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Repeated hospital readmissions and death after discharge: findings from a prospective multicentre cohort of older adults

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Abstract

Background: The fate of older adults after admission to an acute geriatric unit (AGU) is heterogeneous in terms of hospital readmission and death. This heterogeneity has not been well explained.

Objective: The objective of the present study was to identify specific subgroups of older patients at risk of repeated hospital readmissions and death.

Methods: We analyzed the prospective, multicentre, DAMAGE cohort of adults aged 75 and over, hospitalized in an AGU, and who had been followed up for 12 months. We performed a latent class analysis to identify subgroups at risk of repeated hospital readmissions and death, followed by a logistic regression analysis to determine the characteristics associated with the identified subgroups.

Results: 3081 patients were included (mean (SD) age: 86.4 (5.5)) and two subgroups were identified. In subgroup 1 (n=2169, 70.4%), only 619 (28.5%) patients were readmitted to hospital once during the follow-up, and 495 (22.5%) died. In subgroup 2 (n=912, 29.6%), all patients were readmitted to hospital at least twice, and 523 (57.8%) died. Subgroup 2 accounted for 29.6% of patients but 74.4% of hospital readmissions, with longer lengths of stay, and 51.6% of deaths.

Conclusion: A latent class analysis showed that a population of older adults hospitalized in an AGU is divided into two subgroups with regard to the post-discharge outcomes: one subgroup (70% of the individuals) will have a low rate of hospital readmission and a moderate death rate, whereas the other will have a high rate of hospital readmission and a very high death rate. There is a need for predictive scores for both events, with a view to better targeting at-risk patients.

WHAT IS ALREADY KNOWN ON THIS TOPIC

- Most of the initiatives to reduce the risk of hospital readmission among older adults have had mixed results and are based on the determination of clinical characteristics associated with the first hospital readmission.
- Recent research results have shown that the hospital readmission process is not limited to the first readmission.
- The heterogeneity of older adults, in terms of repeated hospital readmissions, has not been well explained.

WHAT THIS STUDY ADDS

- Our study shows that barely 30% of patients accounted for more than two-thirds of future hospital readmissions and more than half of all deaths, after discharge.

- These patients had longer hospital stays and spent more time in hospital during the follow-up period, whereas some patients were never or rarely readmitted to hospital and were unlikely to die.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- Our results may call into question the appropriateness of the use of healthcare resources for older patients: were all these hospital readmissions driven primarily by medically justified reasons, and in line with the patient's wishes? Would home care have been possible? Our study also suggests that work is needed to identify characteristics more strongly associated with the risk of multiple hospital readmissions and death.

INTRODUCTION

Hospital readmission is frequent in older adults and is associated with greater morbidity and mortality, loss of autonomy, and excessive healthcare costs.[1–4] Initiatives to reduce the risk of hospital readmission among older adults have had mixed results.[5,6] Most of these initiatives are based on the determination of clinical characteristics associated with the first hospital readmission (typically within a timeframe ranging from 30 days to 12 months) and thus the identification of at-risk older adults.[3,7,8]

Recent research results have shown that the hospital readmission process is not limited to the first readmission; the process is dynamic, with each new hospital readmission increasing the risk of further readmissions within increasingly shorter timeframes. Moreover, the hospital readmission process is associated with the risk of death.[9] Lastly, clinical characteristics do not account for much of the variability in the risk of multiple hospital readmissions.[10] All these elements suggest that there is poorly explored, poorly explained heterogeneity in older adults' outcomes (i.e. hospital readmission, and death after the first readmission). In this context, it can be useful to identify within the whole heterogeneous population some subgroups, which are more homogeneous in terms of different characteristics (potential risk factors for the repeated hospital admissions). The difficulty is that specific characteristics which determine these subgroups are often not directly observed, even though they depend on the observed patients' features. It is assumed that the subgroups are determined by some latent (not observed) variable, called latent class. The statistical tool, called latent class analysis can be used to identify subgroups within a large but heterogeneous population.[11] Usefully, this approach does not require *a priori* knowledge or explanations in terms of clinical characteristics, but the identified subgroups (latent classes) can be characterized *a posteriori* by observed clinical characteristics. To the best of our knowledge, latent class analysis has not previously been used to study the heterogeneity of older adults with regard to the risk of repeat hospital readmissions and death after the first hospital readmission.

The objectives of the present study were to (i) identify specific subgroups of older patients at risk of repeat hospital readmissions and death after the initial hospital stay and (ii) determine the associated characteristics.

METHODS

Study Design

The DAMAGE study is a multicentre, prospective cohort study of patients aged 75 or over hospitalized in an acute geriatric unit (AGU) in the Hauts-de-France and Normandie regions of France (NCT02949635). The six recruiting centres are Lille University Hospital (Lille, France; 2 AGUs), Saint Philibert Hospital (Lille, France; 1 AGU), Amiens-Picardie University Hospital (Amiens, France; 1 AGU), Caen University Hospital (Caen, France; 1 AGU), and Saint Quentin General Hospital (Saint Quentin, France; 1 AGU). Patients discharged from the AGU to a non-acute facility (the patient's home, a residential home, or a rehabilitation unit) were followed up for one year. The inclusion period ran from September 14th, 2016, to January 29th, 2018. The last 12-month follow-up visit was performed on January 29th, 2019.

Ethical Approval

The DAMAGE study was conducted in compliance with the terms of the Declaration of Helsinki and was approved by the local independent ethics committee (*CPP Nord-Ouest IV*, Lille, France) on February 13th, 2015, with an amendment approved on January 21st, 2016 (reference: IDRCB 2014 A01670 47, CNIL bxA15352514). The patients and their primary family caregivers or legal representatives were given detailed verbal and written information about the study, in order to ensure that the patients fully understood the potential risks and benefits of participation. In accordance with the French legislation on observational, non-interventional studies of routine clinical care, written consent was not required. The patients were informed that they could refuse to participate in the study and that refusal would not have any impact on their treatment in the AGU. If the patient was potentially unable to state his/her refusal to participate in the DAMAGE study, the next of kin or legal representative could refuse participation.

Inclusion and Exclusion Criteria

All patients aged 75 and over, with health insurance coverage and hospitalized in an AGU were eligible for inclusion in the study. Patients hospitalized in the AGU for less than 48 hours were not included because this short duration prevented the completion of a comprehensive geriatric assessment. Patients admitted for immediate palliative care were not considered for inclusion in the study because of the high risk of death. Lastly, patients who

refused to participate to the study (as notified by the patient or his/her primary family caregiver or legal representative) were not included. However, cognitive impairment was not an exclusion criterion *per se*.

Patients who died in the AGU were excluded because one of the study's objectives concerned the assessment of the death rate after discharge. Patients transferred to another acute care ward (a surgical ward or a non-geriatric ward) without returning to the AGU were also excluded. Lastly, patients transferred to palliative care units or having received palliative care during the stay in the AGU were excluded because of the above-mentioned high risk of death.

Collection of Data During the Stay in the AGU

Data were collected at various time points during the initial stay in the AGU, using a case report form. The social, clinical and geriatric variables recorded within 72 hours of admission, during the hospital stay, and upon discharge are listed in Supplement 1.

- The social and clinical variables recorded on admission included the age, sex, type of home environment (own home or residential home), number of previous hospital stays, the Charlson Comorbidity Index (CCI),[12] and whether or not the patient had a diagnosis of cancer. The geriatric variables recorded on admission included the number of medications usually taken, dependency before hospital admission (the Katz Index of independence in activities of daily living (Katz ADL)),[13] malnutrition (weight loss and the body mass index), cognitive disorders, any history of depression, swallowing disorders, and walking ability. Standard laboratory variables were also recorded.

- During the hospital stay, a daily evaluation of clinical status enabled us to classify the patient into one of five predefined states: late discharge, a medical obstacle to discharge (other than infection), treatment of a community-acquired infection, treatment of a hospital-acquired infection, and palliative care. These clinical states were mutually exclusive (i.e. only one state per day and per patient) and were determined by the patient's attending physician.

- On the day of discharge, geriatric variables were also recorded: the patient's bodyweight, the bodyweight difference between admission and discharge, the Katz ADL on discharge, the difference in Katz ADL between admission and discharge, and the discharge destination (the patient's own home, a residential home, or a rehabilitation unit). The collected data were audited. Lastly, data collected during

the hospital stay was used to calculate the one-year mortality risk score (the DAMAGE score) developed in a previous study of the same cohort.[14]

Follow-Up

The exact date of hospital readmission and the exact date of death (if applicable) were collected at 3 and 12 months after the index discharge from the AGU; this was done by phoning the patient (if alive), his/her next of kin or caregiver or the referring healthcare professional in a community setting (e.g. the general practitioner). Patient mortality was also evaluated by consulting freely available national mortality data.

Statistical Analysis

Categorical variables were expressed as the frequency (percentage). Continuous variables were expressed as the mean ± standard deviation (SD) if normally distributed or as the median [interquartile range (IQR)] otherwise. Normal data distributions were checked graphically and by applying the Shapiro–Wilk test.

To identify homogeneous subgroups of patients in terms of the risk of repeated hospital admission, we performed a latent class analysis.[15] This approach combines the well-known Andersen-Gill model,[16] which models the occurrence of recurrent events and has already been used to study hospital readmissions of older adults,[9,10] with the mixture model,[17] allowing to account for a mixture of distributions (distributions with different parameters). The probability of belonging to a so-called "latent" class, i.e. one not directly observed in the data, is a parameter estimated from observed data. Patients are assigned to classes with the highest probability of membership *a posteriori* (after the model parameters estimation), and the variables associated with the recurrence process in the Andersen-Gill model can be specific to these latent classes. This approach has the advantage of not requiring *a priori* knowledge of the classes or an explanation of the classes in terms of clinical characteristics.

The intergroup difference between the identified latent classes was assessed *a posteriori* in Student's t-test (for normally distributed data) or Wilcoxon's test (in all other cases) for continuous variables ; for qualitative variables, a chi-squared test was applied.

A logistic regression model was used to explore *a posteriori* (i.e. after the classes had been identified by the latent class model) patients' risk of belonging to a specific subgroup of hospital readmission process (corresponding to the identified latent class), based on the observed characteristics measured at baseline. The variables included in

the logistic regression model were selected in several stages. As many of the explanatory variables were redundant, a principal component analysis[18] was carried out to pre-select a subset of independent variables for inclusion in the model. Next, to avoid case loss in univariate and multivariate analyses, missing data for candidate predictors (the proportion of missing data ranged from 0% to 8.6%, depending on the variable) were imputed by multiple imputation using the regression-switching approach (chained equations, m=5 imputations).[19] The imputation procedure was performed with the missing-at-random assumption, with the predictive mean-matching method for quantitative variables and logistic regression models (binary, ordinal, or multinomial) for qualitative variables. Rubin's rules were used to combine the estimates derived from multiple imputed data sets.[20] Lastly, an automatic step-by-step variable selection procedure (based on the Akaike information criterion[21] was used in a duration model for recurrent events (hospital readmission, in our case).[16]

All analyses were performed with R software (version 3.4.3) (R core team, 2013).[22]

RESULTS

Study population

Of the 3509 patients hospitalized in an AGU, 202 died during the hospital stay, 97 were transferred to another non-geriatric acute medical or surgical unit (without returning to the AGU), and 98 were lost to follow-up after receiving palliative care and/or transfer to a palliative care unit. A total of 3112 patients met all the inclusion criteria and none of the exclusion criteria. 31 patients had hospital admission date errors during the follow-up period. Our analyses, therefore, covered a total of 3081 patients.

