Using the Hospital Frailty Risk Score to Assess Mortality Risk in Older Medical Patients Admitted to the Intensive Care Unit

Detsky ME, Shin S, Fralick M, Munshi L, Kruser JM, Courtright KR, Lapointe-Shaw L, Tang T, Rawal S, Kwan JL, Weinerman A, Razak F*, Verma AA*

Abstract word count: 249

Manuscript word count: 2,704

Affiliations
Michael E. Detsky, MD, MSc
Department of Medicine, Sinai Health System
Interdepartmental Division of Critical Care Medicine, University of Toronto
Department of Medicine, University of Toronto

Saeha Shin MPH
Li Ka Shing Knowledge Institute, St. Michael's Hospital

Michael Fralick, MD, PhD
Department of Medicine, Sinai Health System
Department of Medicine, University of Toronto

Laveena Munshi, MD, MSc
Department of Medicine, Sinai Health System
Interdepartmental Division of Critical Care Medicine, University of Toronto
Department of Medicine, University of Toronto

Jacqueline M. Kruser MD, MS
Department of Medicine, Division of Allergy, Pulmonary and Critical Care
University of Wisconsin School of Medicine and Public Health

Katherine R. Courtright, MD, MSc
Department of Medicine, Perelman School of Medicine, University of Pennsylvania
Palliative and Advanced Illness Research (PAIR) Center, Perelman School of Medicine, University of Pennsylvania

Lauren Lapointe-Shaw, MD, PhD
Division of General Internal Medicine, University Health Network
Department of Medicine, University of Toronto

Terence Tang, MD
Trillium Health Partners
Department of Medicine, University of Toronto

Shail Rawal, MD, MPH

Division of General Internal Medicine, University Health Network
Department of Medicine, University of Toronto

Janice L. Kwan MD, MPH
Department of Medicine, Sinai Health System
Department of Medicine, University of Toronto

Adina Weinerman MD, MHSc
Department of Medicine, Sunnybrook Health Sciences Centre
Department of Medicine, University of Toronto

Fahad Razak MD, MSc
Department of Medicine, St. Michael's Hospital
Li Ka Shing Knowledge Institute, St. Michael's Hospital
Institute of Health Policy, Management and Evaluation, University of Toronto

Amol A. Verma MD, MPH
Department of Medicine, St. Michael's Hospital
Li Ka Shing Knowledge Institute, St. Michael's Hospital
Department of Medicine, University of Toronto
Institute of Health Policy, Management and Evaluation, University of Toronto

Conflicts of interest –Amol Verma and Fahad Razak are employees of Ontario Health (Quality), which had no role in this work. Dr. Courtright receives funding from the National Institutes of Health. Dr. Kruser's time was supported, in part, by the National Heart, Lung, and Blood Institute (grant K23HL146890)

- Amol A. Verma and Fahad Razak were co-senior authors for this manuscript.

Corresponding Author;
Dr. Michael Detsky
600 University Ave, Suite 18-232-1
Toronto, ON
M5G1X5
michael.detsky@sinaihealth.ca

Abstract

Background
Prognostic information at the time of hospital discharge can help guide goals of care discussions for future care. The Hospital Frailty Risk Score (HFRS) may highlight patients risk for future hospitalizations at the time of hospital discharge.

Methods
We performed a multicentre retrospective cohort study including patients ≥75 years of age and readmitted to hospital within 12 months. HFRS (categorized as low, moderate and high risk) was calculated at the time of discharge from the first hospital admission. Outcomes included ICU admission and mortality for patients' second hospital admission that occurred within 12 months.

Results
Patients (n=22,178) were categorized as high (8.0%), moderate (42.7%) and low (49.4%) frailty risk. The proportion of high frailty risk patients admitted to the ICU was 5.7%, compared to moderate (6.0%, Risk Difference (RD)) and low frailty risk patients (7.2% RD). Among patients admitted to the ICU, 75.0% of high frailty risk patients died, compared to 56.0% of moderate (RD 19.0%) and 52.7% of low (RD 22.3%) frailty risk patients. After multivariable adjustment, the risk of mortality after ICU admission for high frailty risk patients was significantly higher than moderate (aOR=2.35) and low (aOR=2.59) frailty risk patients.

Interpretation
Among patients readmitted to hospital, high frailty risk patients were equally likely to be admitted to the ICU, but more likely to die if admitted to ICU, compared to lower frailty risk patients. The HFRS at hospital discharge can inform prognosis, which can help guide discussions for preferences for ICU care during future hospitalizations.

Introduction

Medical patients discharged from acute care hospitals are at increased risk of experiencing a myriad of adverse events, including hospital readmission (1). Medical patients admitted to the intensive care unit (ICU) during a hospital readmission are at increased risk of death or survival with new or worsening disabilities (2), especially for those that have life limiting illness or impaired baseline function (3-5). Understanding the risks of an ICU admission can be coupled with a patient's values and preferences to engage in shared decision making to determine the appropriateness of an ICU admission (6).

