Predictors of Rehospitalization Among Elderly Patients Admitted to a Rehabilitation Hospital: The Role of Polypharmacy, Functional Status, and Length of Stay

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**A B S T R A C T**

*Objective:* Rehospitalizations for elderly patients are an increasing health care burden. Nonetheless, we have limited information on unplanned rehospitalizations and the related risk factors in elderly patients admitted to in-hospital rehabilitation facilities after an acute hospitalization.

*Setting:* In-hospital rehabilitation and aged care unit.

*Design:* Retrospective cohort study.

*Participants:* Elderly patients 65 years or older admitted to an in-hospital rehabilitation hospital after an acute hospitalization between January 2004 and June 2011.

*Measurements:* The rate of 30-day unplanned rehospitalization to hospitals was recorded. Risk factors for unplanned rehospitalization were evaluated at rehabilitation admission: age, comorbidity, serum albumin, number of drugs, decline in functional status, delirium, Mini Mental State Examination score, and length of stay in the acute hospital. A multivariable Cox proportional regression model was used to identify the effect of these risk factors for time to event within the 30-day follow-up.

*Results:* Among 2735 patients, with a median age of 80 years (interquartile range 74–85), 98 (4%) were rehospitalized within 30 days. Independent predictors of 30-day unplanned rehospitalization were the use of 7 or more drugs (hazard ratio [HR], 3.94; 95% confidence interval, 1.62–9.54; *P* = .002) and a significant decline in functional status (56 points or more at the Barthel Index) compared with the month before hospital admission (HR 2.67, 95% CI: 1.35–5.27; *P* = .005). Additionally, a length of stay in the acute hospital of 13 days or more carried a twofold higher risk of rehospitalization (HR 2.67, 95% CI: 1.39–5.10; *P* = .003).

*Conclusions:* The rate of unplanned rehospitalization was low in this study. Polypharmacy, a significant worsening of functional status compared with the month before acute hospital admission, and hospital length of stay are important risk factors.

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Among high-income countries, older people (age 65 and older) make up a large (15%-20%) proportion of the population and many require hospitalization for aging-related diseases. In the United States, almost one-fifth (24.8%) of the government-sponsored Medicare beneficiaries discharged from a hospital were hospitalized again within 30 days of their index admission. Rehospitalizations for elderly patients account for about $15 billion of Medicare expenses and an estimated £1.6 billion each year in the United Kingdom. A substantial number of older patients leaving the hospital receive postacute care (PAC) services in either skilled nursing facilities (SNF) (38% of those who receive services after a hospitalization in the United States) or in a hospital rehabilitation setting (9% of all patients in the United States who receive services after a hospitalization). The rate of 30-day repeat hospitalizations range from 23.5% in skilled nursing and 20% in the inpatient rehabilitation settings (P. Gozalo and V Mor, Rates of 30-day rehospitalization by PAC setting, unpublished data). Despite these high rates of hospital readmission, there are limited data about the risk factors for readmission from either setting.

One study reported an 18% hospital readmission rate for a heterogeneous group of patients discharged to a SNF in the United States and also identified patients with congestive heart failure, urinary tract infection, renal failure, and respiratory diseases at the highest risk for readmission. A second study found that a history of a malignant solid tumor, a recent hospitalization involving gastrointestinal diseases, and a low serum albumin level were associated with an increased risk for 30-day unplanned rehospitalization from an SNF.

There are no data reported on risk factors for readmission in patients who receive PAC services in hospital rehabilitation settings. To fill this research gap, we examined a cohort of elderly Italian patients admitted to an in-hospital rehabilitation setting after an acute hospitalization, given that in Italy about 58% of beds for PAC services after a hospitalization are in rehabilitation hospital settings. Our primary aim was to describe the rate of unplanned rehospitalization occurring within 30 days and to identify clinical risk factors for rehospitalization, considering the importance of controlling the phenomenon to avoid the stress to elderly frail patients induced by repeated hospital readmissions.