The general characteristics of the DAMAGE cohort (Table 1) shows that the population was very old (mean (SD) age: 86.4 (5.5)) and predominantly female (66%). Around a third of the patients were malnourished (28%) or had been diagnosed with a neurocognitive disorder (36%). At the end of the one-year follow-up period, 1447 patients (47%) had been readmitted to hospital: 856 patients had been readmitted (19%) only once, and 591 (28%) had been readmitted at least twice. A total of 1014 patients (32.9%) had died by the end of the follow-up period.

Patient outcomes at discharge from the AGU

The latent class analysis identified two subgroups within the DAMAGE cohort in terms of post-hospitalization outcomes (Table 2). The difference was mainly related to the number of hospital readmissions. The vast majority of older adults in subgroup 1 (n=2169, 70.4%) were not readmitted to hospital during follow-up, and a few were readmitted but only once. In contrast, all the older adults in subgroup 2 (n=912, 29.6%) were readmitted to hospital at least twice during follow-up. The death rate was also 2.5 times higher in subgroup 2 than in subgroup 1. Subgroup 2 accounted for 29.6% of the overall population but 74.4% of hospital readmissions and 51.6% of deaths. The mean cumulative number of hospitalizations by subgroups 1 or 2, over the follow-up period, is summarized in Figure 1. At the end of follow-up, patients in subgroup 2 had, on average, more than three hospital readmissions, while those in subgroup 1 had fewer than one.

The proportion (in %) of the total follow-up period spent in hospital was three times higher in subgroup 2 (median [IQR]: 6.3% [3.6; 11.7]) than in subgroup 1 (median [IQR]: 2.2% [1.4; 4.1]). Hospital stays were also significantly longer for subgroup 2 patients, with a median of 18 days (IQR: [10; 30]), compared with 8 days (IQR: [5; 14]) for subgroup 1 patients. Of the 523 patients who died in subgroup 2, all were readmitted to hospital before death,

whereas a minority of the 491 patients who died in subgroup 1 (N= 37, 7.5%) were readmitted to hospital during follow-up, before death.

Subgroup prediction based on variables

In a bivariate analysis, a total of 12 characteristics were associated with belonging to the most at-risk subgroup (Supplemental Data 3). In the multivariate analysis, only four characteristics were independently associated with belonging to the most at-risk subgroup: at least one hospital admission in the six months preceding the index hospital admission, cancer, polymedication, and weight changes (gain or loss) during the index hospital admission. The ORs associated with these characteristics were low and ranged from 1.05 to 1.63 (Table 3). The area under the receiver operating characteristic (ROC) curve was 63% (Supplemental Data 4). Bivariate analysis with the DAMAGE death risk score showed a weak association, with an OR 95% confidence interval (CI) of 1.37(1.22,1.53).

DISCUSSION

Our results showed that older adults discharged from an AGU can be divided into two outcome categories. Barely 30% of patients accounted for more than two-thirds of future hospital readmissions and more than half of all deaths in the entire cohort. These patients had longer hospital stays and spent more time in hospital during the follow-up period.

Most studies of the post-hospitalization fate of older adults have been limited to either an analysis of the first hospital readmission (within a timeframe ranging from 1 to 24 months)[7,8,23,24] or the risk of death (within a timeframe ranging from 1 month to several years).[25,26] These approaches have clear limitations, such as inability to deal with multiple hospital readmissions during follow-up or to take account of the link between hospital readmission and death.[23] The results of our latent class analysis confirmed that the outcomes in a population of older adults hospitalized in the AGU were heterogeneous. In subgroup 1, few older adults are readmitted to hospital, the death rate is 22%, and most deaths occur without hospital readmission. This situation appears to correspond to the wishes expressed by older adults as to the preferred place of death (home).[27,28] In contrast, the older adults in subgroup 2 were often readmitted to hospital – sometimes for longer periods – and had a death rate of 52% at the end of the study. This situation probably runs counter to the wishes of older adults with regard to the end-of-life. Furthermore, this situation may call into question the appropriateness of the use of healthcare resources for these patients: were all these hospital readmissions driven primarily by medically justified reasons, and in line with the patient's wishes? Would home care have been possible? In the case of progressive illnesses or multimorbidity, the wishes of older patients change, with a final preference for home care.[29] Multiple hospital readmission is a risk factor for fragmented care and inconsistent management of chronic diseases, and is not necessarily chosen by older adults.[29,30]

In order to adapt the care offered to patients and their carers, it would therefore be necessary to predict the risk of belonging to subgroup 2. In this respect, the results of our study are disappointing. While 40 distinct characteristics (including per-hospital events) were recorded in the DAMAGE study, all were only weakly associated with the risk of belonging to subgroup 2, and the area under the ROC curve was only 63%. The association with the DAMAGE death risk score was weak, even though the latter was developed specifically in this cohort. This is explained by the fact that 48.8% of the patients who died belonged to subgroup 1: the risk of death is not very discriminant for belonging to subgroup 1 vs. subgroup 2. Several scores for predicting the risk of hospital readmission at 30 days have been developed.[26,31] These scores effectively predict the occurrence of a new hospital

admission[32] and identify the patients most at risk of failure to return home.[33] However, our study showed that 42.7% of the patients readmitted to hospital belong to subgroup 1. These older adults will only be readmitted to hospital once over 12 months and are very unlikely to die during that period of time. The risk of the first hospital readmission is therefore of little significance in determining whether a patient belongs to subgroup 1 or subgroup 2. All in all, our results call for a change in the objectives of these scores, and a move beyond the separate, exclusive prediction of two classes, "first hospital readmission " or "death". Our results also suggest that work is needed to identify characteristics more strongly associated with the risk of multiple hospital readmissions and death (subgroup 2). In older patients, a multitude of factors other than clinical characteristics come into play: support for caregivers,[34] optimized care provision on discharge from the hospital, etc.[35]

The main strengths of our work are as follows: the use of high-quality data from a multicentre cohort of AGU patients; a low proportion of missing data (often less than 5%); novelty, as (to the best of our knowledge) the first multicentre studies of older adults admitted to an AGU and with a standardized geriatric assessment; the small number of exclusion criteria; and the use of latent class analysis, which had not previously been applied in studies of multiple hospital readmissions and death at discharge from an AGU.

Our study had several limitations. Firstly, the older patients in our cohort were discharged from an AGU and were most often very old, with multiple comorbidities. Hence, our results cannot be extrapolated to the population if older adults as a whole. Secondly, the case report form was initially filled in manually and then recoded electronically for statistical analysis. This may have led to data entry errors. Lastly, the latent classes identified here might be specific to the population of older patients in the DAMAGE cohort and might not be found among all older patients discharged from an AGU. However, the number of older patients in the DAMAGE cohort was large (over 3,000).

CONCLUSION

Our results showed that older adults discharged from an AGU can be divided into two outcome categories. On one hand, some patients accounted for more than a third of hospital readmissions, more than half of the deaths, and the longest hospital stays. On the other, some patients were never or rarely readmitted to hospital and were unlikely to die. There is a need for predictive scores for both events, with a view to better targeting at-risk patients.

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Conflicts of Interest:

The authors report no conflicts of interest.

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Data Availability

The data are available upon request to the corresponding author.

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Tables

Table 1: Characteristics of the overall study population

	Study population (n=3081)	
	N	**Value**
SOCIAL & CLINICAL CHARACTERISTICS		
Age, years (mean ± SD)	3081	86.4 ± 5.5
Sex (male) *N* (%)	3081	1050 (34.1)
Place of residence *N* (%)	3077	
At home		2484 (80.7)
In a residential home		593 (19.2)
Hospitalized in the previous 6 months *N* (%)	3028	1178 (38.9)
Charlson Comorbidity Index *N (%)*	3081	
0 – 2		1295 (42)
3 – 4		1485 (48)
>4		300 (9.9)
Cancer *N* (%)	3059	459 (15.0)
GERIATRIC SYNDROMES		
Living alone *N* (%)	3063	1412 (46.1)
Socially isolated *N* (%)	3050	261 (8.6)
Number of medications taken at home (mean ± SD)	3077	7.9 ± 3.6
Polypharmacy[a] *N* (%)	3026	655 (21.6)
Psychotropic medication *N* (%)	3047	1679 (55.1)
Katz ADL at home[b] *N (%)*	2905	
≥ 3		2217 (76.3)
< 3		688 (23.7)
Body mass index (mean ± SD)	2800	25.1 ± 5.7
Malnutrition[c] *N* (%)	2890	808 (28)
Swallowing disorder *N* (%)	3023	449 (14.8)
History of depression *N* (%)	3055	614 (20.1)
Cognitive disorder[d] *N* (%)	3081	
No		1406 (45.6)
Memory complaints		566 (18.4)
Known neurocognitive disorders		1109 (36)
Walking ability *N* (%)	3065	
No, confined to bed		151 (4.9)
No, bed or chair only		416 (13.6)
Walks with assistance		1412 (46.1)
Walks unaided		1086 (35.4)
CHANGES IN HOSPITAL		
Katz ADL on admission (median [IQR])	3066	3.0 [1.0; 5.0]
Katz ADL on discharge (median [IQR])	3028	4.0 [2.0; 5.0]
Change in Katz ADL in hospital *N* (%)	3024	
Worse		274 (9.1)
Stable		1699 (56.2)
Better		1051 (34.8)

Body weight on admission, kg (median [IQR])	2926	64.9 [55.0; 76.6]
Body weight on discharge, kg (median [IQR])	2225	64.0 [54.0; 76.0]
Change in body weight in hospital *N* (%)	2176	
Decrease		1034 (47.5)
Stable		398 (18.3)
Increase		744 (34.2)
Serum albumin level, g/L (mean ± SD)	3015	31.8 ± 5.4
Blood haemoglobin level, g/L (mean ± SD)	3075	11.7 ± 1.9
Serum creatinine level, µmol/mL (median [IQR])	3075	87.5 [64.5; 114.9]
Delirium on admission *N* (%)	3081	425 (13.8)
Time spent in each state during the hospital stay, days (mean ± SD)	3081	
Late discharge[e]		3.6 ± 4.1
Medical obstacle to discharge[f]		5.3 ± 4.7
Community-acquired infection		1.4 ± 2.9
Hospital-acquired infection		0.3 ± 1.7
FOLLOW-UP		
Number of hospital admissions during follow-up *N*		2670
Patients readmitted to hospital *N* (%)		1531 (49)
1 hospital readmission		856 (19)
2 hospital readmissions		350 (11)
3 hospital readmissions		142 (4.6)
4 hospital readmissions		63 (2.0)
5 hospital readmissions		18 (0.5)
Death during follow-up *N* (%)		1014 (32.9)

Note.
N: number of patients with no missing data
ADL: activities of daily living
SD: standard deviation.
IQR: interquartile range.
[a] at least 10 medications taken at home.
[b] Dependence before admission was defined as a Katz ADL score at home <3.
[c] Weight loss >5% in 1 month or >10% in 6 months, or body mass index <21.
[d] Memory complaints reported by the family or the patient, or known neurocognitive disorders.

