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Original Study

Early Predictors for Discharge to Geriatric Rehabilitation after Hip Fracture Treatment of Older Patients

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A B S T R A C T

Objective: To investigate early predictors for discharge to a geriatric rehabilitation department at a skilled nursing home in older patients after hospitalization for hip fracture surgery.
Design: Retrospective cohort study.
Setting and Participants: Data from 21,176 patients with hip fracture aged ≥70 years, who were registered in the Dutch Hip Fracture Audit database between January 1, 2017, and December 31, 2019, were included.
Methods: Patients were categorized into 3 discharge groups: home (n=7326), rehabilitation (n=11,738), and nursing home (n=2112). Age, gender, Pre-Fracture Mobility Score (PFMS), premorbid Katz index of independence in Activities of Daily Living (Katz-ADL), history of dementia, American Society of Anesthesiologists physical status classification (ASA score), type of anesthesia, fracture type, surgical treatment, and cotreatment by a geriatrician were gathered. Multinomial regression analysis was used to assess for early predictors.
Results: Higher age, poor premorbid mobility, lower premorbid Katz-ADL, no history of dementia, ASA score 3-5, general anesthesia, intramedullary implant, and cotreatment by a geriatrician were independent predictors for discharge to geriatric rehabilitation vs discharge home. Identical predictors were found for discharge to a nursing home vs discharge home. History of dementia and premorbid Katz-ADL were distinguishing factors; a higher premorbid Katz-ADL and a history of dementia were associated with a higher risk of discharge to a nursing home vs discharge home. The multinomial regression model correctly predicted 86%, 38.6%, and 2.4% of the patients in the rehabilitation group, home group, and nursing home group, respectively.
Conclusions and Implications: This study showed that age, PFMS, premorbid Katz-ADL, surgical treatment, ASA score, type of anesthesia, history of dementia, and cotreatment by a geriatrician were independent early predictors for discharge to geriatric rehabilitation vs discharge home in older patients after hip fracture surgery. Identical predictors were found as predictors for discharge to a nursing home vs discharge home, except for history of dementia and premorbid Katz-ADL.
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Hip fractures are a serious problem in older adults. Each year, approximately 17,000 patients aged 70 years or older are hospitalized with a hip fracture in the Netherlands.[1] This number will further increase in the upcoming years because of the aging population. The consequences of hip fractures are serious. Around 25% to 30% of the older patients die within the first year after hip fracture treatment.[2–6] In 40% to 60% of the patients, the mobility is still impaired after

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1 year.[7,8] In the Netherlands, approximately half of the older patients with hip fracture are temporary admitted to a geriatric rehabilitation department at a skilled nursing home. Geriatric rehabilitation is defined by the European Consensus group as "a multidimensional approach of diagnostic and therapeutic interventions, the purpose of which is to optimize functional capacity, promote activity and preserve functional reserve and social participation in older people with disabling impairments" and is recommended for patients who have the ability to increase their functional outcomes.[9] As the number of older patients with a hip fracture increases, the number of patients admitted to a geriatric rehabilitation department will also increase. Discharge planning for patients with a geriatric rehabilitation indication can be logistically challenging. Discharge to geriatric rehabilitation needs to be requested and approved, and after approval, a suitable rehabilitation unit must be found. As a consequence, this often results in a prolonged hospital stay, which has a negative effect on the functional recovery of older patients, because prolonged hospital stay is associated with a delay in the recovery process, and a higher chance of complications and mortality.[4,7,10–12] In order to promote the discharge planning and the functional recovery of a patient, it is considered important to predict early in the hospital phase if a patient is eligible for geriatric rehabilitation or not.

