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Predicting Adverse Hospital Discharge in Orthopaedic Trauma Patients Utilizing Common Medical Frailty Indices

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Abstract

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Background: Frailty is a risk indicator that has been validated to influence health outcomes in a variety of patients, including those who experience traumatic injury. There is a need for effective risk assessment tools to predict post-surgical outcomes in order to appropriately triage patients (both in-hospital and post-discharge) at high-risk of poor outcome. This study aims to prospectively determine which modified frailty index (mFI) [-11 vs -5 vs -15] best predicts adverse hospital discharge, defined as a destination other than home (rehab, nursing facility, long-term care).

Methods: Data was collected prospectively from all orthopedic trauma patients from April of 2019 to July of 2019 at Grady Memorial Hospital. We obtained data on patient demographics, injury details, comorbidities, and nutrition lab values (albumin). Frailty scores were calculated for each participant. Using univariate logistic regression, discharge dispositions were assessed for each index. Receiver operating characteristics (ROC) curves were generated to determine the regression accuracy.

Results: A total of 122 patients were included in the cohort. Mean age was 45 ± 18 years, 65% male, and 60% black. At discharge, 73% (n=89) patients went home. The mFI-5 yielded the highest predictability for non-home discharges (OR 5.1, 95% CI 1.9-13.7, $p<0.001$); ROC 63.1%. The mFI-11 (ROC 53.8%) and the mFI-15 (ROC 53.7%) were not significantly associated with a non-home discharge. Incorporating hypoalbuminemia as a frailty indicator into the model increased the AUC for both the 11-item and the 5-item, respectively (ROC 57.2% and 64.1%).

Conclusions: We have prospectively demonstrated that a non-home discharge in frail, orthopedic trauma patients is associated with an mFI-5 ≥ 0.27 and potentiated by hypoalbuminemia. The mFI-5 appears to be the most accurate tool of the three indices as evidenced by its highest ROC. The mFI-5 is a simplistic and predictive tool that can be easily implemented for predicting adverse hospital discharge in trauma patients.

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Introduction

Traumatic injuries in the United States account for nearly 150,000 deaths and result in over 100 billion healthcare dollars spent annually (1). A significant, but largely unaccounted for cost in the after-math of trauma occurs beyond the acute care episode, in rehabilitation costs, complications and readmissions. Identifying at-risk populations for medical complications and poor healthcare utilization is imperative to streamline coordinated, individual patient care, while also driving down costs. This is particularly relevant as the U.S. population ages with multiple medical co-morbidities (2-3).

Frailty is a multi-dimensional state of weakness, vulnerability, and decreased physiological reserve – a marker of "unsuccessful aging." Numerous frailty indices have been shown to predict mortality, complications, and adverse hospital discharge in both old and young trauma patients (1, 4-6, 7-12).

The purpose of this study is to prospectively compare multiple frailty indices in their ability to predict non-hospital discharge for trauma patients. Research has been focused on refining the larger Frailty Index (FI), a 50-variable score index that measures patient physiologic impairment as a proportion. A concern with the FI is that it is cumbersome to clinically utilize, particularly in the trauma setting, due to its large number of variables. This prompted the need to find modified indices with fewer factors, that retains comparable outcome predictability (5, 8, 11). The mFI-15 has been proposed as a trauma-specific frailty index and includes multiple pre-injury function-specific factors (Appendix 2). This has been validated in prospective studies (7, 11), but is burdensome to implement in traumatized patients, as it involves direct patient questioning. The mFI-11 is an index that was derived from the National Surgical Quality

Improvement Program (NSQIP), a national database of surgical data collected from 615 participating hospitals (1, 3). The 11-item index contains 11 dichotomous co-factors, including both medical co-morbidities and functional status. This is one of the most widely reported indices in trauma studies (7). The mFI-5 is a subset of the mFI-11 variables, and includes 4 medical co-morbidities and a functional status assessment. Use of the mFI-5 has been advocated due to its relative simplicity, and the fact that the variables are already reported as part of the standard institutional dataset to the National Trauma Database (8, 13-14). One additional co-factor that has been shown to be predictive of adverse complications following trauma is underlying nutritional status, as measured by albumin. The mFI-15 includes albumin as one of the 15 factors, but it has been suggested that hypoalbuminemia should be included as a factor in any frailty scale, including the mFI-11 and -5 (7, 15-18).