[e] Late discharge, defined as being in a stable state for all 24 hours of the previous working day.
[f] Medical obstacle to discharge: assigned if the patient was not in any of the other states (late discharge, treatment of a community-acquired infection, treatment of a hospital-acquired infection, or palliative care).

Table 2: Patient outcomes, by subgroup

FOLLOW-UP	Subgroup 1 (n=2169)	Subgroup 2 (n=912)	*P*
Number of hospital admissions during follow-up *N*	619	2051	
Patients readmitted to hospital *N*	619	912	**< 0.001**
1 hospital readmission	619 (100)	912 (100)	
2 hospital readmissions	0	608 (66.7)	
3 hospital readmissions	0	232 (25.4)	
4 hospital readmissions	0	95 (10.4)	
5 hospital readmissions	0	59 (6.5)	
Length of hospital stay, days (median [IQR])	8 [5; 14]	18 [10; 30]	**< 0.001**
Proportion (%) of the total follow-up time spent in hospital (median [IQR])	2.2 [1.4; 4.1]	6.3 [3.6; 11.7]	**< 0.001**
Length of hospital stay before death, day (median [IQR])	10 [5; 13]	15.5 [8; 29]	**< 0.001**
Death during follow-up *N*	491	523	**< 0.001**
Patients readmitted to hospital before death N (%)	37 (7.5)	523 (100)	**< 0.001**

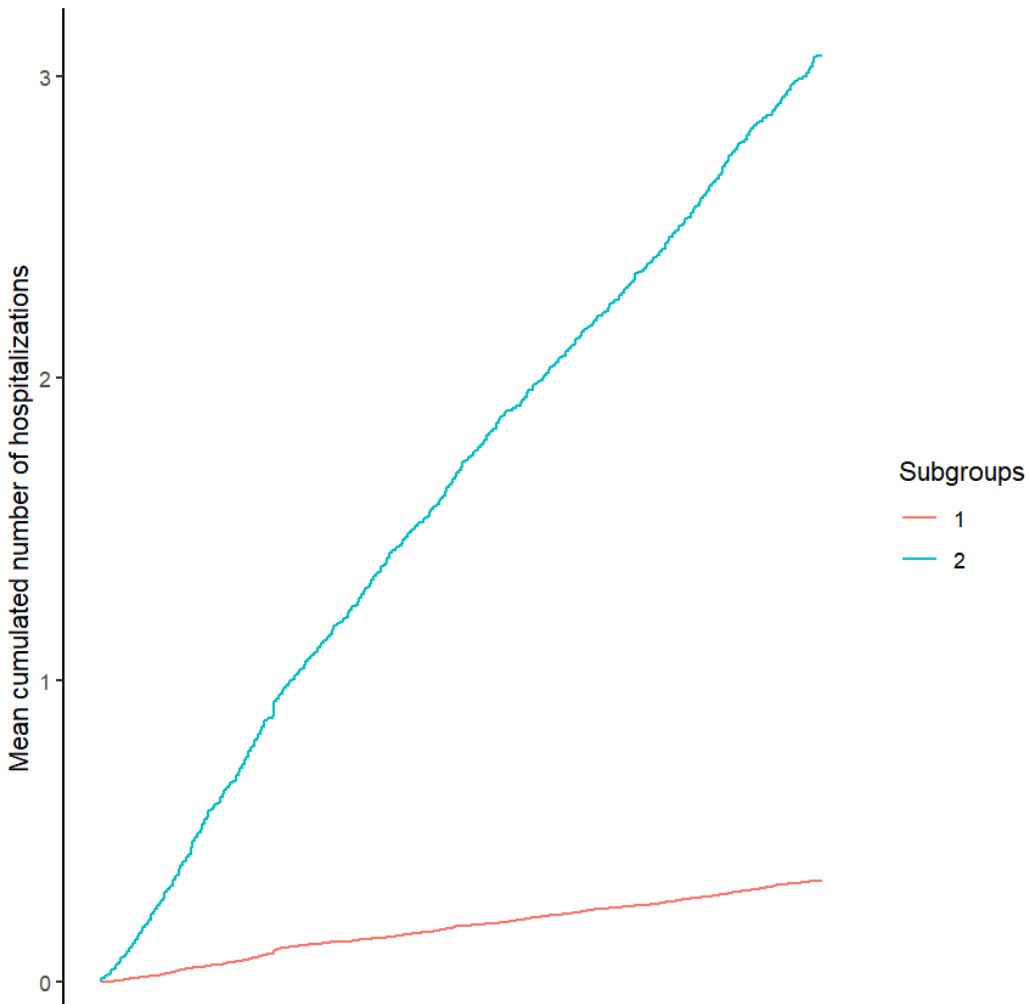
Table 3: Results of the multivariate analysis of the logistic regression model predicting membership of subgroup 2

	OR	95%CI
SOCIAL AND CLINICAL CHARACTERISTICS		
Age (years)		
(74 – 89)	Reference	-
(90 - 104)	1.07	(0.85, 1.35)
Sex (female)	0.81	(0.66, 1.01)
Place of residence		
At home	Reference	-
In a residential home	0.83	(0.61, 1.13)
Hospitalized in the previous 6 months	**1.25**	**(1.15, 1.36)**
Cancer (present)	**1.46**	**(1.11, 1.93)**
GERIATRIC SYNDROMES		
Malnutrition	1.29	(0.95, 1.74)
Swallowing disorder	1.21	(0.88, 1.66)
Katz ADL at home		
≥ 3	Reference	-
< 3	0.93	(0.85, 1.02)
Polypharmacy	**1.05**	**(1.02, 1.08)**
Cognitive disorder		
No	Reference	-
Known neurocognitive disorders	0.94	(0.75, 1.21)
Walking ability		
Walks unaided	Reference	-
Walks with assistance	1.07	(0.84, 1.37)
No, confined to bed	1.39	(071, 2.69)
No, bed or chair only	1.02	(0.68, 1.52)
Socially isolated	1.23	(0.85, 1.77)
CHANGES IN HOSPITAL		
Change in body weight in hospital		
Stable	Reference	-
Decrease	**1.44**	**(1.08, 1.94)**
Increase	**1.63**	**(1.21, 2.22)**
Change in Katz ADL in hospital		
Stable	Reference	-

Worse	1.28	(0.88, 1.84)
Better	1.04	(0.84, 1.31)

Figure 1 (color should be used): Graphical representation of the mean cumulative number of hospitalizations for each time point, by subgroups.

The average number of cumulated hospitalisations is calculated over all individuals at risk at each time point. Hospital readmissions accumulate faster in subgroup 2 than in subgroup 1. Overall, patients in subgroup 2 had more hospital readmissions, on average, than those in subgroup 1.



Supplemental data 1: Clinical assessment, outcomes, and data collection

- ***On admission***

A comprehensive geriatric assessment was performed during the stay in the AGU. Data on comorbidities, disease severity, previous hospital stays, medication, walking status, nutritional status, cognitive status, laboratory variables, and the caregiver burden were collected.

During the first 48 hours, the baseline characteristics were recorded:

- Age, sex, place of residence (at home, in a residential home), living alone (yes/no), social isolation (yes/no), number of hospital stays in the previous 6 months, the number of medications taken at home, and the number of psychotropic medications.
- AGU admission route (directly from home, transfer from the emergency department, transfer from a medical or surgical ward, or transfer from a rehabilitation unit or a residential home).
- The Katz ADL score (29) on admission and 1 month before admission.
- Body weight on admission and the reference weight during a stable period in the previous year, weight loss (yes/no; >5% in 1 month or >10% in 6 months, >10% in 1 month or >15% in 6 months), estimated height, and body mass index (weight/height²), and swallowing disorder at home (yes/no).
- The serum albumin level (if, according to the attending physician, the serum albumin level is likely to be inaccurate due to an abnormal state of hydration, the value on D2 or D3 can be recorded instead of the value on D0), prealbumin level, haemoglobin level, lymphocyte count, creatinine level, and vitamin D 25(OH) level.
- The Charlson Comorbidity Index (20), the NYHA score (30), a history of depression (yes/no; confirmed by the attending physician or a psychiatrist), cancer progressing at the time of treatment (yes/no), and the presence of metastases (yes/no).
- Known neurocognitive disorders (yes/no; diagnosed by a geriatrist or a neurologist), previous Mini Mental State Examination (MMSE) score (31) recorded during a stable period, memory complaints (yes/no; according to the patient and/or the family circle).
- Ability to walk during a stable period before hospital admission (yes, yes with assistance, confined to bed or a chair, or confined to bed), number of falls in the previous year, history of osteoporosis-related fractures (yes/no), and treatment of osteoporosis (none, calcium, vitamin D, bisphosphonates).

- ***During the hospital stay***

A state is assigned to the patient on each day of the hospital stay. There are five mutually exclusive states:

1. Late discharge, defined as the physician's reply to the following question: if the patient was in a stable state for all 24 hours of the previous working day (from 8am to 8am), and if he/she had received all the material and organisational assistance required for discharge (family circle, home help, financial assistance, an immediate place in a rehabilitation unit or a residential home, etc.), would you have authorized his/her discharge on that previous day?
2. Community-acquired infection, defined as: hospital admission justified by a confirmed community-acquired infection if the clinical, laboratory and radiological symptoms started before hospital admission or within

72 hours of admission to the establishment. The site of the infection is specified (urinary tract, respiratory tract, bacteraemia, digestive tract, *Clostridium difficile*, skin).

3. Hospital-acquired infection, defined as: hospital admission justified by an infection that appeared at least 72 hours after admission to the healthcare establishment. Surgical site infections were excluded for methodological reasons. The site of the infection is specified (urinary tract, respiratory tract, bacteraemia, *Clostridium difficile*, other).

4. Palliative care: hospital care with limitation of treatment decided in a multidisciplinary staff meeting, in view of the patient's state of health.

5. Medical obstacle to discharge: assigned if the patient does not meet any of the definitions 1 to 4.

Furthermore, the patient was assessed daily for delirium (according to the Confusion Assessment Method). The MMSE was administered at the end of the hospital stay if the patient was stable.

- **Discharge**

The following items were recorded on the day of discharge: the Katz ADL score, the body weight, and the destination/outcome:

- Home
- Rehabilitation unit
- Return to a residential home
- Transfer to a medical or surgical ward
- Transfer to a palliative care unit
- Death

Supplement data 2:

Characteristics of the two subgroups.