Even though various studies have been performed regarding predictors for discharge destination after hip fracture surgery, still little is known about the predictors for discharge to geriatric rehabilitation. Only Sivertson et al[13] and Sathiyakumar et al[14] assessed the predictors for discharge to geriatric rehabilitation. Sivertson et al[13] found that a lower score for mobility and functional status 3-5 days after hip fracture surgery in older patients was associated with discharge to geriatric rehabilitation.[13] However, only 43 patients were included, all with a femoral neck fracture and without cognitive impairment. Sathiyakumar et al[14] found that higher age, female gender, an American Society of Anesthesiologists physical status classification (ASA score) higher than 2, and general anesthesia during hip fracture surgery were independent risk factors for discharge to a rehabilitation department. However, they did not take into account other potential predictors, like the premorbid functional level and cognition. All other studies found in literature described predictors for discharge to a long-term care facility,[15–19] predictors for discharge after rehabilitation,[20,21] or predictors for discharge home vs discharge to an alternative discharge location (ie, to all other discharge locations except home).[10,22–24] Vochteloo et al[25,26] described a Discharge of Hip fracture Patients score (DHP), which is a prediction model that accurately predicts, on admission to the hospital, the discharge location of patients. However, the DHP can only make a distinction between discharge home and discharge to an alternative discharge location and was not aimed at predicting discharge to geriatric rehabilitation.

The Dutch Hip Fracture Audit (DHFA) is a national multidisciplinary quality registry and was founded in the Netherlands in 2016.[27] The rationale behind the DHFA was to give insight into the provided care and outcomes of older patients with a hip fracture and to improve the quality of care. In 2019, a total of 63 of 82 hospitals (77%) treating patients with hip fracture in the Netherlands registered these patients. The present study aims to investigate early predictors for discharge to a geriatric rehabilitation department at a skilled nursing home in patients aged 70 years or older after hospitalization for hip fracture surgery using data from the DHFA.

Methods

Study Population

Data from patients with hip fracture aged 70 years or older who were registered in the DHFA database between January 1, 2017, and December 31, 2019, were used in this study. The DHFA database included demographic information, in-hospital information, and follow-up information after 3 months and 1 year. Inclusion criteria for this study were living at home prior to the hip fracture with or without help; this also included patients who lived at a residential home. Exclusion criteria were in-hospital mortality and an unknown discharge destination. Patients with periprosthetic or pathologic fractures are already excluded by the DHFA. Patients are categorized into 3 groups regarding the discharge destination: home environment (home group), geriatric rehabilitation department (rehabilitation group), and nursing home for long-term care (nursing home group).

Data Collection

The following baseline and perioperative variables were collected from the DHFA database for this study: age, gender, Pre-Fracture Mobility Score (PFMS), premorbid Katz index of independence in Activities of Daily Living (Katz-ADL), usage of osteoporosis medication, history of dementia, nutritional status, ASA score, type of anesthesia, fracture type, surgical treatment, and cotreatment by a geriatrician. The duration of hospital stay, complications, and the Fracture Mobility Score (FMS) at discharge were collected as discharge variables.

The PFMS and FMS measure the mobility of a patient and range from 1 (free mobility without any aids) to 5 (no functional mobility).[28] Patients were classified into 3 groups, depending on their score: fully mobile (1), mobile with aids (2-3), and indoor confined (4-5). The Katz-ADL scored the independence in activities of daily living (ADL) and ranges from 0 (completely independent) to 6 (completely dependent).[29,30] Nutritional status was scored with the use of the Short Nutritional Assessment Questionnaire or the Malnutrition Universal Screening Tool, depending on the hospital which administered the patient in the DHFA database.[31,32] The Short Nutritional Assessment Questionnaire score ranges from 0 to 7, with a score $\geq$3 indicating malnutrition. The Malnutrition Universal Screening Tool score ranges from 0 to 6, with a score $\geq$2 indicating a high risk of malnutrition. The ASA score is an assessment tool of the overall health of a patient prior to surgery and ranges from 1 (normal healthy patient) to 5 (a moribund patient).[33] Patients were classified into 2 groups, depending on their score. The first group consisted of patients with ASA score 1 or 2, and the second group consisted of patients with ASA scores 3 to 5.

Statistical Analysis

Continuous variables were described as mean with the standard deviation (SD), or as median with the interquartile range in case of nonparametric data. Categorical variables were shown as number with the corresponding percentages. The relationship between the variables and discharge destination was assessed using a 1-way analysis of variance or Kruskal-Wallis test for continuous variables and with the use of a chi-square test for categorical variables. A Holm-Bonferroni post hoc correction was applied to analyze the differences between the 3 groups. As it is considered important to predict the discharge destination early in the postoperative recovery phase, only the baseline and the perioperative variables were considered for further analyses. Variables in the univariate analysis with a $P < .1$ were entered in a multinomial regression model. Subsequently, variables that were not statistically significant were eliminated from the model according to backward stepwise selection, starting with the highest P value. A $P < .05$ was regarded as statistically significant. Subsequently a classification table was made, using the same patient data, to assess the classification accuracy of the multinomial regression model by showing the predicted discharge destination vs the actual (observed) discharge destination. All statistical analyses were carried out using IBM SPSS statistics, version 25.