We sought to prospectively determine which frailty index (5 vs 11 vs 15) best predicts adverse hospital discharge in an orthopedic trauma population. Furthermore, we will be implementing albumin as a novel, additional cofactor for the mFI-11 and the mFI-5 and assessing its impact on outcome predictability. The ability to make proper discharge decisions plays a significant role in reducing negative post-operative outcomes for trauma patients, and studies have indicated that frailty is a favored predictor for postoperative trauma outcomes due to its associations with physiologic reserve (5, 7, 19-20).

Methods

Data collection

We performed an observational prospective cohort analysis of all adult trauma patients admitted to Grady Orthopedics between June of 2019 and August of 2019. We excluded patients < 18 years of age, incarcerated or pregnant individuals, intubated patients, and any other persons unable to provide informed consent. We obtained data on patient demographics, injury details, comorbidities, and laboratory values. Our primary outcome of interest was adverse (i.e. non-home) hospital discharge.

Frailty scores for each mFI variation were calculated based on patient records and patient survey responses, and baseline albumin levels were recorded. We obtained an approval from the institutional review board (IRB) at Emory University for this study.

Frailty Measurement

The 5, 11, and 15 factors that comprise the mFI (-5, -11, and -15) are indicated in Appendices 1 and 2. Nearly all factors in the models are dichotomous, stipulated by whether a patient has a comorbidity present, or not. The lone exception was functional status, which was recoded as independent, partially, dependent, and totally dependent. To calculate the frailty scores, each positive factor is equivalent to one point. The sum of the points is then divided by the total number of points available. A score closer to 1.0 indicates increased frailty. Missing data was excluded from the score denominator. Albumin was similarly treated as a dichotomous variable, with < 3 grams per deciliter classified as hypoalbuminemia (11). From prior studies, the cutoff between fit and frail patients was determined to be an mFI of 0.27 (1, 4, 11). Previous mFI-5 literature has treated the 5-factor as a continuous or ordinal variable, and thus frailty status was assigned with a score of 0.4 or higher to obtain an adequate sample size.

Statistical Analysis

Univariate logistic regression was performed to assess the predictive value of frailty scores on adverse hospital discharge. The model was adjusted for age. C-statistics (area under the receiver-operating characteristics curve) were performed to compare the predictive power of the individual frailty scores for adverse hospital discharge. C-statistics range from values of 0.5 to 1, with 0.50 indicating that a model performed no better than chance, and 1.0 indicating perfect outcome prediction. Sensitivity and predictive values were assessed for each score index to determine its value for use as a hospital screening tool. Additionally, Spearman's rho correlation was used to measure rank of correlation between the mFI score and radiographic evidence of frailty. In our study, alpha was set at 0.05, and a value of $p < 0.05$ was considered statistically significant. All statistical analyses were performed using Statistical Analysis Software (SAS version 9.4).

Results

A total of 122 patients were enrolled in the study. Mean age was 45 ± 18 years and 35% were female. 60% of the participants were African American, 34% were white. The most common mechanism of injury reported was a motor vehicle accident (57%, n=69), followed by a fall (25%, n=30) (Table 1).

Hypertension requiring medication was the most common patient comorbidity (35%), followed by diabetes (15%), and hypoalbuminemia (15%). Distributions of comorbidities within frail and non-frail strata groups for each mFI variation are depicted in Table 1. 65 patients (53%) did not present with any comorbidities at all and the mean age for these patients was 36 years (Table 1).

The likelihood of a frailty diagnosis depended on the index utilized. Using the mFI-5, 17% of patients were frail, which increased to 19% with albumin included as a co-factor. Using the mFI-11, 7% were classified frail, which increased to 11% with albumin included as a co-factor. Using the mFI15, 11% were frail (already incorporates albumin). Patients classified as frail across all score indices tended to be older, had more comorbidities, and were more likely to have sustained their injuries from falls, as opposed to higher-energy traumatic mechanisms (Table 1).