Identifying patients that would benefit from goals of care discussions is challenging (7), but feasible using electronic medical records (8). The Hospital Frailty Risk Score (HFRS) is a tool that uses diagnostic codes at the time of hospital discharge to determine the patient's risk of adverse outcomes following hospital discharge (9). The HFRS uses administrative data that is routinely collected in health systems without requiring collection of granular clinical data. The HFRS could potentially identify patients at the time of hospital discharge and provide prognostic estimates of death if these patients are admitted to the ICU on a subsequent hospitalization.

We sought to assess the association between HFRS at the time of hospital discharge with hospital mortality for patients admitted to the ICU on a subsequent hospital admission. The rationale was to determine if the HFRS could quantify prognosis at the time of hospital discharge, which could inform goals of care discussions, including decisions for ICU admission in the future. We also measured ICU and resource utilization to assess differences based on HFRS.

Methods

Design, Setting and Participants

We conducted a multicentre retrospective cohort study that included patients admitted at least twice over a 12 month period to the general medicine service at seven hospitals participating in the General Medicine Inpatient Initiative (GEMINI) from April 1, 2010 to December 31, 2019. The hospitals included academic centres and large community-based teaching hospitals in Toronto and Mississauga, Ontario, Canada (10). The GEMINI database includes clinical and administrative data extracted from hospitals and linked at the individual patient-level. GEMINI data have 98-100% accuracy compared to detailed manual medical record review of more than 23,000 data points, including 100% for both ICU admission and hospital death (11). GEMINI received research ethics board approval at each participating site to conduct this research.

The HFRS was calculated at the time of discharge from the first hospital admission (9). Outcomes were assessed on the most recent subsequent hospital admission within 12 months. The cohort included medical patients 75 years of age and older. Patients were admitted from the emergency department and were transferred to the general medical ward from the ICU, or vice versa. Because the cohort only includes data for patients who were admitted to the general medicine service at some point during the hospital stay, it does not include patients who were admitted directly from the emergency department to the ICU and either died in the ICU or were discharged directly from the ICU. We also excluded inter-hospital transfers.

Data collection

We used the GEMINI database to collect the following baseline patient characteristics: age, sex, residence prior to hospitalization and comorbidities (using International Statistical Classification of Diseases (ICD-10) codes). We also collected hospital-based data including laboratory test results, ICU admission, diagnostic imaging, and invasive procedures including dialysis, endoscopy and interventional radiology.

Hospital Frailty Risk Score

The HFRS is a score calculated using ICD-10 codes at the time of hospital discharge (9). It was originally developed and validated in patients 75 years of age and older. The HFRS was designed to identify patients at increased risk of adverse events within 30 days of hospital discharge, including mortality and hospital readmission (9). In its initial description, the HFRS was trichotomized to categorize patients as high (score >15), moderate (score 5-15) or low (score <5) frailty risk. The HFRS has been validated in Ontario, Canada, where the present study was performed (12). We calculated the HFRS using discharge diagnoses as reported by hospitals to the Canadian Institute for Health Information for the Discharge Abstract Database and National Ambulatory Care Reporting System. In the current study, we calculated the HFRS at the time of discharge from the first hospitalization between April 1, 2010 and December 31, 2019.

Outcomes

Outcomes were assessed during the second hospital admission between April 1, 2010 and December 31, 2019. The primary outcome was hospital mortality among patients admitted to the ICU. Secondary outcomes included hospital mortality among non-ICU admitted patients, ICU admission, and measures of resource utilization. Measures of resource utilization included ICU and hospital length of stay, diagnostic imaging, dialysis, endoscopy, and interventional radiology procedures.

Statistical Analysis

Descriptive statistics were summarized using proportions and medians with interquartile ranges (IQR) where appropriate. We compared differences in outcomes based on three categories of prognosis per the original HFRS manuscript: high (HFRS>15), moderate (HFRS 5-15) and low (HFRS<5) frailty risk (9). We reported 95% confidence intervals (CI) for the absolute risk difference in outcomes between high frailty risk and both moderate and low frailty risk patients. These were obtained using adjusted standard errors from a two-tailed independent proportions test for clustered data to account for clustering of observations at the hospital-level (13). We used chi-square tests for significant differences in categorical variables and the Kruskal-Wallis tests for significant differences in interval and continuous variables. We constructed three multivariable logistic regression models for the outcome variables of ICU admission, hospital mortality for patients admitted to ICU and hospital mortality for patients not admitted to ICU. These models were used to calculate the adjusted OR (aOR) and assess if mortality and ICU admission were associated with HFRS when controlled for other clinically important patient covariates, including; age, sex, hospital, weekday (compared to weekend) admission, daytime (compared to night) admission and Laboratory based Acute Physiology Score (LAPS) (14). We also compared HFRS and baseline characteristics of the study cohort with patients who were excluded because they only had one hospital admission within 12 months to illustrate the selection effects resulting from the study design.