	Subgroup 1 (n=2169)		Subgroup 2 (n=912)		p-values
	N	Value	N	Value	
SOCIAL & CLINICAL CHARACTERISTICS					
Age, years (mean ± SD)	2169	86.5 ± 5.4	912	86.3 ± 5.5	0.7
Sex (male) *N* (%)	2169	707 (32.5)	912	344 (37.8)	**0.004**
Place of residence *N* (%)	2167		910		0.3
At home		1743 (80.3)		744 (81.8)	
In a residential home		424 (19.3)		166 (18.1)	
Hospitalized in the previous 6 months *N* (%)	2121	758 (35.7)	884	441 (49.6)	**0.001**
Charlson Comorbidity Index *N (%)*	2169		912		**0.001**
0 – 2		983 (45)		310 (34)	
3 – 4		1001 (46)		484 (53)	
>4		185 (8.5)		118 (13)	
Cancer *N* (%)	2160	291 (13.5)	905	169 (18.7)	**< 0.001**
GERIATRIC SYNDROMES					

Living alone *N* (%)	2165	1001 (46.2)	905	41[illegible] (44.5)	0.7
Socially isolated *N* (%)	2164	178 (8.3)	903	84 (9.3)	0.3
Number of medications taken at home (mean ± SD)	2169	7.7 ± 3.5	912	8.[illegible] ± 3.7	**< 0.001**
Polypharmacy[1] *N* (%)	2169	613 (23.4)	912	31[illegible] (34.4)	**< 0.001**
Psychotropic medication *N* (%)	2151	1197 (54.8)	903	50[illegible] (55.5)	0.7
Katz ADL at home[2] *N (%)*	2056		854		**0.007**
≥ 3		1583 (73)		6[illegible] (69.8)	
< 3		586 (27)		2[illegible] (30.8)	
Body mass index (mean ± SD)	1967	25.1 (5.7)	838	25.[illegible] (6.8)	0.4
Malnutrition[3] *N* (%)	2109	247 (11.7)	889	14[illegible] (16.4)	**0.026**
Swallowing disorder *N* (%)	2133	309 (14.5)	896	14[illegible] (16.6)	0.3
History of depression *N* (%)	2160	453 (21)			0.068
Cognitive disorder[4] *N* (%)	1936		912		0.5
No		433 (14.8)		2[illegible] (28.7)	
Memory complaints		943 (48.7)		3[illegible] (35.1)	
Known neurocognitive disorders		793 (36.5)		3[illegible] (36.2)	
Walking ability *N* (%)	2165		907		0.3
No, confined to bed		101 (4.7%)		5[illegible] (5.6)	
No, bed or chair only		292 (13.5%)		125 (13.7)	
Walks with assistance		986 (45.5%)		429 (47.[illegible])	
Walks unaided		786 (36.3%)		302 (33.1)	

CHANGES IN HOSPITAL					
Katz ADL on admission (median [IQR])	2167	3.0 [1.0; 5.0]	906	3.0 [1.0; 5.0]	0.3
Katz ADL on discharge (median [IQR])	2143	4.0 [2.0; 5.0]	891	4.0 [2.0; 5.0]	**0.041**
Change in Katz ADL in hospital *N* (%)	2141		889		0.28
Worse		183 (9)		92 (10)	
Stable		1213 (56)		497 (56)	
Better		745 (35)		300 (34)	
Body weight on admission, kg (median [IQR])	2064	64.5 [54.6; 76.6]	867	65.4 [55.3; 76.7]	**0.034**
Body weight on discharge, kg (median [IQR])	1558	63.8 [54; 75.7]	672	64.9 [55.3; 76.6]	0.2
Change in body weight in hospital *N* (%)	1515		665		0.093
Decrease		719 (47)		328 (49)	
Stable		294 (19)		135 (20)	
Increase		502 (34)		202 (30)	
Serum albumin level, g/L (mean ± SD)	2132	32 ± 5.3	889	31.4 ± 5.5	**0.007**
Blood haemoglobin level, g/L (mean ± SD)	2169	11.8 ± 1.9	910	11.5 ± 1.9	**< 0.001**
Serum creatinine level, µmol/mL (median [IQR])	2169	82.7 [62.5; 113.5]	912	90.6 [66.8; 126.9]	**< 0.001**
Delirium on admission *N* (%)	2169	314 (14.4)	912	113 (12.4)	0.13
Time spent in each state during the hospital stay, days (mean ± SD)	2169		912		**0.046**
Late discharge[5]		3.6 ± 4.2		3.6 ± 4.7	
Medical obstacle to discharge[6]		5.1 ± 4.5		5.6 ± 5.2	
Community-acquired infection		1.3 ± 2.7		1.5 ± 3.2	

Hospital-acquired infection	0.3 ± 1.6	0.4 ± 1.9	
FOLLOW-UP			
Patients readmitted to hospital *N* (%)	1550 (71.5)	912 (100)	**< 0.001**
1 hospital readmission	619 (28.5)	912 (100)	
2 hospital readmissions	0	608 (66.7)	
3 hospital readmissions	0	232 (25.4)	
4 hospital readmissions	0	95 (10.4)	
5 hospital readmissions	0	59 (6.5)	
Death during follow-up *N* (%)	495 (22.8)	523 (57.8)	**< 0.001**

Supplement data 3:

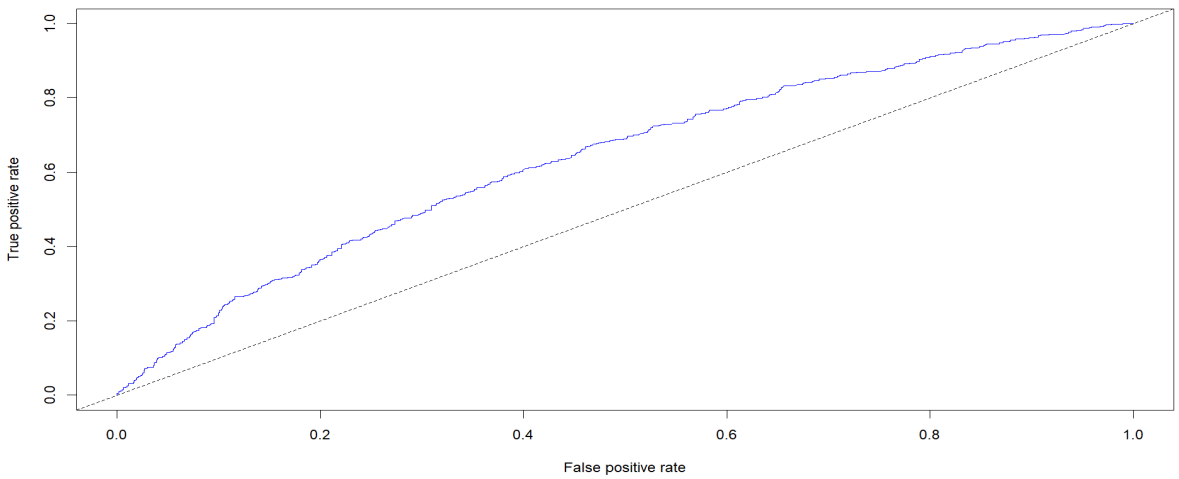
Results of a bivariate analysis of the logistic regression model predicting membership of subgroup 2

	OR	95%CI
SOCIAL & CLINICAL CHARACTERISTICS		
Age, years	0.96	(0.81, 1.14)
Sex (male)	**0.79**	**(0.67, 0.93)**
Place of residence		
At home	Reference	-
In a residential home	0.92	(0.75, 1.12)
Hospitalized in the previous 6 months	**1.24**	**(1.17, 1.33)**
Charlson Comorbidity Index		
0 – 2	Reference	-
3 – 4	**1.53**	**(1.29, 1.81)**
>4	**1.97**	**(1.51, 2.56)**
Cancer	**1.47**	**(1.20, 1.81)**
GERIATRIC SYNDROMES		
Living alone	0.97	(0.83, 1.14)
Socially isolated	1.39	(0.86, 1.49)
Number of medications taken at home	**1.05**	**(1.03, 1.07)**
Polypharmacy	**1.26**	**(1.05, 1.51)**
Psychotropic medication	1.06	(0.99, 1.15)
Katz ADL at home	**0.95**	**(0.92, 0.99)**
Body mass index	1.00	(0.99, 1.02)
Malnutrition	1.18	(0.93, 1.48)
Swallowing disorder	1.11	(0.89, 1.38)
History of depression	0.83	(0.68, 1.01)
Cognitive disorder	0.94	(0.80, 1.11)
Walking ability		
Walks unaided	Reference	-
No, confined to bed	1.16	(0.81, 1.64)
No, bed or chair only	0.98	(0.77, 1.25)
Walks with assistance	0.88	(0.74, 1.05)
CHANGES IN HOSPITAL		
Katz ADL on admission	0.98	(0.94, 1.02)
Katz ADL on discharge	0.96	(0.93, 1.00)
Change in Katz ADL in hospital		
Stable	Reference	
Worse	1.24	(0.94, 1.63)
Better	1.01	(0.86, 1.20)
Body weight on admission, kg	1.01	(1.00, 1.02)
Body weight on discharge, kg	1.00	(0.99, 1.02)
Change in body weight in hospital		
Stable	Reference	-
Decrease	1.24	(0.96, 1.61)
Increase	**1.35**	**(1.03, 1.77)**
Serum albumin level, g/L	**0.97**	**(0.96, 0.99)**
Blood haemoglobin level, g/L	**0.92**	**(0.88, 0.96)**
Serum creatinine level, µmol/mL	**1.03**	**(1.02, 1.04)**
Delirium on admission	0.84	(0.66, 1.05)
Time spent in each state during the hospital stay, days		
Late discharge	Reference	-

Medical obstacle to discharge	1.03	(0.62, 1.76)
Community-acquired infection	1.03	(0.61, 1.79)
Hospital-acquired infection	2.03	(0.91, 4.55)
DAMAGE death risk score	**1.37**	**(1.22, 1.51)**

Supplement data 4 (color should be used):

ROC curve for the prediction of hospital readmission



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Identifying specific subgroups of older patients at risk of repeated hospital readmissions and death after discharge in a prospective multicentre cohort in France

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Title: Identifying specific subgroups of older patients at risk of repeated hospital readmissions and death after discharge in a prospective multicentre cohort in France

Abstract

Objective: To identify specific subgroups of older patients at risk of repeated hospital readmissions and death.

Design: prospective, multicentre, DAMAGE cohort of adults aged 75 and over, discharged from an acute geriatric unit, and followed-up for 12 months.

Setting: Six recruiting hospital centres in the Hauts-de-France and Normandie regions of France.

Main outcome measures: We performed a latent class analysis to identify subgroups at risk of repeated hospital readmissions and death, followed by a logistic regression analysis to determine the characteristics associated with the identified subgroups.