Following inpatient admission for trauma, 27% of the patients had an adverse hospital discharge. Sensitivity of the indices for predicting adverse hospital discharge ranged from 6% (mFI-15) to 39% (mFI-5+albumin), and specificity ranged from 87% (mFI-15) to 96% (mFI-11) (Table 2). In unadjusted models, mFI-5 (AUC=0.631, $p<0.001$), mFI-5 + hypoalbuminemia (AUC= 0.641, $p<0.001$)), mFI-11 + hypoalbuminemia (AUC= 0.572, $p=0.03$)) predicted adverse hospital discharge, while mFI-11 alone (AUC= 0.538, $p=0.15$) and mFI-15 (AUC= 0.537, $p=0.27$) did not (Table 3). After adjusting for patient age, all models displayed increased predictive value for discharge outcome, with mFI-5+hypoalbuminemia maintaining predictive significance ($p<0.001$) and retaining the highest AUC value (Table 3).

Discussion

The purpose of this prospective cohort study was to compare the relative strength of several previously reported frailty indices to predict adverse hospital discharge in trauma patients. We also aimed to test whether adding a nutritional assessment (hypoalbuminemia) as a co-factor within the existing mFI structures would improve predictive ability. In this pilot study, mFI-5 was found to be superior to mFI-11 and mFI-15 in predicting adverse hospital discharge, regardless of whether hypoalbuminemia was included in the model or not. This result held constant after model adjustment for patient age. In our study, we defined favorable outcomes as discharge to the patient's home with or without an Organized Home Health Service because it represents state of functional independence.

Frailty Assessment in Trauma as a Predictor of Mortality, Complications, and Hospital Utilization

Frailty has been highlighted as an indicator of special interest for adverse outcomes in trauma populations. The concept of frailty as a marker for low physiologic capacity and increased vulnerability has been shown in numerous studies to be a versatile predictor of complications and hospital utilization, both in younger and older trauma patient populations.

Early frailty studies utilized the larger 50-item Frailty Index, which was validated in a prospective geriatric trauma cohort (n=100) and found to outperform ISS, GCS, and head Abbreviated Injury Scale (hAIS) for predicting adverse discharge under univariate analysis (5).

As a response to concerns that the FI would be too cumbersome for reliable use prospectively, the mFI was developed in three variations, a 5-item, a 11-item, and a 15-item. Each of these modified indices have been validated in trauma populations (1, 4, 7-8, 11, 13-14, 20). Joseph et al. found that the mFI-15 was independently associated with unfavorable discharge disposition in 200 geriatric trauma patients (11). Traven et al. reported that the mFI-5 retrospectively predicted morbidity and mortality for geriatric hip fracture patients (14). Rege et al. endorsed the mFI-11 for predicting outcomes in chronologically young trauma patients, affirming its application outside of geriatric populations (1). Weaver et al. noted that prospective application of a reliable frailty index supplies providers with risk stratification with the goal of lowering costs by reducing complications and improving coordinated patient care (13).

Comparing Frailty Instruments

In this study, the mFI-5 had the highest sensitivity and positive predictive values when compared to the mFI-11 and -15. This has a particular relevance for building future models both due to its simplicity and the fact that the data is already contained in large national databases. In 2012, the NSQIP changed and deleted certain variables, leaving only the 5 variables in the mFI-5.

Prior work has compared predictive abilities of the mFI-11 and 5, but since the mFI-15 must be collected prospectively, studies utilizing this trauma-specific frailty index are limited. One such study compared the mFI-15 to the mFI-11 and several other indices in prospectively predicting mortality, unplanned readmission, and in-hospital complications, finding the 15-factor model to be superior or comparable for all outcomes tested (7). Despite its limitations with retrospective testing, the researchers endorsed the mFI-15 as a universal frailty score candidate for geriatric trauma patients. Subramaniam et al. compared mFI-11 and mFI-5 in the ability to predict mortality, postoperative infection, and unplanned readmission in over 500,000 patients from the national NSQIP database (8). Outcome predictability was similar between indices across a variety of surgical sub-specialties. The researchers advocated for the mFI-5 due to its relative ease of use, prospectively, compared to mFI-11. Due to the predictive validity and the containment of the mFI-5 variables in large databases for comparison studies, we would advocate for it's use more widely.