Methods

We performed a retrospective cohort study of patients older than 65 years and consecutively admitted to an in-hospital rehabilitation setting following an acute care hospitalization. The in-patient rehabilitation setting was the ‘Ancelle della Carità’ Hospital (Cremona, Italy). Patients were admitted to the Department of Rehabilitation and Aged Care (DRAC), a 90-bed unit staffed by full-time geriatricians, physiatrists, nurses, nurse aids, and physical, speech, and occupational therapists. An on-site physician provided 24-hour medical coverage. We excluded patients who were admitted from non–acute care settings, patients younger than 65 years, and those who died during the rehabilitation stay. The DRAC admits patients after an acute hospitalization for surgical procedures (hip fracture surgical repair; hip or knee arthroplasty; abdominal, cardiac, vascular, or thoracic surgery), stroke (recent or chronic), acute heart failure, chronic obstructive pulmonary diseases, Parkinson disease, or gait and balance disorders. Patients are considered eligible for the DRAC admission if they are capable of performing a standard rehabilitative program including 2 daily sessions per patient (40 minutes in the morning and 40 minutes in the afternoon) from Monday to Friday and a single session (40 minutes in the morning) on Saturday. Specific training is then required according to the admission diagnosis. The Ethics Committee of Gerontological Sciences of the Geriatric Research Group, Italy, approved the study protocol and the waiver of informed consent.

Data Sources

All data were collected through existing administrative databases.

Risk Factors for 30-Day Unplanned Rehospitalization to Hospital After Admission to DRAC

Risk factors for unplanned rehospitalization were determined a priori according to previous research in acute hospital settings, clinical importance, and availability/completeness in the administrative databases. In addition, we focused on factors readily available at the time of admission to rehabilitation so as to provide clinicians with variables useful to identify patients at higher risk of hospitalization.

Demographic factors included age. Comorbidity was defined according to the Cumulative Illness rating score (CIRS). CIRS is a comorbidity index, assessing chronic medical illness burden while taking into account the severity of chronic diseases; the score for each of the 14 conditions can range from 1 (absence of pathology) to 5 (maximum level of severity of the disease). The CIRS severity index is the average score of the first 13 items, whereas the Comorbidity Index total score represents the number of the 14 items with a score of 3 or higher. Admission diagnoses to the in-hospital rehabilitation setting were recorded. Additionally, we recorded the diagnoses related to the re-admission in acute hospital and we categorized them by reviewing each patient's medical record. A surrogate measure of nutritional status was measured with albumin levels at the time of DRAC admission. Functional status was assessed with the Barthel Index (BI) through patient and surrogate interview referring to the month before the acute hospital admission, at rehabilitation admission, and discharge. We examined the change in BI (delta-BI), defined as the BI before acute hospital admission minus the BI at rehabilitation admission; cognitive assessments at DRAC admission included the presence of delirium evaluated by expert geriatricians with the Confusion Assessment Method (CAM) and global cognitive performance with Mini Mental State Examination (MMSE). As per the CAM algorithm, delirium was considered as present if there was an acute onset or fluctuating course, inattention, and either disorganized thinking or altered level of consciousness. Medication burden was measured by the total number of drugs at DRAC admission. Finally, health care use was measured using length of stay (LOS) at the acute hospital measured in days.

Outcome Definition

Rehospitalization was defined as every unplanned readmission to the hospital occurring within 30 days after admission to the DRAC. If a patient was rehospitalized more than once, each episode was counted as a separate hospitalization.

