Safety of Elderly Fallers: Identifying Associated Risk Factors for 30-Day Unplanned Readmissions Using a Clinical Data Warehouse

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Background: Hospital readmissions are a major problem in the older people as they are frequent, costly, and life-threatening. Falls among older adults are the leading cause of injury, deaths, and emergency department visits for trauma.

Objective: The main objective was to determine risk factors associated with a 30-day readmission after index hospital admission for fall-related injuries.

Methods: A retrospective nested case-control study was conducted. Data from elderly patients initially hospitalized for fall-related injuries in 2019, in 11 of the Greater Paris University Hospitals and discharged home, were retrieved from the clinical data warehouse. Cases were admission of elderly patients who subsequently experienced a readmission within 30 days after discharge from the index admission. Controls were admission of elderly patients who were not readmitted to hospital.

Results: Among 670 eligible index admissions, 127 (18.9%) were followed by readmission within 30 days after discharge. After multivariate analysis, men sex (odds ratio [OR] = 2.29, 95% confidence interval [CI] = 1.45–3.61), abnormal concentration of C-reactive protein, and anemia (OR = 2.22, 95% CI = 1.28–3.85; OR = 1.85, 95% CI = 1.11–3.11, respectively) were associated with a higher risk of readmission. Oppositely, having a traumatic injury at index admission decreased this risk (OR = 0.47, 95% CI = 0.28–0.81).

Conclusions: Reducing early unplanned readmission is crucial, especially in elderly patients susceptible to falls. Our results indicate that the probability of unplanned readmission is higher for patients with specific characteristics that should be taken into consideration in interventions designed to reduce this burden.

Key Words: risk factors, readmissions, elderly, falls

Hospital readmissions are defined as patient admissions within a specified time frame after discharge from index hospital admission. Hospital readmission rate within 30 days of discharge from an index admission serves as a key indicator for measuring the quality of patient health care and is adopted by major healthcare stakeholders nationally and internationally.

Readmissions increase patient morbidity and mortality particularly among the older people and result in a huge financial burden on healthcare. In 2011, there were approximately 3.3 million readmissions in the United States (US), contributing to $41.3 billion in total hospital costs. Finally, readmissions constitute a substantial burden for health care systems with incidences as high as 15.5% to 19.6%. The reasons that account for hospital readmission are multifactorial, and it is obvious that they result from factors related to comorbidities (e.g., natural progression of the diseases), factors related to the patient (social and family environment or treatment adherence), or a combination of all of these. Several studies have demonstrated links between hospital readmissions and specific diseases or comorbidities, several studies have demonstrated links between hospital readmissions and specific diseases or comorbidities, or a combination of all of these. Several studies have demonstrated links between hospital readmissions and specific diseases or comorbidities, or a combination of all of these. Several studies have demonstrated links between hospital readmissions and specific diseases or comorbidities, or a combination of all of these.

Methods

The main objective of our study was to identify risk factors associated with unplanned hospital readmission within 30 days after discharge. We thus conducted a nested case-control study using the Clinical Data Warehouse (CDW) of the Greater Paris University Hospitals (AP-HP) among elderly patients initially admitted for FRIs (e.g., fracture or injuries). Our secondary objectives were to assess the rate of unplanned readmission within 30 days after discharge and their time of occurrence, to determine the number of hospital readmissions per patient, as well as to describe and to compare the characteristics of cases of unplanned readmission within 30 days after discharge and controls.

Methods

This study is presented according to the RECORD (REporting of studies Conducted using Observational Routinely collected health Data) Statement.

Study Design and Setting

An observational retrospective nested case-control study within a cohort of patients admitted to the Greater Paris University Hospitals (AP-HP) among elderly patients initially admitted for FRIs (e.g., fracture or injuries). Our secondary objectives were to assess the rate of unplanned readmission within 30 days after discharge and their time of occurrence, to determine the number of hospital readmissions per patient, as well as to describe and to compare the characteristics of cases of unplanned readmission within 30 days after discharge and controls.

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Variables

The primary outcome of this study was the risk factors for hospital readmission within 30 days after discharge from index admission for FRI.