Nutrition and Frailty

Studies have shown that frailty and undernutrition are associated and predict adverse outcomes in patients undergoing surgical procedure (15-17, 21-25). Blevins et al. recently demonstrated that of 5 commonly used nutritional markers for adverse outcomes, hypoalbuminemia had the highest positive predictive value for the development of prosthetic joint infection (25). Albumin has thus, been utelized as a predictor for adverse outcomes in trauma populations (21-22, 26-27).

One of the reported strengths of the prospectively collected mFI-15 is that it incorporates a nutritional assessment (hypoalbuminemia), in addition to assessments of co-morbidities and functional status. This was substantiated by Buys et al., who demonstrated that undernutrition alone predicted the need for skilled nursing facility (SNF) placement after surgical discharge (21). Furthermore, Wilson et al. supported hypoalbuminemia's predictive value for orthopedic trauma populations, finding that patients admitted with undernutrition were more likely to present with postoperative adverse outcomes, as well as experience unplanned readmission in a cohort of 5673 patients (22).

In a comparison study, Hamidi et al. prospectively demonstrated that the mFI-15 outperformed the mFI-11 in predicting mortality, in-hospital complications, and 30-day unplanned readmission. They cited the 11-item index's lack of a nutritional component as a likely explanation for lesser predictability (7). Our results suggest that the incorporation of a nutritional assessment in the less cumbersome mFI-5, may at the very least, be non-inferior to the mfi-15.

Strengths and Weaknesses

This study's primary strength lies in the prospective comparison of several indices that are reported for frailty assessment across the trauma literature. This study included young trauma patients as well as older patients, while most prior research focuses solely on geriatric patients. In addition, this study is the first as far as we know that compares adverse outcome predictability among the mFI-11, the mFI-5, and the mFI-15 within the same trauma population.

There are some limitations that we need to address in this study. First, this is a pilot study and the sample size of 122 patients is small. By increasing the sample size of the population, we will be able to use this data to predict other variables beyond adverse hospital discharge, including mortality, in-hospital complications, length of stay, and re-admission. An increase in study power will allow further exploration towards effects associated with frailty in the future.

Future Directions

By demonstrating that the mFI-5 is non-inferior to the mFI-11 and mFI-15 in predicting adverse hospital discharge in trauma patients, we are comfortable utilizing this scale (incorporating albumin as a co-factor) in our system to direct in-hospital care coordination interventions. Studies have proposed novel pathways that are enacted in-hospital upon receiving a positive frailty diagnosis (28-29). Care coordination is initiated at the time of hospital admission, and incorporates medical co-management, palliative care, early physical therapy, and targeted discharge planning. A thorough post-discharge follow-up helps mitigate improper discharge decisions and screens for potential complications and re-admission risk. Engelhardt et al. reported utilizing the mFI-15 to triage frail patients with the goal to reduce hospital length of stay and 30-day readmission rates for surgical patients (28).

Conclusions

In conclusion, this study demonstrates that the mFI-5 is not inferior, and is possibly superior in predicting adverse hospital discharge in orthopaedic trauma patients. In addition, the results support that adding albumin as a co-factor may improve the predictive capacity of the mFI-5. Additional powered prospective studies are needed to compare the relative ability of the mFI-5, mFI-11, and mFI-15 with nutritional inclusion to predict mortality, in-hospital complications, length of stay, and re-admission after trauma. Similarly, prospective trials are needed to utilize this effective screening tool as a triage tool to direct care coordination pathways.