Results

From 2017 to 2019 a total of 31,802 patients, with an age of 70 years or older and who had hip fracture surgery, were registered in the DHFA database. From those patients 10,626 patients were excluded owing to not living at home prior to the hip fracture, in-hospital mortality, or an unknown discharge destination. From the remaining 21,176 patients, the home group consisted of 7326 patients (34.6%), the rehabilitation group of 11,738 patients (55.4%), and the nursing home group of 2112 patients (10%) (Figure 1).

Table 1 shows the baseline and perioperative variables of the total group and the 3 discharge destination groups separately. The mean (SD) age of the total study population was 83.2 (7.1) years, and 70.1% (n=14,829) of the patients were female. Based on the 1-way analysis of variance, Kruskal-Wallis, and chi-square, statistically significant differences were found for all variables between the 3 groups.

Table 2 shows the discharge variables. Patients in the rehabilitation group had more complications (39% vs 22.5%) and a longer duration of stay [mean (SD) of 9.3 (6.4) days vs 6.5 (6.1) days] and were more often indoor confined (35.8% vs 18.9%) compared with patients in the home group. Compared with the nursing home group, patients in the rehabilitation group had fewer complications (48.1% vs 39%) and a shorter duration of hospital stay [mean (SD) of 10.8 (8.8) days vs 9.3 (6.4) days], and fewer patients were indoor confined (46.1% vs 35.8%).

Age, gender, PFMS, premorbid Katz-ADL, history of dementia, ASA score, type of anesthesia, surgical treatment, and cotreatment by a geriatrician were included in the multinomial regression model. Because malnutrition and usage of osteoporosis medication occurred in less than 15% of the included patients, the multinomial regression model could not make a proper prediction based on these variables and were therefore not included in the model. Fracture type was also excluded, as fracture type was strongly related to the surgical treatment. Surgical treatment was considered more patient specific, as it not only depends on the fracture type, but also on the condition of the patient. Discharge home was set as reference.

The final model included the following variables: age, PFMS, premorbid Katz-ADL, history of dementia, ASA score, type of anesthesia, surgical treatment, and cotreatment by a geriatrician (Table 3). Higher age [odds ratio (OR)=1.1, 95% confidence interval (CI) 1.1-1.1], being mobile with aids or indoor confined prior to the hip fracture vs fully mobile (OR=1.8, 95% CI 1.6-1.9, and OR=1.7, 95% CI 1.4-1.9, respectively), lower premorbid Katz-ADL (OR=1/0.9=1.1, 95% CI 1.1-1.3), no history of dementia vs history of dementia (OR=2.0, 95% CI 1.8-2.2), ASA score of 3 to 5 vs ASA score of 1 or 2 (OR=1.4, 95% CI 1.3-1.5), general anesthesia vs spinal anesthesia (OR=1.1, 95% CI 1.1-1.2), intramedullary implant vs hemiarthroplasty (OR=1.5, 95% CI 1.4-1.6), and cotreatment by a geriatrician vs no cotreatment (OR=1.4, 95% CI 1.3-1.6) were independent predictors of discharge to geriatric rehabilitation vs discharge home (Table 3A). A sliding hip screw or cannulated screw and total hip arthroplasty vs hemiarthroplasty resulted in a lower risk of discharge to geriatric rehabilitation vs home (Table 3A).