Data were extracted at the index admission, and the analyzed variables included: demographic characteristics (age, sex), admission characteristics (entry mode, length of stay, and previous hospital admission in the 6 months before the index admission), therapeutic characteristics (prescribed drugs were grouped according to the anatomical, pharmacological, or chemical level of the Anatomical Therapeutic Classification according to the significance of the clinical interpretation), number of drugs, number of pharmacological classes, polymedication (more than 5 drugs), presence of potentially inappropriate medication (PIM) defined by Beers criteria, diagnosis characteristics (according to the ICD-10), number of comorbidities, and Charlson Index based on the algorithm developed by Quan et al. \(^\text{25}\) Laboratory test results were also analyzed (electrolytes, blood count, leukocyte formula, lymphocyte populations, C-reactive protein (CRP), uremia, glomerular filtration rate, proteinemia), according to the significance of the clinical interpretation, and some of these variables were categorized according to normal clinical rates.

Statistical Analysis

A descriptive analysis of the study population (cases and controls) was performed. Baseline characteristics were described by the usual parameters: mean and standard deviation for continuous variables, as well as numbers and percentages for qualitative variables. The median and the interquartile range were used to describe the time to readmission. A Kaplan-Meier survival curve was also used to describe readmission time within 30 days of discharge.

We used a \( t \)-test to compare means for quantitative variables and \( \chi^2 \)-test to compare the percentages of qualitative variables between cases and controls. The variables with a difference between groups (\( P \leq 0.1 \)) or widely described in the literature were included in the multivariate analysis. A collinearity diagnosis and a correlation matrix were made to determine the correlations between selected variables. If 2 variables were correlated, we decided to remove the variable with the highest \( P \) value. Multivariate logistic regression models, providing odds ratio (OR) and 95% confidence intervals (95% CIs), were used to assess the association between unplanned readmission within 30 days and potential risk factors while adjusting relevant influencing factors (backward elimination). All \( P \) values of less than 0.05 were taken as statistically significant.

We carried out a sensitivity analysis, which consisted in comparing ORs obtained in full case analysis and after imputation of missing data, to ensure that the missing data did not affect our risk estimate.

All statistical analyzes were performed using SAS software version 9.4 (SAS Institute, Cary, NC).

RESULTS

Participants

From January 1 to December 31, 2019, a total of 1397 admissions of elderly patients (\( \geq 75 \) y or older), initially admitted for FRI in 1 of the 11 AP-HP hospitals of the study were included. Among them, 670 admissions have met our definition of index admission. A total of 127 index admissions were followed by a readmission within 30 days after discharge and classified as cases. On the other hand, 543 index admissions were not followed by a readmission within 30 days after discharge and were classified as controls (Fig. 1). The 30-day readmission rate was therefore 18.9%.

A total of 579 patients met our inclusion criteria: 113 were readmitted to the hospital within 30 days of discharge from index admission and 503 patients were not readmitted. Among the readmitted patients, 103 (91.1%) had 1 readmission, 8 (7.1%) had 2 readmissions, and 2 (1.8%) had 4 readmissions. The 30-day readmission rate was therefore 17.8%. The median time to readmission was 7 days (interquartile range = 2–18; Fig. 2).

Characteristics of the Study Population

The patients’ mean age was 86.1 (6.0) years; 62.1% were women and 66.6% came directly from home. For diagnosis characteristics, the mean number of comorbidities was 6.7 (3.5) and the mean of Charlson Index was 1.4 (1.5). The mean number of prescribed drugs was 8.9 (3.3), and 84.0% of the patients were polymedicated (>5 drugs); 33.6% of the patients were initially admitted with a tendency to fall (Table 1).

Comparison of Case and Control Characteristics

We compared demographic, therapeutic, diagnosis, and laboratory tests results and admission characteristics between cases and controls to select the variables for the multivariate analysis. Table 2 shows the characteristics that have a difference (\( P \leq 0.1 \)) or widely described in the literature comparing cases and controls.
Admissions of patients aged 75 years or over, initially admitted for FRI between January 1st and December 31st, 2019

- Exclusion of outpatients: N\text{visit} = 66
- Exclusion of admissions with missing or aberrant dates: N\text{visit} = 6

Admission with a FRI

- Exclusion of admissions with death during admission: N\text{visit} = 67
- Exclusion of admissions with discharge to another hospital or clinical ward: N\text{visit} = 576

Index admission with FRI and discharge home

- Exclusion of deceased patients within 30 days after discharge: N\text{visit} = 12