Results: 3081 patients were included (mean (SD) age: 86.4 (5.5)) and two subgroups were identified. In subgroup 1 (n=2169, 70.4%), only 619 (28.5%) patients were readmitted to hospital once during the follow-up, and 495 (22.5%) died. In subgroup 2 (n=912, 29.6%), all patients were readmitted to hospital at least twice, and 523 (57.8%) died. Subgroup 2 accounted for 29.6% of patients but 74.4% of hospital readmissions, with longer lengths of stay, and 51.6% of deaths. A multivariate logistic regression analysis identified only four characteristics weakly associated with the risk of being in subgroup 2 (at least one hospital admission in the six months preceding the index hospital admission, cancer, polymedication, and weight changes (gain or loss) during the index hospital admission). The area under the receiver operating characteristic curve was 63%.

Conclusion: A latent class analysis showed that a population of older adults hospitalized in an AGU is divided into two subgroups with regard to the post-discharge outcomes: one subgroup (70% of the individuals) will have a low rate of hospital readmission and a moderate death rate, whereas the other will have a high rate of hospital readmission and a very high death rate. There is a need for predictive scores for both events, with a view to better targeting at-risk patients.

STRENGHTS AND LIMITATIONS OF THIS STUDY

- Use of high-quality data from a multicentre cohort.

- Long follow-up (one-year).

- Accounting for hospital readmissions as a recurrent events process, using a specific statistical analysis adapted for such data.

- Use of clustering to classify patients into a class increases the chances of having groups correlated with hospital readmissions and death.

- The analysis was limited to older patients discharged from an acute geriatric unit

INTRODUCTION

Hospital readmission is frequent in older adults and is associated with greater morbidity and mortality, loss of autonomy, and excessive healthcare costs.[1–4] Initiatives to reduce the risk of hospital readmission among older adults have had mixed results.[5,6] Most of these initiatives are based on the determination of clinical characteristics associated with the first hospital readmission (typically within a timeframe ranging from 30 days to 12 months) and thus the identification of at-risk older adults.[3,7,8]

Recent research results have shown that the hospital readmission process is not limited to the first readmission; the process is dynamic, with each new hospital readmission increasing the risk of further readmissions within increasingly shorter timeframes. Moreover, the hospital readmission process is associated with the risk of death.[9] Lastly, clinical characteristics do not account for much of the variability in the risk of multiple hospital readmissions.[10] All these elements suggest that there is poorly explored, poorly explained heterogeneity in older adults' outcomes (i.e. hospital readmission, and death after the first readmission). In this context, it can be useful to identify within the whole heterogeneous population some subgroups, which are more homogeneous in terms of different characteristics (potential risk factors for the repeated hospital admissions). The difficulty is that specific characteristics which determine these subgroups are often not directly observed, even though they depend on the observed patients' features. It is assumed that the subgroups are determined by some latent (not observed) variable, called latent class. The statistical tool, called latent class analysis can be used to identify subgroups within a large but heterogeneous population.[11] Usefully, this approach does not require *a priori* knowledge or explanations in terms of clinical characteristics, but the identified subgroups (latent classes) can be characterized *a posteriori* by observed clinical characteristics. To the best of our knowledge, latent class analysis has not previously been used to study the heterogeneity of older adults with regard to the risk of repeat hospital readmissions and death after the first hospital readmission.

The objectives of the present study were to (i) identify specific subgroups of older patients at risk of repeat hospital readmissions and death after the initial hospital stay and (ii) determine the associated characteristics.

METHODS

Study Design

The DAMAGE study is a multicentre, prospective cohort study of patients aged 75 or over hospitalized in an acute geriatric unit (AGU) in the Hauts-de-France and Normandie regions of France (NCT02949635). The six recruiting centres are Lille University Hospital (Lille, France; 2 AGUs), Saint Philibert Hospital (Lille, France; 1 AGU), Amiens-Picardie University Hospital (Amiens, France; 1 AGU), Caen University Hospital (Caen, France; 1 AGU), and Saint Quentin General Hospital (Saint Quentin, France; 1 AGU). Patients discharged from the AGU to a non-acute facility (the patient's home, a residential home, or a rehabilitation unit) were followed up for one year. The inclusion period ran from September 14th, 2016, to January 29th, 2018. The last 12-month follow-up visit was performed on January 29th, 2019.

Ethical Approval

The DAMAGE study was conducted in compliance with the terms of the Declaration of Helsinki and was approved by the local independent ethics committee (*CPP Nord-Ouest IV*, Lille, France) on February 13th, 2015, with an amendment approved on January 21st, 2016 (reference: IDRCB 2014 A01670 47, CNIL bxA15352514). The patients and their primary family caregivers or legal representatives were given detailed verbal and written information about the study, in order to ensure that the patients fully understood the potential risks and benefits of participation. In accordance with the French legislation on observational, non-interventional studies of routine clinical care, written consent was not required. The patients were informed that they could refuse to participate in the study and that refusal would not have any impact on their treatment in the AGU. If the patient was potentially unable to state his/her refusal to participate in the DAMAGE study, the next of kin or legal representative could refuse participation.

Inclusion and Exclusion Criteria

All patients aged 75 and over, with health insurance coverage and hospitalized in an AGU were eligible for inclusion in the study. Patients hospitalized in the AGU for less than 48 hours were not included because this short duration prevented the completion of a comprehensive geriatric assessment. Patients admitted for immediate palliative care were not considered for inclusion in the study because of the high risk of death. Lastly, patients who

refused to participate to the study (as notified by the patient or his/her primary family caregiver or legal representative) were not included. However, cognitive impairment was not an exclusion criterion *per se*.

Patients who died in the AGU were excluded because one of the study's objectives concerned the assessment of the death rate after discharge. Patients transferred to another acute care ward (a surgical ward or a non-geriatric ward) without returning to the AGU were also excluded. Lastly, patients transferred to palliative care units or having received palliative care during the stay in the AGU were excluded because of the above-mentioned high risk of death.

Collection of Data During the Stay in the AGU

Data were collected at various time points during the initial stay in the AGU, using a case report form. The social, clinical and geriatric variables recorded within 72 hours of admission, during the hospital stay, and upon discharge are listed in Supplement 1.

- The social and clinical variables recorded on admission included the age, sex, type of home environment (own home or residential home), number of previous hospital stays, the Charlson Comorbidity Index (CCI),[12] and whether or not the patient had a diagnosis of cancer. The geriatric variables recorded on admission included the number of medications usually taken, dependency before hospital admission (the Katz Index of independence in activities of daily living (Katz ADL)),[13] malnutrition (weight loss and the body mass index), cognitive disorders, any history of depression, swallowing disorders, and walking ability. Standard laboratory variables were also recorded.

- During the hospital stay, a daily evaluation of clinical status enabled us to classify the patient into one of five predefined states: late discharge (defined by the doctor in charge as being medically fit for discharge but remain in hospital for social or personal reasons[14]), a medical obstacle to discharge (other than infection), treatment of a community-acquired infection, treatment of a hospital-acquired infection, and palliative care. These clinical states were mutually exclusive (i.e. only one state per day and per patient) and were determined by the patient's attending physician.

- On the day of discharge, geriatric variables were also recorded: the patient's bodyweight, the bodyweight difference between admission and discharge, the Katz ADL on discharge, the difference in Katz ADL between admission and discharge, and the discharge destination (the patient's own home, a

residential home, or a rehabilitation unit). The collected data were audited. Lastly, data collected during the hospital stay was used to calculate the one-year mortality risk score (the DAMAGE score) developed in a previous study of the same cohort.[14]

Follow-Up

The exact date of hospital readmission and the exact date of death (if applicable) were collected at 3 and 12 months after the index discharge from the AGU; this was done by phoning the patient (if alive), his/her next of kin or caregiver or the referring healthcare professional in a community setting (e.g. the general practitioner). Patient mortality was also evaluated by consulting freely available national mortality data. The 12-month follow-up period corresponded to the main objective of the DAMAGE cohort, which sought to develop a prognostic score for 3- and 12-month mortality after discharge from an AGU, based on a comprehensive geriatric assessment, and in-hospital events. [14]

Statistical Analysis

Categorical variables were expressed as the frequency (percentage). Continuous variables were expressed as the mean ± standard deviation (SD) if normally distributed or as the median [interquartile range (IQR)] otherwise. Normal data distributions were checked graphically and by applying the Shapiro–Wilk test.

To identify homogeneous subgroups of patients in terms of the risk of repeated hospital admission, we performed a latent class analysis.[15] This approach combines the well-known Andersen-Gill model,[16] which models the occurrence of recurrent events and has already been used to study hospital readmissions of older adults,[9,10] with the mixture model,[17] allowing to account for a mixture of distributions (distributions with different parameters). The probability of belonging to a so-called "latent" class, i.e. one not directly observed in the data, is a parameter estimated from observed data. Latent classes are constructed on the basis of the observed responses (hospital readmission) of cases (patients) on a set of indicator variables (observed and collected variables). Patients are assigned to classes with the highest probability of membership *a posteriori* (after the model parameters estimation), and the variables associated with the recurrence process in the Andersen-Gill model can be specific to these latent classes. This approach has the advantage of not requiring *a priori* knowledge of the classes or an explanation of the classes in terms of clinical characteristics. Death, on the other hand, is considered as censorship.

The intergroup difference between the identified latent classes was assessed *a posteriori* in Student's t-test (for normally distributed data) or Wilcoxon's test (in all other cases) for continuous variables; for qualitative variables, a chi-squared test was applied.

A logistic regression model was used to explore *a posteriori* (i.e. after the classes had been identified by the latent class model) patients' risk of belonging to a specific subgroup of hospital readmission process (corresponding to the identified latent class), based on the observed characteristics measured at baseline. The variables included in the logistic regression model were selected in several stages. As many of the explanatory variables were redundant, a principal component analysis[18] was carried out to pre-select a subset of independent variables for inclusion in the model. Next, to avoid case loss in univariate and multivariate analyses, missing data for candidate predictors (the proportion of missing data ranged from 0% to 8.6%, depending on the variable) were imputed by multiple imputation using the regression-switching approach (chained equations, m=5 imputations).[19] The imputation procedure was performed with the missing-at-random assumption, with the predictive mean-matching method for quantitative variables and logistic regression models (binary, ordinal, or multinomial) for qualitative variables. Rubin's rules were used to combine the estimates derived from multiple imputed data sets.[20] Lastly, an automatic step-by-step variable selection procedure (based on the Akaike information criterion[21] was used in a duration model for recurrent events (hospital readmission, in our case).[16] The overall procedures of the data analysis is shown in figure 1.

All analyses were performed with R software (version 3.4.3) (R core team, 2013).[22]

Patient and public involvement

None.

RESULTS

Study population

Of the 3509 patients hospitalized in an AGU, 202 died during the hospital stay, 97 were transferred to another non-geriatric acute medical or surgical unit (without returning to the AGU), and 98 were lost to follow-up after receiving palliative care and/or transfer to a palliative care unit. A total of 3112 patients met all the inclusion criteria and none of the exclusion criteria. 31 patients had hospital admission date errors during the follow-up period. Our analyses, therefore, covered a total of 3081 patients.