Almost the same independent predictors were found for discharge to a nursing home vs discharge home (Table 3A). However, type of anesthesia was not statistically significant, and the association with premorbid Katz-ADL and history of dementia were in the opposite direction; a higher premorbid Katz-ADL (OR=1.1, 95% CI 1.1-1.2) was associated with a higher risk of discharge to a nursing home vs home, and no history of dementia vs history of dementia was associated with a lower risk of discharge to a nursing home vs home (OR=0.6, 95% CI 0.5-0.7). This was also shown when comparing discharge to a nursing home with discharge to geriatric rehabilitation; patients with a higher premorbid Katz-ADL had a higher risk of discharge to a nursing home (OR=1.2, 95% CI 1.2-1.3), whereas patients with no history of dementia vs history of dementia had a higher risk of discharge to geriatric rehabilitation (OR=3.3, 95% CI 2.8-3.7) (Table 3B). Furthermore, a higher age (OR=1.0, 95% CI 1.0-1.0) resulted in a higher risk of discharge to a nursing home vs geriatric rehabilitation, and being ambulatory with aids vs fully mobile (OR=0.9, 95% CI 0.8-1.0) and total hip arthroplasty, sliding hip screw or cannulated screw and intramedullary implant vs hemiarthroplasty (OR=0.6, 95% CI 0.4-1.0; OR=0.8, 95% CI 0.7-1.0; and OR=0.8, 95% CI 0.7-0.9, respectively) resulted in a lower risk of discharge to a nursing home vs geriatric rehabilitation (Table 3B).

Table 4 presents the classification model of the multinomial regression model. The sum of the rows represents the actual (ie, observed) number of patients in each discharge group. The sum of the columns represents the number of patients in each discharge group predicted by the model. The table shows that the model correctly predicts 86% of the patients in the rehabilitation group,

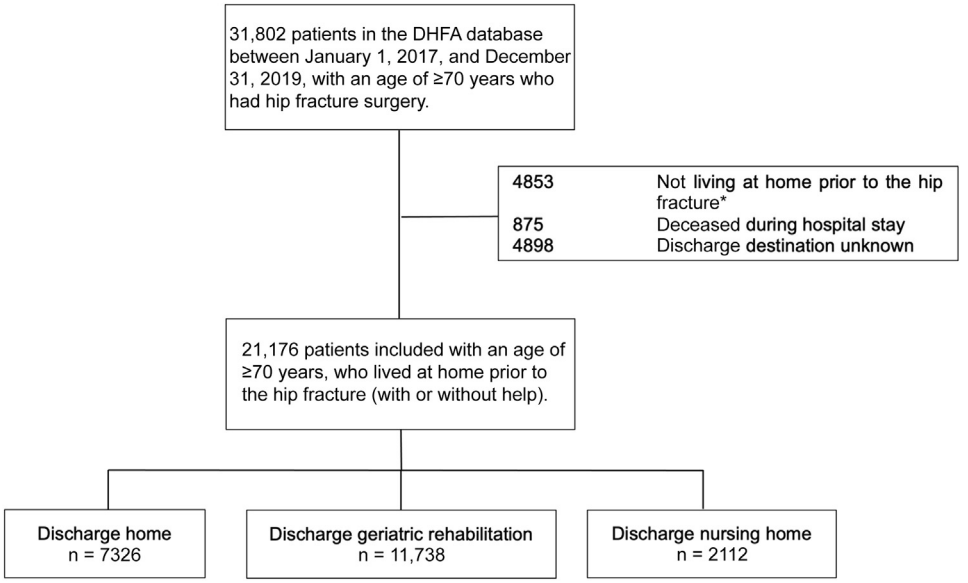

Fig. 1. Study inclusion and exclusion criteria. *Living at home included living at home with or without help and living at a residential home.