Index admissions

Cases
- N\text{patient} = 113
- N\text{visit} = 127

Controls
- N\text{patient} = 503
- N\text{visit} = 543

FIGURE 1. Flow diagram of patient selection process.
Bivariate analysis shows differences between cases and controls. The rate of readmission for men was higher in cases (52.8% versus 34.4%, \( P = 0.0001 \)). For therapeutic characteristics, cases were significantly more exposed to antiarrhythmics, antigout drugs, anxiolytics, hypnotics, sedatives, systemic corticosteroids, diuretics, and benzene prostate hyperplasia drugs than controls. The number of pharmacological classes and PIM was higher in cases compared with controls. Cases were more likely to have been diagnosed with anemia (25.2% versus 18.4%, \( P = 0.0837 \)), a malignant tumor (19.7% versus 11.2%, \( P = 0.0104 \)), other heart disease (43.3% versus 35.4, \( P = 0.0946 \)), a higher Charlson Index (1.6 ± 1.7 versus 1.4 ± 1.5, \( P = 0.0861 \)) on index admission, and less likely to have a traumatic injury (28.3% versus 40.3%, \( P = 0.0123 \)) than controls. Furthermore, cases were more likely to have an abnormal concentration of CRP and hemoglobin and a previous hospital admission. The length of stay was higher in controls than in cases (24.7 ± 29.7 versus 18.7 ± 27.2, \( P = 0.0385 \)).

**Multivariate Analysis**

The variables in the bivariate analysis did not show any collinearity or correlation; therefore, they were all included in the multivariate analysis. We performed our multivariate analysis on cases and controls with complete data (105 cases and 459 controls).

In this final logistic regression model (Table 3), male sex, abnormal concentration of CRP, anemia, and traumatic injury were still significantly associated with hospital readmission \((P < 0.05)\), after adjustment for use of anxiolytics, hypnotics and sedatives, systemic corticosteroids, length of stay, and previous hospital admission. Therefore, men had a higher readmission risk \((OR = 2.29, 95\% CI = 1.45–3.61)\). Having an abnormal concentration of CRP and anemia at the index admission increased the readmission risk \((OR = 2.22, 95\% CI = 1.28–3.85; OR = 1.85, 95\% CI = 1.11–3.11, \text{ respectively})\). On the contrary, having a traumatic injury at the index admission decreased the readmission risk \((OR = 0.47, 95\% CI = 0.28–0.81)\).

**Sensitivity Analysis**

We performed a multiple imputation of missing data to ensure that the missing data did not affect our risk estimate. Tables S2 to S4 in the supplementary files http://links.lww.com/JPS/A417 show the results of our sensitivity analysis. Male sex, abnormal concentration of CRP, and anemia were still significantly associated with hospital readmission after adjustment for use of anxiolytics, hypnotics and sedatives, systemic corticosteroids, traumatic injury, and previous hospital admission \((OR = 2.14, 95\% CI = 1.42–3.22; OR = 1.83, 95\% CI = 1.08–3.09; OR = 1.67, 95\% CI = 1.03–2.71, \text{ respectively})\). Comparison of the ORs of the final models (with and without imputation) showed no difference. In the final model with imputation, the length of stay was significantly associated with the readmission risk \((OR = 0.98, 95\% CI = 0.97–0.99)\)—having a longer length of stay decreases the readmission risk.

**DISCUSSION**

In this observational retrospective case-control study conducted using the AP-HP clinical data warehouse, among the elderly patients 75 years or older initially hospitalized for FRIs (e.g., fractures, injury), the rate of all-cause hospital readmission within 30 days from index admission discharge was 18.9%. This finding is close to that of the French advisory council for the future of health insurance regarding readmission, which was 17.5%. Likewise, our readmission rate is also close to that generally reported in the literature, which varies from 14% to 20% according to differences in methodology (e.g., definition of unplanned readmission) and study population (e.g., older people, heart failure,...). However, previous studies specifically conducted on patients admitted after injury have shown lower rates. Osler et al. have shown that 6.7% of patients admitted for traumatic injury were readmitted within 30 days and this low rate could be explained by the fact that their study population consists of nonelderly individuals.
adults. These patients may not have multiple comorbidities and might be in a better health than our patients. Furthermore, Strosberg et al. have also shown a lower readmission rate (8.4%) among older trauma patients. However, this result was obtained for adults 45 years and older discharged after index admission to several destinations (home, rehabilitation facilities, and extended care facilities). It seems that methodological differences do not allow for direct comparisons between our readmission rate identified here and in these studies.