The general characteristics of the DAMAGE cohort (Table 1) shows that the population was very old (mean (SD) age: 86.4 (5.5)) and predominantly female (66%). Around a third of the patients were malnourished (28%) or had been diagnosed with a neurocognitive disorder (36%). At the end of the one-year follow-up period, 1447 patients (47%) had been readmitted to hospital: 856 patients had been readmitted (19%) only once, and 591 (28%) had been readmitted at least twice. A total of 1014 patients (32.9%) had died by the end of the follow-up period.

Patient outcomes at discharge from the AGU

The latent class analysis identified two subgroups within the DAMAGE cohort in terms of post-hospitalization outcomes (Table 2). The difference was mainly related to the number of hospital readmissions. The vast majority of older adults in subgroup 1 (n=2169, 70.4%) were not readmitted to hospital during follow-up, and a few were readmitted but only once. In contrast, all the older adults in subgroup 2 (n=912, 29.6%) were readmitted to hospital at least twice during follow-up. The death rate was also 2.5 times higher in subgroup 2 than in subgroup 1. Subgroup 2 accounted for 29.6% of the overall population but 74.4% of hospital readmissions and 51.6% of deaths. The mean cumulative number of hospitalizations by subgroups 1 or 2, over the follow-up period, is summarized in Figure 2. At the end of follow-up, patients in subgroup 2 had, on average, more than three hospital readmissions, while those in subgroup 1 had fewer than one.

The proportion (in %) of the total follow-up period spent in hospital was three times higher in subgroup 2 (median [IQR]: 6.3% [3.6; 11.7]) than in subgroup 1 (median [IQR]: 2.2% [1.4; 4.1]). Hospital stays were also significantly longer for subgroup 2 patients, with a median of 18 days (IQR: [10; 30]), compared with 8 days (IQR: [5; 14]) for subgroup 1 patients. Of the 523 patients who died in subgroup 2, all were readmitted to hospital before death,

whereas a minority of the 491 patients who died in subgroup 1 (N= 37, 7.5%) were readmitted to hospital during follow-up, before death.

Subgroup prediction based on variables

In a bivariate analysis, a total of 12 characteristics were associated with belonging to the most at-risk subgroup (Supplemental Data 3). In the multivariate analysis, only four characteristics were independently associated with belonging to the most at-risk subgroup: at least one hospital admission in the six months preceding the index hospital admission, cancer, polymedication, and weight changes (gain or loss) during the index hospital admission. The ORs associated with these characteristics were low and ranged from 1.05 to 1.63 (Table 3). The area under the receiver operating characteristic (ROC) curve was 63% (Supplemental Data 4). Bivariate analysis with the DAMAGE death risk score showed a weak association, with an OR 95% confidence interval (CI) of 1.37(1.22,1.53).

DISCUSSION

Our results showed that older adults discharged from an AGU can be divided into two outcome categories. Barely 30% of patients accounted for more than two-thirds of future hospital readmissions and more than half of all deaths in the entire cohort. These patients had longer hospital stays and spent more time in hospital during the follow-up period.

Most studies of the post-hospitalization fate of older adults have been limited to either an analysis of the first hospital readmission (within a timeframe ranging from 1 to 24 months)[7,8,23,24] or the risk of death (within a timeframe ranging from 1 month to several years).[25,26] These approaches have clear limitations, such as inability to deal with multiple hospital readmissions during follow-up or to take account of the link between hospital readmission and death.[23] The results of our latent class analysis confirmed that the outcomes in a population of older adults hospitalized in the AGU were heterogeneous. In subgroup 1, few older adults are readmitted to hospital, the death rate is 22%, and most deaths occur without hospital readmission. This situation appears to correspond to the wishes expressed by older adults as to the preferred place of death (home).[27,28] In contrast, the older adults in subgroup 2 were often readmitted to hospital – sometimes for longer periods – and had a death rate of 52% at the end of the study. This situation probably runs counter to the wishes of older adults with regard to the end-of-life. Furthermore, this situation may call into question the appropriateness of the use of healthcare resources for these patients: were all these hospital readmissions driven primarily by medically justified reasons, and in line with the patient's wishes? Would home care have been possible? In the case of progressive illnesses or multimorbidity, the wishes of older patients change, with a final preference for home care.[29] Multiple hospital readmission is a risk factor for fragmented care and inconsistent management of chronic diseases, and is not necessarily chosen by older adults.[29,30]

In order to adapt the care offered to patients and their carers, it would therefore be necessary to predict the risk of belonging to subgroup 2. In this respect, the results of our study are disappointing. While 40 distinct characteristics (including per-hospital events) were recorded in the DAMAGE study, all were only weakly associated with the risk of belonging to subgroup 2, and the area under the ROC curve was only 63%. The association with the DAMAGE death risk score was weak, even though the latter was developed specifically in this cohort. This is explained by the fact that 48.8% of the patients who died belonged to subgroup 1: the risk of death is not very discriminant for belonging to subgroup 1 vs. subgroup 2. Several scores for predicting the risk of hospital readmission at 30 days have been developed.[26,31] These scores effectively predict the occurrence of a new hospital

admission[32] and identify the patients most at risk of failure to return home.[33] However, our study showed that 42.7% of the patients readmitted to hospital belong to subgroup 1. These older adults will only be readmitted to hospital once over 12 months and are very unlikely to die during that period of time. The risk of the first hospital readmission is therefore of little significance in determining whether a patient belongs to subgroup 1 or subgroup 2. All in all, our results call for a change in the objectives of these scores, and a move beyond the separate, exclusive prediction of two classes, "first hospital readmission " or "death". Our results also suggest that work is needed to identify characteristics more strongly associated with the risk of multiple hospital readmissions and death (subgroup 2). In older patients, a multitude of factors other than clinical characteristics come into play: support for caregivers,[34] optimized care provision on discharge from the hospital, etc.[35]

The main strengths of our work are as follows: the use of high-quality data from a multicentre cohort of AGU patients; a low proportion of missing data (often less than 5%); novelty, as (to the best of our knowledge) the first multicentre studies of older adults admitted to an AGU and with a standardized geriatric assessment; the small number of exclusion criteria; and the use of latent class analysis, which had not previously been applied in studies of multiple hospital readmissions and death at discharge from an AGU. This analysis uses a specific statistical model, suitable for tracking recurrent events such as hospital readmissions. It therefore provides a methodology adapted to and in line with clinical intuitions, in order to reliably model the reality of patients' repeated hospital readmissions. [36] Similarly, the use of a mixture model to classify patients into a class that is not directly observed in the data, but is estimated from the data, draws a direct parallel with the intuition that an experienced clinician may draw, when faced with a patient at the end of life and at high risk of repeated hospitalizations. The advantage of this approach is that it increases the chances of having groups correlated with hospital readmissions, whereas classifying on the basis of independent variables would risk producing groups less relevant to the hospital readmission process.

Our study had several limitations. Firstly, the older patients in our cohort were discharged from an AGU and were most often very old, with multiple comorbidities. Hence, our results cannot be extrapolated to the population of older adults as a whole, nor to patients transferred to a medical department other than the AGU before discharge, which did not prevent them from being readmitted at a later date. Secondly, the case report form was initially filled in manually and then recoded electronically for statistical analysis. This may have led to data entry errors. Lastly, the latent classes identified here might be specific to the population of older patients in the DAMAGE cohort and

might not be found among all older patients discharged from an AGU. However, the number of older patients in the DAMAGE cohort was large (over 3,000).

CONCLUSION

Our results showed that older adults discharged from an AGU can be divided into two outcome categories. On one hand, some patients accounted for more than a third of hospital readmissions, more than half of the deaths, and the longest hospital stays. On the other, some patients were never or rarely readmitted to hospital and were unlikely to die. There is a need for predictive scores for both events, with a view to better targeting at-risk patients.

Contributors: VF: Conception, statistical analysis, writing and editing. BG: Statistical analysis, critical review and editing. CBJ: Statistical analysis, critical review and editing. DG: Conception, critical review and editing. VV: Statistical analysis, critical review and editing. BJB: Conception, statistical analysis, writing and editing. VF is responsible for the overall content as the guarantor. All authors contributed to the final draft of the manuscript.

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Conflicts of Interest:

The authors report no conflicts of interest.

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Data Availability

The data are available upon request to the corresponding author.

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Figure legends

Figure 1: The overall procedures of the data analysis.

Figure 2: Graphical representation of the mean cumulative number of hospitalizations for each time point, by subgroups.

Tables

Table 1: Characteristics of the overall study population

	Study population (n=3081)	
	N	**Value**
SOCIAL & CLINICAL CHARACTERISTICS		
Age, years (mean ± SD)	3081	86.4 ± 5.5
Sex (male) *N* (%)	3081	1050 (34.1)
Place of residence *N* (%)	3077	
At home		2484 (80.7)
In a residential home		593 (19.2)
Hospitalized in the previous 6 months *N* (%)	3028	1178 (38.9)
Charlson Comorbidity Index *N (%)*	3081	
0 – 2		1295 (42)
3 – 4		1485 (48)
>4		300 (9.9)
Cancer *N* (%)	3059	459 (15.0)
GERIATRIC SYNDROMES		
Living alone *N* (%)	3063	1412 (46.1)
Socially isolated *N* (%)	3050	261 (8.6)
Number of medications taken at home (mean ± SD)	3077	7.9 ± 3.6
Polypharmacy[a] *N* (%)	3026	655 (21.6)
Psychotropic medication *N* (%)	3047	1679 (55.1)
Katz ADL at home[b] *N (%)*	2905	
≥ 3		2217 (76.3)
< 3		688 (23.7)
Body mass index (mean ± SD)	2800	25.1 ± 5.7
Malnutrition[c] *N* (%)	2890	808 (28)
Swallowing disorder *N* (%)	3023	449 (14.8)
History of depression *N* (%)	3055	614 (20.1)
Cognitive disorder[d] *N* (%)	3081	
No		1406 (45.6)
Memory complaints		566 (18.4)
Known neurocognitive disorders		1109 (36)
Walking ability *N* (%)	3065	
No, confined to bed		151 (4.9)
No, bed or chair only		416 (13.6)
Walks with assistance		1412 (46.1)
Walks unaided		1086 (35.4)
CHANGES IN HOSPITAL		
Katz ADL on admission (median [IQR])	3066	3.0 [1.0; 5.0]
Katz ADL on discharge (median [IQR])	3028	4.0 [2.0; 5.0]
Change in Katz ADL in hospital *N* (%)	3024	
Worse		274 (9.1)
Stable		1699 (56.2)
Better		1051 (34.8)

Body weight on admission, kg (median [IQR])	2926	64.9 [55.0; 76.6]
Body weight on discharge, kg (median [IQR])	2225	64.0 [54.0; 76.0]
Change in body weight in hospital *N* (%)	2176	
Decrease		1034 (47.5)
Stable		398 (18.3)
Increase		744 (34.2)
Serum albumin level, g/L (mean ± SD)	3015	31.8 ± 5.4
Blood haemoglobin level, g/L (mean ± SD)	3075	11.7 ± 1.9
Serum creatinine level, µmol/mL (median [IQR])	3075	87.5 [64.5; 114.9]
Delirium on admission *N* (%)	3081	425 (13.8)
Time spent in each state during the hospital stay, days (mean ± SD)	3081	
Late discharge[e]		3.6 ± 4.1
Medical obstacle to discharge[f]		5.3 ± 4.7
Community-acquired infection		1.4 ± 2.9
Hospital-acquired infection		0.3 ± 1.7
FOLLOW-UP		
Number of hospital admissions during follow-up *N*		2670
Patients readmitted to hospital *N* (%)		1531 (49)
1 hospital readmission		856 (19)
2 hospital readmissions		350 (11)
3 hospital readmissions		142 (4.6)
4 hospital readmissions		63 (2.0)
5 hospital readmissions		18 (0.5)
Death during follow-up *N* (%)		1014 (32.9)

Note.
N: number of patients with no missing data
ADL: activities of daily living
SD: standard deviation.
IQR: interquartile range.
[a] at least 10 medications taken at home.
[b] Dependence before admission was defined as a Katz ADL score at home <3.
[c] Weight loss >5% in 1 month or >10% in 6 months, or body mass index <21.
[d] Memory complaints reported by the family or the patient, or known neurocognitive disorders.