Table 1
Baseline and Perioperative Variables

	Total (n=21,176)	Discharge Home (n=7326)	Discharge Geriatric Rehabilitation (n=11,738)	Discharge Nursing Home (n=2112)	*P* Value*
Age, mean (SD)	83.2 (7.1)	80.8 (7.2)	84.3 (6.8)	85.5 (6.7)	<.001
Female gender, n (%)†	14,829 (70.1)	5023 (68.6)	8302 (70.8)	1504 (71.2)	.003
Pre-Fracture Mobility Score, n (%)‡					<.001
Fully mobile (1)	9491 (47.9)	4203 (61.2)	4702 (42)	586 (33.1)	
Mobile with aids (2-3)	8688 (43.9)	2171 (31.8)	5543 (49.5)	974 (55.1)	
Indoor confined (4-5)	1619 (8.2)	451 (6.6)	960 (8.5)	208 (11.8)	
Premorbid Katz-ADL, median (IQR)§	0 (0-2)	0 (0-2)	0 (0-2)	2 (0-4)	<.001
Usage of osteoporosis medication, n (%)‖	2580 (13)	791 (11.4)	1527 (13.8)	262 (14)	<.001
Diagnosed with dementia, n (%)**	2634 (13)	940 (13.4)	1058 (9.3)	636 (33.6)	<.001
Malnutrition, n (%)††	1932 (9.6)	515 (7.4)	1145 (10.3)	272 (13.5)	<.001
ASA score, n (%)‡‡					<.001
1-2	8303 (40.3)	3583 (50.4)	4153 (36.2)	567 (28.3)	
3-5	12,285 (59.7)	3530 (49.6)	7319 (63.8)	1436 (71.7)	
Anesthesia type, n (%)§§					.001
General anesthesia	7745 (37.8)	2579 (36.1)	4358 (38.5)	808 (40)	
Spinal anesthesia	12,748 (62.2)	4558 (63.9)	6976 (61.5)	1214 (60)	
Fracture type, n (%)‖‖					<.001
Femoral neck	11,373 (55.3)	4546 (63.6)	5715 (50.3)	1112 (53.8)	
Trochanteric	8529 (41.4)	2415 (33.8)	5230 (46)	884 (42.8)	
Subtrochanteric	677 (3.3)	185 (2.6)	421 (3.7)	71 (3.4)	
Surgical treatment, n (%)***					<.001
Hemiarthroplasty	8479 (40)	2882 (39.4)	4655 (39.7)	942 (44.6)	
Intramedullary implant	8695 (41.1)	2389 (32.6)	5385 (45.9)	921 (43.6)	
Total hip arthroplasty	1020 (4.8)	661 (9)	320 (2.7)	39 (1.9)	
Sliding hip screw/cannulated screw	2980 (14.1)	1394 (19)	1377 (11.7)	209 (9.9)	
Cotreatment geriatrician, n (%)†††					<.001
No cotreatment	4768 (22.7)	2158 (29.7)	2191 (18.8)	419 (20)	
Cotreatment	16,273 (77.3)	5102 (70.3)	9493 (81.2)	1678 (80)	

ASA, American Society of Anesthesiologists physical status classification; IQR, interquartile range; Katz-ADL, Katz index of independence in Activities of Daily Living; SD, standard deviation.

**P* value of the 1-way analysis of variance, Kruskal-Wallis, and chi-square tests.

†Number of missing = 18.

‡Number of missing = 1378.

§Number of missing = 599.

‖Number of missing = 1304.

**Number of missing = 928.

††Number of missing = 1071.

‡‡Number of missing = 588.

§§Number of missing = 683.

‖‖Number of missing = 597.

***Number of missing = 2.

†††Number of missing = 135.

38.6% of the patients in the home group, and 2.4% of the patients in the nursing home group. Misclassified patients in the rehabilitation group were mostly classified by the model as discharge home, and misclassified patients in the home group or nursing home group as discharge to geriatric rehabilitation. From the 13,631 patients classified by the prediction model as being discharged to the rehabilitation group, 8660 patients (63.5%) were actually discharged to this group.

Table 2
Discharge Variables

	Total (n=21,176)	Discharge Home (n=7326)	Discharge Geriatric Rehabilitation (n=11,738)	Discharge Nursing Home (n=2112)	*P* Value*
Complications present, n (%)†	7212 (34.2)	1642 (22.5)	4556 (39)	1014 (48.1)	<.001
Duration of hospital stay, mean days (SD)‡	8.5 (6.7)	6.5 (6.1)	9.3 (6.4)	10.8 (8.8)	<.001
Fracture Mobility Score discharge, n (%)§					<.001
Fully mobile (1)	173 (0.9)	103 (1.6)	56 (0.5)	14 (0.8)	
Mobile with aids (2-3)	13,052 (68.2)	5260 (79.5)	6874 (63.7)	918 (53.1)	
Indoor confined (4-5)	5908 (30.9)	1254 (18.9)	3858 (35.8)	796 (46.1)	

SD, standard deviation.