Statistical Analysis

Demographics and clinical variables were summarized using median and interquartile range (IQR) for continuous variables or proportions for categorical variables. For descriptive purposes, the admission diagnoses to the in-hospital rehabilitation and the readmission diagnoses were reported. A multivariable Cox proportional regression model was used to identify the effect of the previously mentioned risk factors on the time to unplanned rehospitalization within the 30-day follow-up. Patient data were censored at time to hospital readmission. All the risk factors were first entered in the model as continuous variables, except for delirium at DRAC admission. The variables found to be statistically associated with a higher risk of hospital readmission (P < .05) were then categorized in tertiles, according to their distribution, to provide clinicians with actionable
thresholds that could be applied in daily practice. Because there is no formal definition of polypharmacy, we chose the tertiles cutoff for the number of medications, which produced results similar to a previous publication. A test for trend showed an increased risk of hospitalization across 3 different risk factors: total number of drugs, the delta-BI, and the LOS in the acute hospital. A test for proportional hazard assumption was also performed ($P = .0000$), the delta-BI ($P = .002$), and the LOS in the acute hospital ($P = .0000$). A test for proportional hazard assumption was also performed ($\chi^2 = 6.92$, df 12; $P = .8625$), which showed that there was no evidence to contradict the proportionality of hazard assumption. Kaplan-Meier analyses and log-rank test were also used to assess the effect of these risk factors on time to hospital re-admission. All statistical analyses were performed using STATA version 11 (http://www.stata.com/stata11/) (Stata Corp, College Station, TX).

Results

Between January 2004 and June 2011, a total of 6383 patients were admitted to the DRAC. Of these, 3648 were excluded: 896 were transferred from other rehabilitation settings, 2144 were admitted from home or SNFs, 512 were younger than 65 years, and 96 died during the DRAC stay. The remaining cohorts of 2735 patients are described in Table 1. The cohort had a median age of 80 years and most (71%) were women. The main overall admission diagnoses to the DRAC were orthopedic (44%), followed by neurologic (16%), respiratory (17%), and cardiologic (10%). The rate of 30-day unplanned rehospitalization was 4% (n = 98). In Figure 1 are shown the main causes of readmission to the acute hospital wards. About half of the patients who were admitted to the DRAC with a musculoskeletal (46%), cardiovascular (64%), or respiratory (46%) diagnosis were readmitted with the same diagnosis (online Appendix 1).

Table 1

<table>
<thead>
<tr>
<th>Variable*</th>
<th>n = 2735</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>80 (74–85)</td>
</tr>
<tr>
<td>Female, n (%)</td>
<td>1.975 (71)</td>
</tr>
<tr>
<td>Barthel Index prehospital admission*</td>
<td>94 (78–100)</td>
</tr>
<tr>
<td>Barthel Index at rehabilitation admission</td>
<td>44 (26–62)</td>
</tr>
<tr>
<td>Barthel Index at rehabilitation discharge</td>
<td>82 (57–94)</td>
</tr>
<tr>
<td>Delta Barthel Index*</td>
<td>40 (24–56)</td>
</tr>
<tr>
<td>Cumulative illness rating score severity index*</td>
<td>1.62 (1.46–1.84)</td>
</tr>
<tr>
<td>No. of drugs at rehabilitation admission</td>
<td>5 (4–7)</td>
</tr>
<tr>
<td>Albumin at rehabilitation admission, mg/dL</td>
<td>3.1 (2.8–3.3)</td>
</tr>
<tr>
<td>Delirium at rehabilitation admission, n (%)</td>
<td>500 (18)</td>
</tr>
<tr>
<td>Mini Mental State Examination at rehabilitation admission</td>
<td>23 (17–27)</td>
</tr>
</tbody>
</table>

Admission diagnoses to the in-hospital rehabilitation setting, n (%)

| Orthopedic | 1204 (44) |
| Neurologic | 422 (16) |
| Respiratory | 457 (17) |
| Cardiologic | 281 (10) |
| Gait disturbances | 255 (9) |
| Other | 116 (4) |
| Length of stay acute hospital | 8 (6–13) |
| Length of stay rehabilitation setting | 24 (20–34) |
| Rehospitalization within 30 days, n (%) | 98 (4) |

*Median and interquartile range, unless otherwise noted.

1Barthel Index a month before the index admission to the acute hospital evaluated through surrogate interview.

2Delta Barthel Index was calculated as the difference of Barthel Index prehospital admission (ie, Barthel index a month before the index acute hospital admission) and the Barthel Index at rehabilitation admission.