[e] Late discharge, defined as being in a stable state for all 24 hours of the previous working day.
[f] Medical obstacle to discharge: assigned if the patient was not in any of the other states (late discharge, treatment of a community-acquired infection, treatment of a hospital-acquired infection, or palliative care).

Table 2: Patient outcomes, by subgroup

FOLLOW-UP	Subgroup 1 (n=2169)	Subgroup 2 (n=912)	*P*
Age, years (mean ± SD)	86.5 (5.4)	86.3 ± 5.5	
Sex (male) N (%)	707 (32.5%)	345 (37.8%)	
Number of hospital admissions during follow-up *N*	619	2051	
Patients readmitted to hospital *N*	619	912	**< 0.001**
1 hospital readmission	619 (100)	912 (100)	
2 hospital readmissions	0	608 (66.7)	
3 hospital readmissions	0	232 (25.4)	
4 hospital readmissions	0	95 (10.4)	
5 hospital readmissions	0	59 (6.5)	
Length of hospital stay, days (median [IQR])	8 [5; 14]	18 [10; 30]	**< 0.001**
Proportion (%) of the total follow-up time spent in hospital (median [IQR])	2.2 [1.4; 4.1]	6.3 [3.6; 11.7]	**< 0.001**
Length of hospital stay before death, day (median [IQR])	10 [5; 13]	15.5 [8; 29]	**< 0.001**
Death during follow-up *N*	491	523	**< 0.001**
Patients readmitted to hospital before death N (%)	37 (7.5)	523 (100)	**< 0.001**

Table 3: Results of the multivariate analysis of the logistic regression model predicting membership of subgroup 2

	OR	95%CI
SOCIAL AND CLINICAL CHARACTERISTICS		
Age (years)		
(74 – 89)	Reference	-
(90 - 104)	1.07	(0.85, 1.35)
Sex (female)	0.81	(0.66, 1.01)
Place of residence		
At home	Reference	-
In a residential home	0.83	(0.61, 1.13)
Hospitalized in the previous 6 months	**1.25**	**(1.15, 1.36)**
Cancer (present)	**1.46**	**(1.11, 1.93)**
GERIATRIC SYNDROMES		
Malnutrition	1.29	(0.95, 1.74)
Swallowing disorder	1.21	(0.88, 1.66)
Katz ADL at home		
≥ 3	Reference	-
< 3	0.93	(0.85, 1.02)
Polypharmacy	**1.05**	**(1.02, 1.08)**
Cognitive disorder		
No	Reference	-
Known neurocognitive disorders	0.94	(0.75, 1.21)
Walking ability		
Walks unaided	Reference	-
Walks with assistance	1.07	(0.84, 1.37)
No, confined to bed	1.39	(071, 2.69)
No, bed or chair only	1.02	(0.68, 1.52)
Socially isolated	1.23	(0.85, 1.77)
CHANGES IN HOSPITAL		
Change in body weight in hospital		
Stable	Reference	-
Decrease	**1.44**	**(1.08, 1.94)**
Increase	**1.63**	**(1.21, 2.22)**
Change in Katz ADL in hospital		
Stable	Reference	-

Worse	1.28	(0.88, 1.84)
Better	1.04	(0.84, 1.31)

Figure 1: The overall procedures of the data analysis.

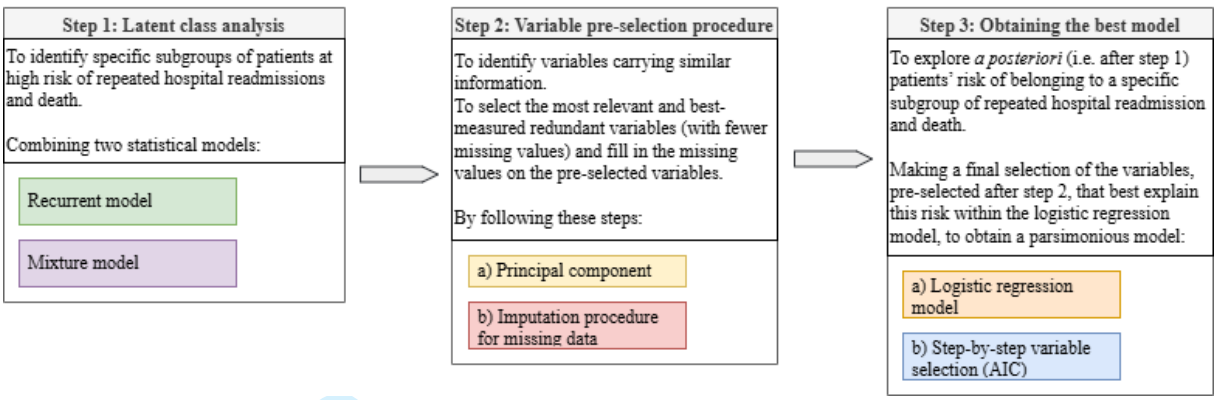
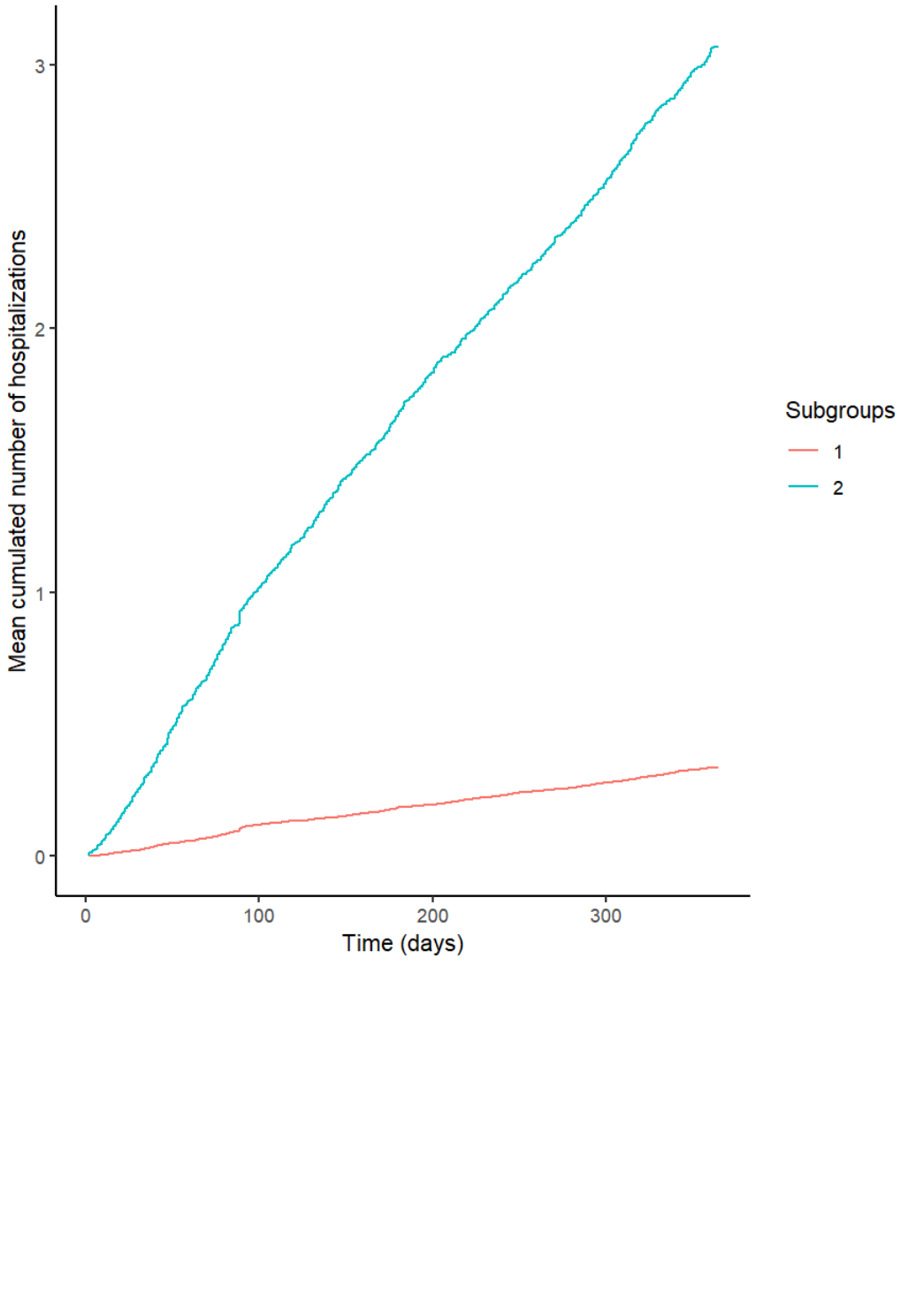


Figure 2 (color should be used): Graphical representation of the mean cumulative number of hospitalizations for each time point, by subgroups.

The average number of cumulated hospitalisations is calculated over all individuals at risk at each time point. Hospital readmissions accumulate faster in subgroup 2 than in subgroup 1. Overall, patients in subgroup 2 had more hospital readmissions, on average, than those in subgroup 1.



Supplemental data 1: Clinical assessment, outcomes, and data collection

- ***On admission***

A comprehensive geriatric assessment was performed during the stay in the AGU. Data on comorbidities, disease severity, previous hospital stays, medication, walking status, nutritional status, cognitive status, laboratory variables, and the caregiver burden were collected.