References

1. Rege, R.M., et al., *Frailty predicts mortality and complications in chronologically young patients with traumatic orthopaedic injuries*. Injury. 2018; **49**(12): 2234-2238.
2. Woolf, A.D. and K. Akesson, *Preventing fractures in elderly people*. BMJ Clinical research ed. 2003; **327**(7406): 89-95.
3. Farhat, J.S., et al., *Are the frail destined to fail? Frailty index as predictor of surgical morbidity and mortality in the elderly*. J Trauma Acute Care Surg. 2012; **72**(6): 1526-30; discussion 1530-1.
4. Vu, C.C.L., et al., *The frail fail: Increased mortality and post-operative complications in orthopaedic trauma patients*. Injury. 2017; **48**(11): 2443-2450.
5. Joseph, B., et al., *Predicting hospital discharge disposition in geriatric trauma patients: Is frailty the answer?* J Trauma Acute Care Surg. 2013; **76**(1): 196-200.
6. De Vries, NM., et al., *Outcome instruments to measure frailty: A systemic review.* Ageing Res Rev. 2011; **10**: 104-114.
7. Hamidi, M., et al., *Prospective Evaluation and Comparison of the Predictive Ability of Different Frailty Scores to Predict Outcomes in Geriatric Trauma Patients*. J Trauma Acute Care Surg. 2019; DOI: 10.1097/TA.0000000000002458
8. Subramaniam, S., et al., *New 5-Factor Modified Frailty Index Using American College of Surgeons NSQIP Data*. J Am Coll Surg. 2018; **226**(2): 173-181.e8.
9. Gowing, R., et al., *Injury patterns and outcomes associated with elderly trauma victims in Kingston, Ontario.* Can J Surg. 2007; **50**(6): 437-44.
10. Rockwood, K., et al., *A global clinical measure of fitness and frailty in elderly people*. Cmaj. 2005; **173**(5): 489-95.
11. Joseph, B., et al., *Validating Trauma-Specific Frailty Index for Geriatric Trauma Patients: A Prospective Analysis*. J Am Coll Surg. 2014; **219**(1): 10-17.
12. Hall, D., et al., *Development and Initial Validation of the Risk Analysis Index for Measuring Frailty in Surgical Populations*. JAMA. 2017; **152**(2): 175-82.
13. Weaver, D., et al., *The Modified 5-Item Frailty Index: A Concise and Useful Tool for Assessing the Impact of Frailty on Postoperative Morbidity Following Elective Posterior Lumbar Fusions*. World Neurosurg. 2019; **124**:e626-e632.
14. Traven, S., et al., *New Five-Factor Modified Frailty Index Predicts Morbidity and Mortality in Geriatric Hip Fractures*. J Orthop Trauma. 2019; **33**(7): 319-23
15. Hebeler, K.R., et al., *Albumin Is Predictive of 1-Year Mortality After Transcatheter Aortic Valve Replacement*. Ann Thorac Surg. 2018; **106**(5): 1302-1307.
16. Grossman, Y., et al. *Addition of albumin to Traditional Risk Score Improved Prediction of Mortality in Individuals Undergoing Transcatheter Aortic Valve Replacement*. J Am Geriatr Soc. 2017; **65**(11): 2413-17.
17. Hong, X., et al., *Relationship between nutritional status and frailty in hospitalized older patients*. Clin Interv Aging. 2019; **14**: 105-11.
18. Goldfarb, M., et al., *Malnutrition and Mortality In Frail and Non-Frail Older Adults Undergoing Aortic Valve Replacement.* Circulation. 2018; **138**: 2202-2211
19. Daly, K., et al., *Reduction in mortality after inappropriate early discharge from intensive care unit: logistic regression triage model*. BMJ. 2001; **322**: 1-6.