3Cumulative illness rating score (CIRS) is a screening tool for comorbidity, assessing the chronic medical illness burden while taking into account the severity of chronic diseases; the score for each of the 14 items can range from 1 (absence of pathology) to 5 (maximum level of severity of the disease). The CIRS severity index is the result of the average score of the first 13 items.

In the multivariable Cox regression models, 3 clinical variables were independent predictors of time to unplanned readmission: the total number of drugs, the delta-BI, and the LOS in the acute hospital (Table 2). For these variables, there was an increasing risk as the dose of exposure increased. Patients taking 7 or more drugs on admission to the DRAC had about a 4 times higher risk of being rehospitalized (hazard ratio [HR] 3.94; 95% confidence interval [CI] 1.62–9.54; $P = .002$), whereas those taking 4 to 6 drugs had nonsignificant risk of rehospitalization (HR 1.59; 95% CI 0.64–3.94; $P = .315$) (Figure 2A). However, the test for trend across categories was statistically significant, indicating that the greater number of medications, the greater the likelihood of readmission. Similarly, those who had the highest decline in functional status (ie, delta-BI >56) from prehospital to DRAC admissions had almost a 3 times higher risk of being rehospitalized (HR 2.67, 95% CI 1.35–5.27; $P = .005$), whereas those with a delta-BI between 25 and 56 did not have an increased risk of rehospitalization (HR 1.48, 95% CI 0.79–2.75; $P = .216$) (Figure 2B). As for the number of medications, the test for trend across BI categories was statistically significant, indicating the greater functional decline, the greater the likelihood of readmission. Finally, patients who had a LOS in the acute hospital longer than 13 days had a more than twofold higher risk of being readmitted to the hospital (HR 2.67, 95% CI 1.39–5.10; $P = .003$), whereas those with a LOS between 7 and 13 days (HR 1.74, 95% CI 0.93–3.25; $P = .080$) were not at increased risk of rehospitalization (Figure 2C). Once again, the test for trend across LOS categories was statistically significant, indicating the longer the LOS, the greater the likelihood of readmission.

Discussion

In a large cohort of elderly patients admitted to an in-hospital rehabilitation unit, we found a low rate of 4% unplanned rehospitalization. Most of the patients who were admitted to the DRAC with musculoskeletal, cardiovascular, or respiratory diagnoses were readmitted to the acute hospital with the same diagnosis. Among the small but important number of readmitted patients, we found that using 7 or more drugs, having a significant decline in functional performance (ie, delta-BI >56 points) in the 30 days before DRAC admission, and having a length of acute hospital stay longer or equal to 13 days were independent predictors of 30-day rehospitalization. These 3 risk factors are readily accessible at the bedside and offer a potentially simple method to screen for patient risk. Although the data are promising, their role in the prevention of unplanned readmission to hospital needs to be further investigated, evaluating programs to improve transitions of care across different settings.

The topic of short-term unplanned readmissions after discharge from a health care facility has received increasing attention. Indeed, most of the investigations have studied readmissions among patients leaving the hospital for home, and 3 studies reported readmissions from the SNFs. This is the first study, to the best of our knowledge, to report rehospitalization and risk factor data from in-hospital PAC rehabilitation facilities.

It is of interest that the readmission rate found in our study is comparable with 30-day readmission data for people discharged from European acute hospital and considerably lower than 30-day readmission rates reported for American patients discharged to all settings.

There are a variety of potential explanations of these findings. The first relies on the differences in the acute hospital LOS between Italy and the United States. Indeed, the average LOS in the United States is 5 days, whereas in Italy the overall median acute hospital LOS is about 8 days, similar to other European countries. Because previous studies have shown that the shorter the LOS in acute hospital wards, the greater the likelihood of being discharged with unresolved
Indeed, previous studies have shown that not only the median in-hospital rehabilitation between the United States and Italy frequently clinically unstable in the United States than in the Italian counterpart. An additional explanation relies on the difference in the LOS of in-hospital rehabilitation between the United States and Italy. Indeed, previous studies have shown that not only the median

### Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hazard Ratio</th>
<th>95% Confidence Interval</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.00</td>
<td>0.96–1.03</td>
<td>.93</td>
</tr>
<tr>
<td>CIRS severity index</td>
<td>1.46 to 1.84</td>
<td>0.98–1.89</td>
<td>.83</td>
</tr>
<tr>
<td>≥1.85</td>
<td>1.56</td>
<td>0.69–3.28</td>
<td>.30</td>
</tr>
<tr>
<td>Albumin (mg/dL)</td>
<td>0.64</td>
<td>0.38–1.05</td>
<td>.63</td>
</tr>
<tr>
<td>No. of drugs at DRAC admission</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;4 drugs</td>
<td>1.59</td>
<td>0.64–3.94</td>
<td>.31</td>
</tr>
<tr>
<td>4 to 6 drugs</td>
<td>3.94</td>
<td>1.62–9.54</td>
<td>.00</td>
</tr>
<tr>
<td>Delta Barthel Index at rehabilitation admission</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;24</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25–56</td>
<td>1.48</td>
<td>0.79–2.75</td>
<td>.21</td>
</tr>
<tr>
<td>&gt;56</td>
<td>2.67</td>
<td>1.35–5.27</td>
<td>.00</td>
</tr>
<tr>
<td>Delirium at DRAC admission</td>
<td>0.77</td>
<td>0.40–1.46</td>
<td>.42</td>
</tr>
<tr>
<td>MMSE score at DRAC admission</td>
<td>0.97</td>
<td>0.94–1.01</td>
<td>.12</td>
</tr>
<tr>
<td>Length of stay in the acute hospital</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;6 days</td>
<td>1.74</td>
<td>0.93–3.25</td>
<td>.08</td>
</tr>
<tr>
<td>7–13 days</td>
<td>2.67</td>
<td>1.39–5.10</td>
<td>.00</td>
</tr>
</tbody>
</table>

CIRS, Cumulative illness rating score; DRAC, Department of Rehabilitation and Aged Care; MMSE, Mini Mental State Examination.

*a* A multivariable Cox proportional regression model was used to identify the effect of risk factors evaluated at the time of DRAC admission on the time to unplanned readmission to the acute hospital within a 30-day follow-up. All the risk factors were first entered in the model as continuous variables, except for delirium at DRAC admission. The variables found to be statistically associated with a higher risk of hospital readmission (P < .05) were then categorized in tertiles, according to their distribution, to provide clinicians with actionable thresholds that could be applied in daily practice.

**Delta Barthel Index was calculated as the difference of Barthel Index preadmission (ie, Barthel index a month before the index acute hospital admission) and the Barthel Index at rehabilitation admission.**

LOS in the American rehabilitation wards fell from 1994 to 2001 from 20 to 12 days (exactly the half of median value in our population), but also that this trend was associated with an increased rate of hospital readmissions in the same period. Therefore, it might be hypothesized that the longer the LOS in the PAC, the lower the risk of being rehospitalized. A plausible explanation of this finding may be that with longer hospital stays, physicians have more time to manage clinical instability when it develops during the rehabilitation processes.

Third, in the United States, the in-hospital rehabilitation settings are mainly staffed with physiatrists, whereas our institution is mainly staffed with geriatricians with the support of physiatrists. Given the advanced age of our population, it might be that a geriatric multidimensional approach provides better care for a frail population with better outcomes, as proven in other settings. Indeed, it is interesting to observe that although 18% of our population had delirium on admission to our DRAC, only 2% of the patients were still delirious at the time of discharge. The prevalence of delirium at discharge is lower than previous investigations in which about 50% of elderly patients who had delirium on admission to PAC still had delirium 1 month later, indirectly suggesting a tight clinical surveillance in our setting to prevent and manage conditions possibly related to clinical instability.