**P* value of the 1-way analysis of variance, Kruskal-Wallis, and chi-square tests.

†Number of missing = 70.

‡Number of missing = 325.

§Number of missing = 2043.

Table 3
Multinomial Regression Analysis to Find Predictors for Discharge Destination

	OR	95% CI	*P* Value
A. Reference group: Discharge home*			
Discharge geriatric rehabilitation			
Age	1.1	1.1-1.1	<.001
Pre-Fracture Mobility Score			
Fully mobile†	—	—	—
Mobile with aids	1.8	1.6-1.9	<.001
Indoor confined	1.7	1.4-1.9	<.001
Premorbid Katz-ADL	0.9	0.9-0.9	<.001
Dementia			
Yes†	—	—	—
No	2.0	1.8-2.2	<.001
ASA score			
1-2†	—	—	—
3-5	1.4	1.3-1.5	<.001
Type of anesthesia			
Spinal anesthesia†	—	—	—
General anesthesia	1.1	1.0-1.2	.001
Surgical treatment			
Hemiarthroplasty†	—	—	—
Total hip arthroplasty	0.5	0.4-0.6	<.001
Sliding hip screw or cannulated screw	0.8	0.7-0.9	<.001
Intramedullary implant	1.5	1.4-1.6	<.001
Cotreatment geriatrician			
No†	—	—	—
Yes	1.4	1.3-1.6	<.001
Discharge nursing home			
Age	1.1	1.1-1.1	<.001
Pre-Fracture Mobility Score			
Fully mobile†	—	—	—
Mobile with aids	1.5	1.3-1.8	<.001
Indoor confined	1.4	1.1-1.7	.007
Premorbid Katz-ADL	1.1	1.1-1.2	<.001
Dementia			
Yes†	—	—	—
No	0.6	0.5-0.7	<.001
ASA score			
1-2†	—	—	—
3-5	1.6	1.4-1.8	<.001
Type of anesthesia			
Spinal anesthesia†	—	—	—
General anesthesia	1.0	0.9-1.2	.70
Surgical treatment			
Hemiarthroplasty†	—	—	—
Total hip arthroplasty	0.3	0.2-0.5	<.001
Sliding hip screw or cannulated screw	0.6	0.5-0.8	<.001
Intramedullary implant	1.2	1.1-1.4	.003
Cotreatment geriatrician			
No†	—	—	—
Yes	1.5	1.3-1.8	<.001
B. Reference group: Discharge geriatric rehabilitation*			
Discharge nursing home			
Age	1.0	1.0-1.0	.036
Pre-Fracture Mobility Score			
Fully mobile†	—	—	—
Mobile with aids	0.9	0.8-1.0	.034
Indoor confined	0.8	0.7-1.0	.06
Premorbid Katz-ADL	1.2	1.2-1.3	<.001
Dementia			
No†	—	—	—
Yes	3.3	2.9-3.8	<.001
ASA score			
1-2†	—	—	—
3-5	1.1	1.0-1.2	.16
Type of anesthesia			
Spinal anesthesia†	—	—	—
General anesthesia	0.9	0.8-1.0	.11
Surgical treatment			
Hemiarthroplasty†	—	—	—
Total hip arthroplasty	0.6	0.4-1.0	.047
Sliding hip screw or cannulated screw	0.8	0.7-1.0	.039
Intramedullary implant	0.8	0.7-0.9	.002
Cotreatment geriatrician			
No†	—	—	—
Yes	1.1	0.9-1.2	.43

(*continued on next page*)

Table 3 (*continued*)

ASA, American Society of Anesthesiologists physical status classification.
*Data from a total of 17,798 patients were used to build the multinomial regression model.
†This parameter is set as a reference category.

Discussion

The aim of this study was to find early predictors for discharge of older patients, who lived at home with or without help prior to admission, to a geriatric rehabilitation department at a skilled nursing home after hospitalization for hip fracture surgery. Results of this study showed that age, PFMS, premorbid Katz-ADL, history of dementia, ASA score, type of anesthesia, surgical treatment, and cotreatment by a geriatrician were independent predictors for discharge to a geriatric rehabilitation department vs discharge home.