20. Patel, K., et al., *Association of a Modified Frailty Index With Mortality After Femoral Neck Fracture in Patients Aged 60 Years and Older*. Clin Orthop Relat Res. 2014; **472**: 1010-17.
21. Buys, D., et al., *Nutritional Risk and Body Mass Index Predict Hospitalization, Nursing Home Admissions, and Mortality in Community-Dwelling Older Adults; Results of the UAB Study of Aging With 8.5 Years of Follow-Up*. J Gerontol A Biol Sci Med Sci. 2014; **69**(9): 1146-53.
22. Wilson, J., et al., *Hypoalbuminemia Is an Independent Risk Factor for 30-Day Mortality, Postoperative Complications, Readmissioon, and Reoperation in the Operative Lower Extremity Orthopaedic Trauma Patient*. J Ortho Trauma. 2019; **33**(6): 284-91.
23. Bohl, DD., et al., *Hypoalbuminemia Independently Predicts Surgical Site Infection, Pneumonia, Length of Stay, and Readmission After Total Joint Arthroplasty*. The Journal of Arthoplasty. 2016; **31**: 15-21.
24. Bohl, DD., et al., *Malnutrition Predicts Infectious and Wound Complications Following Posterior Lumbar Spinal Fusion*. SPINE. 2016; **41**(21): 1693-99.
25. Blevins, K., et al., *Malnutrition and the Development of Periprosthetic Joint Infection in Patients Undergoing Primary Elective Total Joint Arthroplasty*. The Journal of Arthoplasty. 2018; **33**: 2971-2975.
26. Koval, K., et al., *The Effects of Nutritional Status on Outcome after Hip Fracture*. J Ortho Trauma. 1999; **13**(3): 164-69.
27. Bohl, DD., et al., *Serum Albumin Predicts Survival and Postoperative Course Following Surgery for Geriatric Hip Fracture.* J. Bone Jt. Surg. 2017; **99**(24): 2110-18.
28. Engelhardt, KE., et al., *Frailty screening and a frailty pathway decreasing length of stay, loss of independence, and 30-day readmission rates in frail geriatric trauma and emergency general surgery patients*. J Trauma Acute Care Surg. 2018; **85**(1): 167-173.
29. Tillou, A., et al., *Longterm Postinjury Functional Recovery Outcomes of Geriatric Consultation*. JAMA Surg. 2014; **149**(1): 83-9.

Table 1: Patient Demographics

	mFI-15		mFI-11		mFI-11 + hypoalbuminemia		mFI-5		mFI-5 + hypoalbuminemia	
Patient Characteristics	**Frail (n=14)**	**NF (n=108)**	**Frail (n=8)**	**NF (n=114)**	**Frail (n=13)**	**NF (n=109)**	**Frail (n=21)**	**NF (n=101)**	**Frail (n=23)**	**NF (n=99)**
Age (yrs), mean ± SD	55 ± 16	44 ± 17	64 ± 11	44 ± 17	65 ± 11	43 ± 17	66 ± 10	41 ± 16	64 ± 11	41 ± 16
Female, %	50%	33%	3 (38%)	40 (35%)	6 (46%)	37 (34%)	12 (57%	31 (31%)	13 (57)%	30 (30%)
White, %	43%	61%	4 (50%)	37 (32%)	6 (46%)	35 (32%)	9 (43%)	32 (32%)	9 (43%)	32 (32%)
Black, %	50%	32%	4 (50%)	69 (61%)	6 (46%)	67 (61%)	11 (52%)	62 (62%)	13 (57%)	60 (61%)
Mechanism of Injury										
Fall	64%	19%	6 (75%)	24 (21%)	8 (62%)	22 (20%)	12 (57%)	18 (18%)	13 (57%)	17 (17%)
MVC	29%	60%	2 (25%)	67 (59%)	5 (38%)	64 (59%)	9 (43%)	60 (59%)	10 (43%)	59 (60%)
Other	7%	21%	0 (0%)	23 (20%)	0 (0%)	23 (29%)	0 (0%)	23 (23%)	0 (0%)	23 (23%)
ISS, (IQR)	14 (8-17)	13 (9-17)	11 (9-14)	13 (9-17)	12 (9-14)	14 (9-17)	12 (9-14)	14 (9-17)	12 (9-17)	14 (9-17)
Vital Parameters										
ED SBP (mm Hg), mean ± SD	135 ± 30.3	130 ± 24	126 ± 33	131 ± 24	138 ± 32	129 ± 24	139 ± 29	128 ± 24	136 ± 29	129 ± 24
ED HR (BPM), mean ± SD	95 ± 19	88 ± 17	88 ± 17	89 ± 17	88 ± 17	89 ± 17	93 ± 17	89 ± 17	92 ± 16	89 ± 18
GCS, median	15	15	15	14	15	14	15	14	15	14
Comorbidities, %										
DM	4 (29%)	14 (13%)	4 (50%)	14 (12%)	7 (54%)	11 (10%)	15 (71%)	3 (3%)	15 (65%)	3 (3%)
CHF	1 (7%)	1 (1%)	2 (25%)	0 (0%)	2 (15%)	0 (0%)	2 (10%)	0 (0%)	2 (9%)	0 (0%)
CVA	2 (14%)	2 (2%)	4 (50%)	0 (0%)	4 (31%)	0 (0%)	2 (10%)	2 (2%)	3 (13%)	1 (1%)
HTN	8 (57%)	35 (32%)	8 (100%)	35 (31%)	13 (100%)	30 (28%)	21 (100%)	22 (22%)	23 (100%)	20 (20%)
COPD	3 (21%)	3 (3%)	3 (38%)	3 (3%)	4 (31%)	2 (2%)	5 (24%)	1 (1%)	5 (22%)	1 (1%)
Dementia	1 (7%)	1 (1%)	0 (0%)	2 (2%)	1 (8%)	1 (1%)	2 (10%)	0 (0%)	2 (9%)	0 (0%)
Functionally Dependent	3 (21%)	4 (4%)	6 (75%)	1 (1%)	6 (46%)	1 (1%)	4 (19%)	3 (3%)	5 (22%)	2 (2%)
Hypoalbuminemia (<0.3)	3 (21%)	15 (14%)	2 (25%)	16 (14%)	7 (54%)	11 (10%)	6 (29%)	12 (12%)	8 (35%)	10 (10%)
Non-Home Discharges	2 (14%)	31 (29%)	4 (50%)	29 (25%)	7 (54%)	26 (24%)	12 (57%)	21 (21%)	13 (57%)	20 (20%)