Our study showed that male sex, abnormal concentration of CRP, and anemia at index admission were independently associated with increased risk of 30-day hospital readmission. On the contrary, a traumatic injury at the index admission was associated with decreased risk of early hospital readmission and

### TABLE 2. Comparison of Case and Control Characteristics

| Characteristics                        | Cases (n = 127) | Controls (n = 543) | P* |
|----------------------------------------|----------------|-------------------|----|
| **Demographic characteristics**        |                |                   |    |
| Sex, n (%)                             |                |                   |    |
| Male                                   | 67 (52.8)      | 187 (34.4)        | 0.0001 |
| **Therapeutic characteristics**        |                |                   |    |
| Use of antiarrhythmics, n (%)          | 23 (20.0)      | 63 (12.5)         | 0.0375 |
| Use of antigout drugs, n (%)           | 14 (12.2)      | 30 (6.0)          | 0.0198 |
| Use of antiepileptics, n (%)           | 25 (21.7)      | 68 (13.5)         | 0.0268 |
| Use of anxiolytics, hypnotics and sedatives, n (%) | 64 (55.6) | 228 (45.4) | 0.0474 |
| Use of systemic corticosteroids, n (%) | 15 (13.0)      | 40 (8.0)          | 0.0849 |
| Use of diuretics, n (%)                | 60 (52.2)      | 208 (41.4)        | 0.0361 |
| Use of benign prostate hyperplasia drugs, n (%) | 33 (28.7) | 80 (15.9) | 0.0014 |
| No. pharmacological classes, mean ± SD | 11.0 ± 4.2     | 10.3 ± 3.8        | 0.1015 |
| **Diagnostic characteristics**         |                |                   |    |
| Anemia,† n (%)                         | 32 (25.2)      | 100 (18.4)        | 0.0837 |
| Traumatic injury,‡ n (%)               | 36 (28.3)      | 219 (40.3)        | 0.0123 |
| Malignant tumor,§ n (%)                | 25 (19.7)      | 61 (11.2)         | 0.0104 |
| Other heart disease,‖ n (%)            | 55 (43.3)      | 192 (35.4)        | 0.0946 |
| Charlson Index, mean ± SD              | 1.6 ± 1.7      | 1.4 ± 1.5         | 0.0861 |
| **Laboratory analysis characteristics**|                |                   |    |
| Abnormal concentration of CRP, n (%)   | 87 (80.6)      | 309 (66.3)        | 0.0039 |
| Abnormal concentration of hemoglobin, n (%) | 82 (67.8) | 298 (59.1) | 0.0804 |
| **Admission characteristics**          |                |                   |    |
| Length of stay, mean ± SD, d           | 18.7 ± 27.2    | 24.7 ± 29.7       | 0.0358 |
| Previous hospital admission (6 mo before index admission), n (%) | 52 (40.9) | 166 (30.6) | 0.0247 |

### TABLE 3. Multivariable Adjusted ORs (95% CIs) for 30-Day Readmission

| Variable                                            | OR     | 95% CI          | P     |
|-----------------------------------------------------|--------|-----------------|-------|
| Male                                                | 2.29   | 1.45–3.61       | 0.0004* |
| Use of anxiolytics, hypnotics, and sedatives         | 1.56   | 0.99–2.47       | 0.0542 |
| Use of systemic corticosteroids                      | 1.97   | 0.98–3.97       | 0.0572 |
| Abnormal concentration of CRP                        | 2.22   | 1.28–3.85       | 0.0043* |
| Anemia†                                              | 1.85   | 1.11–3.11       | 0.0194* |
| Traumatic injury‡                                     | 0.47   | 0.28–0.81       | 0.0056* |
| Length of stay, d                                    | 0.99   | 0.98–1.00       | 0.0711 |
| Previous hospital admission (6 mo before index admission) | 1.57   | 0.99–2.51       | 0.0563 |

Abnormal concentration of CRP: CRP ≥ 5 mg/L.

*P < 0.05; missing values were not included in the calculation of the P value.

The ICD-10-MC codes: †D50–D64, ‡S00–T14, §C00–C97, and ‖I27–I52.
that after adjustment for use of anxiolytics, hypnotics and sedatives, systemic corticosteroids, history of hospital admission, and length of stay.

These findings are broadly consistent with other observations. Several studies indeed found that male sex was significantly associated with a higher risk of hospital readmission; moreover, previous studies conducted in the US have shown that in a population of patients initially hospitalized for a hip fracture, which is a diagnosis often associated with a fall, men were more likely to be readmitted within 30 days after discharge than women. This finding can be explained by the fact that frailty is more common among older men than women. There are also sex-related differences in quality of hospital care and in the utilization of healthcare services—women have greater medical care service utilization and are more likely to seek health care for prevention and illness. In addition, hospitalized men are more likely to be referred for invasive procedures than women, which results in a higher readmission rate. This result suggests that clinicians should consider sex in discharge planning and for the entire episode of care for the population.