To our knowledge there are only a limited number of studies performed assessing early predictors for discharge to a geriatric rehabilitation department in patients after hip fracture surgery. Sathiyakumar et al[14] found that a higher age, female gender, ASA score >2 and general anesthesia were significant predictors for discharge to a rehabilitation center. Except for female gender, this is comparable with the results found in this study. However, a significant difference in our study compared to the study of Sathiyakumar et al[14] is that the patients in the rehabilitation group of our study were all discharged to a geriatric rehabilitation department at a skilled nursing home, whereas the rehabilitation group of Sathiyakumar et al consisted of patients discharged to different types of rehabilitation facilities, for example, a skilled nursing facility, unskilled nursing facility, separate acute care, or a dedicated rehabilitation center, which makes this group very heterogeneous. This might suggest that the patients in our geriatric rehabilitation group are also very heterogeneous, despite the same discharge location. High heterogeneity within one group probably needs a lot of predictors to predict the discharge destination with a high accuracy for each individual patient.

History of dementia and the premorbid Katz-ADL were predictors that differed between discharge to geriatric rehabilitation and discharge to a nursing home; a lower premorbid Katz-ADL and no history of dementia were clear predictors for discharge to geriatric rehabilitation, and the opposite resulted in discharge to a nursing home. According to the European Consensus Group, geriatric rehabilitation is recommended for patients who have the ability to increase their functional outcomes. Patients should not be excluded for geriatric rehabilitation based on the presence of dementia.[9] However, the presence of dementia has a negative impact on the patient's capacity to learn rehabilitation skills and these patients need a specifically tailored rehabilitation program.[34–37] For these reasons patients with dementia are often excluded for geriatric rehabilitation. Patients with a high dependency before the hip fracture are also highly dependent after hip fracture surgery, which makes them also unsuitable for geriatric rehabilitation, because they have no achievable rehabilitation goals and are therefore not able to rehabilitate. However, it is not scientifically confirmed before that patients with a high dependency prior to the hip fracture are unsuitable for rehabilitation.

Results show that patients in the rehabilitation group had a longer duration of hospital stay compared with patients in the home group and a shorter duration of hospital stay compared with patients in the nursing home group. Differences in the duration of hospital stay could be caused by differences in patient characteristics between the 3

Table 4
Observed Discharge Classification vs Predicted Discharge Classification by the Multinomial Regression Model

Observed	Predicted			
	Home Group	Rehabilitation Group	Nursing Home Group	Percentage Correctly Classified
Home group	2377	3708	70	38.6
Rehabilitation group	1370	8660	39	86
Nursing home group	273	1263	38	2.4

discharge groups, like for example age, the presence of complications, or postoperative functioning.[38–42] However, it could also be caused by system characteristics, like the logistical challenges of discharge planning, or waiting lists at nursing homes. Early prediction of the discharge destination could diminish the effects of system characteristics on the duration of hospital stay, because discharge planning could be started early in the postoperative phase.

The multinomial regression model classified 13,631 patients as being discharged to geriatric rehabilitation. From those patients, 63.5% were actually discharged to geriatric rehabilitation. Geriatric rehabilitation is recommended for patients who have the ability to increase their functional outcomes.[9] Based on this study, one could say that discharge to geriatric rehabilitation is recommended above discharge home for patients with a higher age, who were less mobile prior to the hip fracture, had a lower premorbid Katz-ADL, had no history of dementia, had an ASA score of 3 to 5, had general anesthesia, had an intramedullary implant and were cotreated by a geriatrician. When age, PFMS, premorbid Katz-ADL, cognitive functioning, ASA score, type of anesthesia, surgical treatment, and cotreatment by a geriatrician are known in the early phase, the multinomial regression model can make a first indication of the discharge destination. This could help the multidisciplinary treatment team in making an early discharge decision and could optimize the treatment planning. Because age, PFMS, premorbid Katz-ADL, cognitive functioning, ASA score, type of anesthesia, surgical treatment, and cotreatment by a geriatrician are of prognostic value for the discharge destination, it can be considered to make these variables part of the holistic clinical assessment of older patients with hip fracture at admission to the hospital. It is also suggested to keep these variables as part of the DHFA.