Our primary analysis was in all patients in the cohort. Analyses were done using R version 4.0.2, (R Foundation for Statistical Computing, Vienna, Austria).

Results

The cohort included 22,178 medical patients 75 years of age and older that had at least two admissions to a medical ward at one of the participating GEMINI hospitals within 12 months (Table 1, eFigure 1 in the Supplemental Appendix). The patients in the study cohort were slightly older, had a higher Charlson Comorbidity Index and were more likely to be from a nursing home compared to patients that did not have a hospital readmission within 12 months (eTable 1 in the Supplemental Appendix). In the study cohort 8.0% (n=1,767/22,178) of patients were categorized as high frailty risk, 42.7% (n=9,464/22,178) were moderate frailty risk and 49.4% (n=10,947/22,178) were low frailty risk. The overall hospital mortality rate for high frailty risk patients was 26.1% (n=461/1,767), 22.9% (n=2,167/9,424) for moderate frailty risk patients and 20.1% (n=2,205/10,947) for low frailty risk patients (Table 2). Among patients 75 years of age and older that were not included in the cohort because they were not readmitted to hospital within 12 months, (n=71,190), 7.4% (n=5,239/71,190) were categorized as high frailty risk, 40.3% (n=28,671/71,190) were moderate frailty risk and 52.4% (n=37,280/71,190) were low frailty risk.

ICU admission and mortality

The proportion of patients admitted to ICU during their second hospitalization was 6.6% (n=1,456/22,178), with the majority of patients being admitted to the ICU within the first 2 days of hospitalization (eFigure 2 in the Supplemental Appendix). The proportion of high frailty risk patients admitted to the ICU was 5.7% (n=100/1,767), compared to moderate (6.0%, n=566/9,464, Risk Difference =-0.3% (95% CI: -2.5, 1.9)) and low frailty risk patients (7.2%, n=790/10,947, Risk Difference =-1.6% (95% CI: -4.2, 1.1)) (Table 2). After multivariable adjustment, the odds of ICU admission were not significantly different for high frailty risk patients compared to moderate (aOR: 0.95; 95% CI: 0.76-1.18) and low (aOR: 0.82; 95% CI: 0.66-1.02) frailty risk patients (Figure 1 and eTable 2 in the Supplemental Appendix).

Among patients admitted to the ICU, 55.5% (808/1,456) died in hospital. Among high frailty risk patients admitted to the ICU, 75.0% (n=75/100) died in hospital. The risk of mortality for high frailty risk patients was higher than moderate (56.0%, n=317/566, Risk Difference=19.0% (95% CI: 7.4, 30.6)) and low frailty risk patients (52.7%, n=416/790) Risk Difference=22.3% (95% CI: 12.4, 32.3)). After multivariable adjustment, the odds of hospital mortality after ICU admission were significantly higher for high frailty risk patients compared to moderate (aOR=2.35, 95% CI: 1.46-3.90) and low (aOR=2.59, 95% CI: 1.62-4.27) frailty risk patients (Figure 1, eTable 3 in the Supplemental Appendix).

Mortality among patients not admitted to the ICU

Among patients not admitted to the ICU during their second hospitalization (n=20,722), 19.4% (4,025/20,722) died in hospital, accounting for 83.3% (4,025/4,833) of the total deaths in hospital. The proportion of high frailty risk

patients who died without being admitted to ICU was 23.2% (n=386/1,667) compared to moderate (20.8%, n=1,850/8,898, Risk Difference= -2.4% (95% CI: -0.8, 5.5)) and low frailty risk patients (17.6%, n=1,789/10,157, Risk Difference= 5.5% (95%CI: 2.2, 8.9)) (Table 2). After multivariable adjustment, the odds of hospital mortality was similar for high frailty risk patients that were not admitted to the ICU compared to moderate frailty risk patients (aOR: 1.13; 95% CI: 0.99-1.29), but significantly increased compared to the low frailty risk patients (aOR: 1.28; 95% CI: 1.12-1.46) (Figure 1, eTable 4 in the Supplemental Appendix).

Resource utilization

Resource utilization for patients based on HFRS are summarized in Table 2. Among patients admitted to the ICU during their second hospitalization, there were no significant differences in resource utilization across HFRS categories, including hospital and ICU length of stay, medical imaging, interventional radiology procedures, endoscopy and dialysis (Table 3). Among non-ICU patients, high frailty risk patients had longer hospital length of stay, were more likely to be discharged to a nursing home, and received computed tomography (CT) scans more frequently whereas magnetic resonance imaging (MRI) scans, interventional procedures and endoscopies were received less frequently (Table 4).