Another risk factor for early hospital readmission was an abnormal CRP concentration. This result is consistent with other studies that have found that a high plasma CRP at discharge was an independent predictor of subsequent unplanned readmission. C-reactive protein is a marker of ongoing inflammation linked to the systemic inflammatory response. This finding may indicate that there was residual organ dysfunction, nosocomial infection, and/or an inflammatory process after discharge from index admission resulting in subsequent readmission. Assessment of the evolution of CRP concentrations during hospitalization could be a useful tool in discharge decision making. It may provide additional information regarding the resolution of the critical illness and the development of infections.

We also found that anemia was independently associated with increased early hospital readmission. This is not surprising because a lot of studies have shown that anemia is much more common in hospitalized geriatric patients and linked with increased hospital readmission. However, in our study, anemia and abnormal CRP concentration were correlated, suggesting that anemia could be due to another factor (e.g., malnutrition, bleeding...). As the cause of anemia is often multifactorial, it is important for clinicians to understand the underlying causes and contributing factors when deciding on the most appropriate care for newly admitted patients.

Only 1 protective factor was identified in our study—a traumatic injury was associated with decreased risk of early hospital readmission. A recent study by Morris et al has shown a similar result, and they found that hospitalization after traumatic injury was associated with a decreased risk of early readmission. This finding may be explained by the fact that trauma patients are more vulnerable and they may benefit from a specific health care coordination to prevent hospital readmission and special attention paid to home support.

Several studies have been carried out among elderly patients to assess the unplanned hospital readmission rate and to identify the associated risk factors. In this study, we focused on elderly patients susceptible to falls regarding the need for effective interventions to reduce readmission rate among this specific population and to decrease functional worsening and loss of independence, risks that were widely described. We found a common profile of risk factors among elderly patients susceptible to falls and the general population of older patients. Furthermore, the risk factors that we have identified are close to frailty risk factors in elderly patients, in particular, increased mean levels of CRP and anemia. Our findings confirm the frailty of elderly patients who are susceptible to fall and the results of other studies that defined frailty as a stronger predictor of readmission in older trauma patients. Likewise, Hatcher et al have already shown that after an index admission for trauma-related injury, frail elderly patients were more likely to be readmitted compared with nonfrail (OR = 2.26, 95% CI = 1.39–3.66, P = 0.001).

This study had some limitations. First, among the 39 institutions of the AP-HM, at the time of the study, only 11 had computerized drug prescription system; we did not consider readmission to other hospitals or institutions; and this could lead to a classification bias and underestimation of readmission rate. Indeed, controls might have been readmitted to another hospital after discharge. However, based on previous studies, 91.1% of readmissions were in the same hospital and only 8.9% in another hospital. Secondly, there were some missing data regarding therapeutic characteristics and laboratory test results. Missing data can create potential selection bias and may have generated false-positive results. Hence, we performed a multiple imputation of missing data to ensure that they did not affect our risk estimate. The 2 multivariate models (before and after imputation) produced a very similar result for risk factors associated with 30-day hospital readmission. Thirdly, in our study, we did not include information on patient abilities to perform everyday routine tasks or other measurements of physical functioning. This ability can be a marker of frailty and enhance the risk of hospital readmission. However, we included a large number of other relevant data including patient therapeutics, laboratory tests, and admission characteristics, which enabled us to test several potential factors of hospital readmission.

Finally, the strength of this study is its focus on risk factors at discharge after index admission. Index admission is considered as the care phase where interventions to reduce readmission would have been most effective, thus allowing better intervention and facilitating the implementation of the interventions.

Interestingly, even if our results may not be generalizable to the entire population of elderly patients susceptible to falls, the use of the clinical data warehouse enabled us to study a substantial diversity of patient profiles and thus reflects an accurate representation of this population.

CONCLUSIONS

Early hospital readmission in elderly patients remains a major health care problem in many countries, leading to potentially serious consequences, especially in elderly admitted for FRI, presumably because of the frailty of this population. Prevention calls for the identification of risk factors to target interventions for high-risk patients. Our study shows for the first time, in older patients susceptible to falls, that the probability of unplanned readmission is higher for patients with specific characteristics (men, anemia, and abnormal concentration of CRP). The implementation of a specific postdischarge program for these patients is now crucial to reduce early hospital readmission.

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