However, when using the current prediction model, 3708 patients (60.2%) who were actually discharged home and 1263 patients (80.2%) who were actually discharged to a nursing home were also classified as discharge to geriatric rehabilitation. For the patients who actually went home, this misclassification has in practice no major consequences. Geriatric rehabilitation will be requested early in the hospital phase, and the request can be canceled during hospitalization when it becomes clear that the patient has restored the level of functioning necessary for discharge home. However, for the patients who actually went to a nursing home, this can negatively influence the patient flow, as those patients will be discharged to geriatric rehabilitation. As a consequence, this can also negatively influence the functional recovery of patients who actually need geriatric rehabilitation in order to restore their level of functioning.

The multinomial regression model classified 86% of the patients discharged to geriatric rehabilitation in a correct way. For the patients in the home group and the nursing home group, the multinomial regression model only predicted 38.6% and 2.4% of the patients in a correct way, respectively. The model classified patients in both the home group as well as the nursing home group often as discharge to geriatric rehabilitation. This indicates that the patients in the home group and the nursing home group showed a lot of similarities with the patients in the rehabilitation group but probably were not actually discharged to geriatric rehabilitation based on other variables, that were not included in this study. Other factors considered interesting are the social context and the way of living prior to the fracture, as well as comorbidities. From the literature, it appeared that patients with a high number of comorbidities, who were not married and who were living alone were less likely to be discharged home.[10,13,17–19,21,43–45] Furthermore, factors that might be interesting to include in the model are the mobility and functional status 3-5 days after surgery.[13] However, these factors do not contribute to early prediction.

This study has some limitations. First of all, in the DHFA, the history of dementia is obtained at admission to the hospital in order to assess the cognitive functioning of patients. In this study, the number of patients with a history of dementia at admission was 2634 (13%). This number is likely to increase during hospital stay, because dementia is often underdiagnosed in older patients. Thanks to the cotreatment by a geriatrician, during hospital admission, undiagnosed patients are often revealed. A second limitation was that not all patients were entered in the multinomial regression model. A total of 3378 patients did not had a complete data set, which means that they were excluded from the multinomial regression analysis. An incomplete data set was mostly due to missing data concerning the PFMS (40.8%). Results showed that the PFMS is an important predictor in the multinomial regression model. This highlights the relevance of good data registration. When comparing the ratios of patients in each discharge group between the total group of patients and the group of patients with a complete data set, it turns out that the ratios are almost the same. Slightly more data is incomplete in the nursing home group. The third limitation was that in the current multinomial regression model only the history of dementia and the premorbid Katz-ADL were distinctive between discharge to geriatric rehabilitation and discharge to a nursing home. Furthermore, the model classified too many patients as discharged to geriatric rehabilitation. For these reasons, early discharge prediction is still challenging and, therefore, the current multinomial regression model needs optimization. The final limitation was that the DHFA had not included any information about the social context of the patients. The literature shows that living alone is a strong predictor for discharge to an alternative discharge location. In contrast, having a partner is a strong predictor for discharge home. The authors recommend including the social context to national registries, from which it is believed that it can be easily assessed at admission to the hospital.

Further research is recommended in order to optimize the multinomial regression model. More variables that are considered important in predicting the discharge destination should be included. Based on literature, the social context, the living situation prior to the fracture, and comorbidities, such as chronic systemic diseases, Parkinson's disease or cerebrovascular accident, are relevant to add to the model.[14,21,23] Subsequently, the model needs to be validated. Based on the new multinomial regression model, the aim is to develop and validate a discharge prediction score that predicts, directly after surgery, the discharge location after hospitalization.

Conclusions and Implications

Results of this study showed that age, PFMS, premorbid Katz-ADL, surgical treatment, ASA score, type of anesthesia, history of dementia, and cotreatment by a geriatrician were independent early predictors

for discharge to a geriatric rehabilitation department at a skilled nursing home vs discharge home after hip fracture surgery in older patients, who were living at home with or without help prior to admission. However, most of these predictors were also found as predictors for discharge to a nursing home vs discharge home. History of dementia and the premorbid Katz-ADL are the only distinguishing factors between discharge to a geriatric rehabilitation department and discharge to a nursing home. Further research is however needed to optimize our prediction model.

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