predictive model of readmission to internal medicine wards. *European Journal of Internal Medicine*, *23*(5), 451–456.