Our finding that the longer the LOS in acute hospital, the greater risk of hospital readmissions might find an explanation in the concept of “posthospital syndrome.” Patients with a longer LOS are more likely to develop new active medical issues and physical disabilities, suggesting an underlying condition of frailty. These patients should receive a strict clinical surveillance to avoid further complications. In line with this assumption, it has been shown by Dharmarajan et al that the 30-day readmission diagnoses in frail elderly patients is often attributable to causes involving multiple physiological systems and not only to the conditions related to the initial acute hospitalization. Therefore, as suggested by Ouslander et al, patients who are admitted to a rehabilitation setting should be monitored not only for the primary hospital diagnosis, but also for other active medical problems that may lead to rehospitalizations. It is important to underline that our readmission rate was low and that the readmission diagnoses were, in about half of the cases, the same as the hospital admission diagnoses. These data indirectly suggest that the multidimensional geriatric approach in our institution led to an effective clinical management of the frail patients.
The avoidance of hospital readmission and the management of the "posthospital syndrome" in the rehabilitation setting is not only an important marker of the quality of care but it should be on the top of the list of clinicians’ priorities to avoid further stress to the patients and their families.

In addition to the increased LOS, we found polypharmacy and decline in functional status as risk factors for rehospitalization. These findings support previous research from acute hospital settings. Polypharmacy and inappropriate medication prescription are frequent issues in elderly patients and they intensify with increasing age and acute hospitalization. Between 50% and 85% of elderly patients are discharged with potentially or actually inappropriate medications after an acute hospital stay. Inappropriate medication prescription is associated with greater risk of adverse events, such as confusion and falls, as well as increased health care costs, hospitalization, cognitive impairment, and mortality. The association between polypharmacy and rehospitalization might be the expression of the interaction of several drugs and their related adverse reaction, although we are unable to support this hypothesis with the data included in our investigation. Additionally, certain offending medications might further explain the adverse association between polypharmacy and rehospitalization. For instance, elderly patients are frequently prescribed proton pump inhibitors for stress ulcer prophylaxis during the acute hospital stay. Most of the patients are then discharged on these drugs, potentially exposing the patients to a higher risk of pneumonia and Clostridium difficile infection. In our investigation, we did not gather this granular information, but future investigation should further explore the association between polypharmacy and rehospitalization to explain the underling mechanisms, which should then be target of future interventions.

Finally, the acute decline of functional status also provides clinicians with key information on the patients' global incapacity to react to a stressful condition as an expression of a baseline frailty. The association between functional decline during an acute illness is not just a marker for rehospitalization, but can be used at the bedside also to estimate long-term prognosis.

Our study includes a number of notable strengths. It is the first to evaluate the rate of unplanned readmissions to the hospital, and the related risk factors, in a large population of elderly patients admitted to an in-hospital rehabilitation setting. In addition, our study contains functional and cognitive data obtained from a multidimensional evaluation carried out by expert geriatricians. Findings from this study might represent a basis for national and regional health systems to stimulate benchmarking policies across postacute and rehabilitative centers and to implement reimbursement strategies in relation to rehospitalization rates.

Limitations of our study must be considered as well. First, this was a retrospective cohort study carried out in a single center, thus potentially limiting generalizability. In addition, although we...
examined the total number of medications, we have not addressed whether medication discrepancies, which often occur after the transition from hospital to the setting of discharge, are a risk factor for rehospitalization. Additionally, we were unable to collect information on specific types of drugs (eg, antipsychotics, sedatives, hypnotics). There are additional risk factors we have not accounted for (eg, social determinants of health, such as health literacy, socioeconomic status, caregiver support) that may explain lower rates of readmission and be important predictors of readmission. Last, the inclusion of admission diagnoses as possible confounding factors should also be included in future studies.

This study provides new important information on the epidemiology of unplanned rehospitalization of elderly patients admitted to an in-hospital rehabilitation setting after an acute hospitalization. Furthermore, it identifies 3 risk factors of unplanned 30-day rehospitalization, which are easily accessible at the bedside and should be used as a simple predictive model for clinicians at the time of admission to in-hospital rehabilitation.

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Supplementary Data

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.jamda.2013.03.013.

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