mFI=Modified frailty index; NF=Non-frail; SD= Standard deviation; MVC= Motor vehicle collision; ISS=Injury severity score; IQR= Interquartile range; ED SBP= Emergency department systolic blood pressure;
ED HR= Emergency department heart rate; GCS= Glasgow coma scale; DM= Diabetes mellitus; CHF= Congestive heart failure; CVA= Cerebrovascular accident; HTN=Hypertension;
COPD= Chronic onstructive pulmonary disease;

Table 2. Power Test for the mFI on Non-Home Discharges

Diagnosis	Sensitivity (%)	Specificity (%)	Predictive Values	
			Positive	Negative
mFI-11 ≥ 0.27	12%	96%	50%	75%
mFI-11 + hypoalbuminemia ≥ 0.27	21%	93%	54%	76%
mFI-5 ≥ 0.27	36%	90%	57%	79%
mFI-5 + hypoalbuminemia ≥ 0.27	39%	89%	57%	80%
mFI-15 ≥ 0.27	6%	87%	14%	71%

Table 3: Predicting non-home discharge on univariable analysis

	Unadjusted			Adjusted*		
	OR (95% CI)	**p**	**ROC**	**OR (95% CI)**	**p**	**ROC**
mFI-11 ≥ 0.27	2.93 (0.69, 12.48)	0.146	0.538	1.52 (0.34, 6.77)	0.580	0.684
mFI-11 + hypoalbuminemia ≥ 0.27	3.72 (1.15, 12.07)	0.028	0.572	1.94 (0.56, 6.70	0.292	0.694
mFI-5 ≥ 0.27	5.08 (1.89, 13.65)	0.001	0.631	2.77 (0.93, 8.22)	0.067	0.712
mFI-5 + hypoalbuminemia ≥ 0.27	5.14 (1.97, 13.40)	0.001	0.641	2.96 (1.04, 8.46	0.043	0.717
mFI-15 ≥ 0.27	0.41 (0.09, 1.96)	0.266	0.537	0.27 (0.05, 1.34)	0.001	0.704

Hypoalbuminemia defined as albumin levels > 0.3 grams/deciliter
*Adjusting for age

Appendix 1: mFI-11 and -5 variables
History of diabetes mellitus
History of congestive heart failure
History of hypertension requiring medication
History of cerebrovascular accident
History of peripheral vascular disease
History of cerebrovascular accident with neurological deficit
History of COPD or pneumonia
History of myocardial infarction
History of angina
History of delirium
Functional status 2 (non-independent)

*mFI-5 variables in bold

Appendix 2: mFI-15 variables

Comorbidities

Cancer history

Coronary heart disease

Dementia

Daily Activities

Help with grooming

Help managing money

Help doing housework

Help toileting

Help walking

Health Attitude

Feel less useful

Feel sad

Feels effort to do anything

Feels lonely

Falls

Function

Sexually active

Nutrition

Albumin