During the first 48 hours, the baseline characteristics were recorded:

- Age, sex, place of residence (at home, in a residential home), living alone (yes/no), social isolation (yes/no), number of hospital stays in the previous 6 months, the number of medications taken at home, and the number of psychotropic medications.
- AGU admission route (directly from home, transfer from the emergency department, transfer from a medical or surgical ward, or transfer from a rehabilitation unit or a residential home).
- The Katz ADL score (29) on admission and 1 month before admission.
- Body weight on admission and the reference weight during a stable period in the previous year, weight loss (yes/no; >5% in 1 month or >10% in 6 months, >10% in 1 month or >15% in 6 months), estimated height, and body mass index (weight/height²), and swallowing disorder at home (yes/no).
- The serum albumin level (if, according to the attending physician, the serum albumin level is likely to be inaccurate due to an abnormal state of hydration, the value on D2 or D3 can be recorded instead of the value on D0), prealbumin level, haemoglobin level, lymphocyte count, creatinine level, and vitamin D 25(OH) level.
- The Charlson Comorbidity Index (20), the NYHA score (30), a history of depression (yes/no; confirmed by the attending physician or a psychiatrist), cancer progressing at the time of treatment (yes/no), and the presence of metastases (yes/no).
- Known neurocognitive disorders (yes/no; diagnosed by a geriatrist or a neurologist), previous Mini Mental State Examination (MMSE) score (31) recorded during a stable period, memory complaints (yes/no; according to the patient and/or the family circle).
- Ability to walk during a stable period before hospital admission (yes, yes with assistance, confined to bed or a chair, or confined to bed), number of falls in the previous year, history of osteoporosis-related fractures (yes/no), and treatment of osteoporosis (none, calcium, vitamin D, bisphosphonates).

- ***During the hospital stay***

A state is assigned to the patient on each day of the hospital stay. There are five mutually exclusive states:

1. Late discharge, defined as the physician's reply to the following question: if the patient was in a stable state for all 24 hours of the previous working day (from 8am to 8am), and if he/she had received all the material and organisational assistance required for discharge (family circle, home help, financial assistance, an immediate place in a rehabilitation unit or a residential home, etc.), would you have authorized his/her discharge on that previous day?
2. Community-acquired infection, defined as: hospital admission justified by a confirmed community-acquired infection if the clinical, laboratory and radiological symptoms started before hospital admission or within

72 hours of admission to the establishment. The site of the infection is specified (urinary tract, respiratory tract, bacteraemia, digestive tract, *Clostridium difficile*, skin).

3. Hospital-acquired infection, defined as: hospital admission justified by an infection that appeared at least 72 hours after admission to the healthcare establishment. Surgical site infections were excluded for methodological reasons. The site of the infection is specified (urinary tract, respiratory tract, bacteraemia, *Clostridium difficile*, other).

4. Palliative care: hospital care with limitation of treatment decided in a multidisciplinary staff meeting, in view of the patient's state of health.

5. Medical obstacle to discharge: assigned if the patient does not meet any of the definitions 1 to 4.

Furthermore, the patient was assessed daily for delirium (according to the Confusion Assessment Method). The MMSE was administered at the end of the hospital stay if the patient was stable.

- **Discharge**

The following items were recorded on the day of discharge: the Katz ADL score, the body weight, and the destination/outcome:

- Home
- Rehabilitation unit
- Return to a residential home
- Transfer to a medical or surgical ward
- Transfer to a palliative care unit
- Death

Supplement data 2:

Characteristics of the two subgroups.

	Subgroup 1 (n=2169)		Subgroup 2 (n=912)		p-values
	N	Value	N	Value	
SOCIAL & CLINICAL CHARACTERISTICS					
Age, years (mean ± SD)	2169	86.5 ± 5.4	912	86.3 ± 5.5	0.7
Sex (male) *N* (%)	2169	707 (32.5)	912	344 (37.8)	**0.004**
Place of residence *N* (%)	2167		910		0.3
At home		1743 (80.3)		744 (81.8)	
In a residential home		424 (19.3)		166 (18.1)	
Hospitalized in the previous 6 months *N* (%)	2121	758 (35.7)	884	441 (49.6)	**0.001**
Charlson Comorbidity Index *N (%)*	2169		912		**0.001**
0 – 2		983 (45)		310 (34)	
3 – 4		1001 (46)		484 (53)	
>4		185 (8.5)		118 (13)	
Cancer *N* (%)	2160	291 (13.5)	905	169 (18.7)	**< 0.001**
GERIATRIC SYNDROMES					

Living alone *N* (%)	2165	1001 (46.2)	905	41[illegible] (44.5)	0.7
Socially isolated *N* (%)	2164	178 (8.3)	903	84 (9.3)	0.3
Number of medications taken at home (mean ± SD)	2169	7.7 ± 3.5	912	8.[illegible] ± 3.7	**< 0.001**
Polypharmacy[1] *N* (%)	2169	613 (23.4)	912	31[illegible] (34.4)	**< 0.001**
Psychotropic medication *N* (%)	2151	1197 (54.8)	903	50[illegible] (55.5)	0.7
Katz ADL at home[2] *N (%)*	2056		854		**0.007**
≥ 3		1583 (73)		6[illegible] (79.8)	
< 3		586 (27)		2[illegible] (20.8)	
Body mass index (mean ± SD)	1967	25.1 (5.7)	838	25.[illegible] (6.8)	0.4
Malnutrition[3] *N* (%)	2109	247 (11.7)	889	14[illegible] (16.4)	**0.026**
Swallowing disorder *N* (%)	2133	309 (14.5)	896	14[illegible] (16.6)	0.3
History of depression *N* (%)	2160	453 (21)			0.068
Cognitive disorder[4] *N* (%)	1936		912		0.5
No		433 (14.8)		2[illegible] (28.7)	
Memory complaints		943 (48.7)		3[illegible] (35.1)	
Known neurocognitive disorders		793 (36.5)		3[illegible] (36.2)	
Walking ability *N* (%)	2165		907		0.3
No, confined to bed		101 (4.7%)		5[illegible] (5.6)	
No, bed or chair only		292 (13.5%)		125 (13.7)	
Walks with assistance		986 (45.5%)		429 (47.[illegible])	
Walks unaided		786 (36.3%)		302 (33.1)	

CHANGES IN HOSPITAL					
Katz ADL on admission (median [IQR])	2167	3.0 [1.0; 5.0]	906	3.0 [1.0; 5.0]	0.3
Katz ADL on discharge (median [IQR])	2143	4.0 [2.0; 5.0]	891	4.0 [2.0; 5.0]	**0.041**
Change in Katz ADL in hospital *N* (%)	2141		889		0.28
Worse		183 (9)		92 (10)	
Stable		1213 (56)		497 (56)	
Better		745 (35)		300 (34)	
Body weight on admission, kg (median [IQR])	2064	64.5 [54.6; 76.6]	867	65.4 [55.3; 76.7]	**0.034**
Body weight on discharge, kg (median [IQR])	1558	63.8 [54; 75.7]	672	64.9 [55.3; 76.6]	0.2
Change in body weight in hospital *N* (%)	1515		665		0.093
Decrease		719 (47)		328 (49)	
Stable		294 (19)		135 (20)	
Increase		502 (34)		202 (30)	
Serum albumin level, g/L (mean ± SD)	2132	32 ± 5.3	889	31.4 ± 5.5	**0.007**
Blood haemoglobin level, g/L (mean ± SD)	2169	11.8 ± 1.9	910	11.5 ± 1.9	**< 0.001**
Serum creatinine level, µmol/mL (median [IQR])	2169	82.7 [62.5; 113.5]	912	90.6 [66.8; 126.9]	**< 0.001**
Delirium on admission *N* (%)	2169	314 (14.4)	912	113 (12.4)	0.13
Time spent in each state during the hospital stay, days (mean ± SD)	2169		912		**0.046**
Late discharge[5]		3.6 ± 4.2		3.6 ± 4.7	
Medical obstacle to discharge[6]		5.1 ± 4.5		5.6 ± 5	
Community-acquired infection		1.3 ± 2.7		1.5 ± 3.2	

Hospital-acquired infection	0.3 ± 1.6	0.4 ± 0.9	
FOLLOW-UP			
Patients readmitted to hospital *N* (%)	1550 (71.5)	912 (100)	**< 0.001**
1 hospital readmission	619 (28.5)	912 (100)	
2 hospital readmissions	0	608 (66.7)	
3 hospital readmissions	0	232 (25.4)	
4 hospital readmissions	0	95 (10.4)	
5 hospital readmissions	0	59 (6.5)	
Death during follow-up *N* (%)	495 (22.8)	523 (57.8)	**< 0.001**

Supplement data 3:

Results of a bivariate analysis of the logistic regression model predicting membership of subgroup 2

	OR	95%CI
SOCIAL & CLINICAL CHARACTERISTICS		
Age, years	0.96	(0.81, 1.14)
Sex (male)	**0.79**	**(0.67, 0.93)**
Place of residence		
At home	Reference	-
In a residential home	0.92	(0.75, 1.12)
Hospitalized in the previous 6 months	**1.24**	**(1.17, 1.33)**
Charlson Comorbidity Index		
0 – 2	Reference	-
3 – 4	**1.53**	**(1.29, 1.81)**
>4	**1.97**	**(1.51, 2.56)**
Cancer	**1.47**	**(1.20, 1.81)**
GERIATRIC SYNDROMES		
Living alone	0.97	(0.83, 1.14)
Socially isolated	1.39	(0.86, 1.49)
Number of medications taken at home	**1.05**	**(1.03, 1.07)**
Polypharmacy	**1.26**	**(1.05, 1.51)**
Psychotropic medication	1.06	(0.99, 1.15)
Katz ADL at home	**0.95**	**(0.92, 0.99)**
Body mass index	1.00	(0.99, 1.02)
Malnutrition	1.18	(0.93, 1.48)
Swallowing disorder	1.11	(0.89, 1.38)
History of depression	0.83	(0.68, 1.01)
Cognitive disorder	0.94	(0.80, 1.11)
Walking ability		
Walks unaided	Reference	-
No, confined to bed	1.16	(0.81, 1.64)
No, bed or chair only	0.98	(0.77, 1.25)
Walks with assistance	0.88	(0.74, 1.05)
CHANGES IN HOSPITAL		
Katz ADL on admission	0.98	(0.94, 1.02)
Katz ADL on discharge	0.96	(0.93, 1.00)
Change in Katz ADL in hospital		
Stable	Reference	
Worse	1.24	(0.94, 1.63)
Better	1.01	(0.86, 1.20)
Body weight on admission, kg	1.01	(1.00, 1.02)
Body weight on discharge, kg	1.00	(0.99, 1.02)
Change in body weight in hospital		
Stable	Reference	-
Decrease	1.24	(0.96, 1.61)
Increase	**1.35**	**(1.03, 1.77)**
Serum albumin level, g/L	**0.97**	**(0.96, 0.99)**
Blood haemoglobin level, g/L	**0.92**	**(0.88, 0.96)**
Serum creatinine level, µmol/mL	**1.03**	**(1.02, 1.04)**
Delirium on admission	0.84	(0.66, 1.05)
Time spent in each state during the hospital stay, days		
Late discharge	Reference	-

Medical obstacle to discharge	1.03	(0.62, 1.76)
Community-acquired infection	1.03	(0.61, 1.79)
Hospital-acquired infection	2.03	(0.91, 4.55)
DAMAGE death risk score	**1.37**	**(1.22, 1.51)**

Supplement data 4 (color should be used):

ROC curve for the prediction of hospital readmission: AUC = 63% (IC 95% = 61% – 67%). Sensitivity = 79%. Specificity = 96%. Positive predictive value = 49%. Negative predictive value = 70%.