Discussion

In this large multicentre cohort study of older medical patients, the HFRS calculated at hospital discharge provided useful prognostic information for patients who were admitted to the ICU on a subsequent hospitalization within 12 months. While the proportion of patients admitted to the ICU was similar across frailty risk strata, high frailty risk patients admitted to ICU were more likely to die compared lower frailty risk patients. This suggests there is an opportunity to use the HFRS to identify patients who would benefit from goals of care discussions following hospital discharge. The HFRS also provides a prognostic estimate of a patient's probability of dying if they require an ICU admission.

The ambulatory setting provides an opportunity to address patient's goals of care and preferences for ICU level care. Prior work has shown that these opportunities are frequently missed (15). Interventions addressing goals goals of care discussions in the outpatient setting can reduce both unwanted ICU admissions and ICU length of stay (16). The ambulatory setting avoids the potential interruptions in hospital that can limit the quality of these discussions (17). In our study, the majority of ICU admissions occurred within the first 2 days of the patient's hospitalization where there may be limited time and opportunity to have high quality discussions about care preferences early in a hospital admission. Further, hospitalized patients often lack capacity to engage in these discussions (18), which may be secondary to delirium related to their underlying reason for hospital admission (19).

Discussions of goals of care for a hospital admission should focus on aligning a patient's values and preferences with the patient's prognosis, to ensure the goals of the patients are realistically achievable given the clinical scenario (20). Ideally, these discussions include appropriate stakeholders. This includes patients, and their surrogate decision maker(s) to ensure that the patient's perspective is shared should the patient become unable to express these considerations. Other partners should include clinicians that have a longitudinal relationship with the patient, including a primary care physician and/or a specialist who has been involved in treating a patient's chronic medical condition and understands the patient's expected trajectory. Ideally, these discussions would also include an ICU physician that has the expertise to help patients make an informed decision about the risks of ICU, including but not limited to, delirium (21), impaired sleep (22) and exposure to bacteria with increased antimicrobial resistance (23). It would also include the potential benefits of receiving ICU level care, including the probability of survival.

We found that patients admitted to the ICU after being readmitted to hospital within 12 months have a high risk of dying in hospital. Older medical patients admitted to the ICU had a probability of dying of more than 50%, and this number increased to 75% for high frailty risk patients. This is consistent with prior work that identified that older patients admitted to the ICU are at high risk of death, especially those categorized as frail (24-29). In fact, a randomized control trial comparing systematic ICU admission to usual care for high functioning older patients found that patients

admitted to the ICU were at increased risk of dying within 6 months (30). This highlights the importance of combining each patient's risk of mortality with their values and values and preferences to ensure the care they receive is goal concordant care.

In general, ICU care often includes continuous monitoring, procedures, and the use of invasive life support. In our study, patients admitted to the ICU received invasive investigations and interventions (i.e., endoscopy, dialysis, interventional radiology procedures) in similar proportions regardless of their HFRS. This is consistent with prior work, where older frail patients in the ICU had similar imaging costs compared to non-frail older patients in the ICU (31). This suggests that the care received in the ICU is uniformly intense. Among non-ICU patients, higher frailty risk patients received fewer invasive procedures (i.e., endoscopy, dialysis and interventional procedures) and more CT scans than lower frailty risk patients. This suggests that care on the medical wards may have focused more on non-invasive diagnostic testing, and possibly limiting more invasive investigations.

This study has limitations that merit consideration. First, we used the HFRS as a measure of prognosis. Although the HFRS has been validated against patient outcomes in several settings, including our own province (12), there is potential misclassification of prognosis due to the limited sensitivity of most administrative diagnostic codes. Nevertheless, in our study the HFRS was clearly associated with increased hospital mortality, particularly among ICU patients. Second, while the proportion of older patients who died without an ICU admission is comparable to earlier work (32), we lacked data on patient values and preferences or clinical decision-making and therefore draw no conclusions about the appropriateness of ICU use in our study. Furthermore, we also lack detailed information on what degree of ICU level care was delivered and whether limitations to care were implemented. Detailed qualitative data are needed to understand the relationship between prognosis, patient preferences, informed decision-making, and the invasive nature of ICU use. Third, roughly one of out every four patients categorized as high frailty risk at the time of hospital discharge was readmitted within 12 months. This underscores the challenge in predicting readmissions to hospital. It is possible some of these patients died without a hospital readmission or were readmitted to non-participating hospitals within 12 months. Future work should focus on identifying risk factors for hospital readmission. In our study, patients readmitted to hospital were more likely to be from a nursing home and had higher Charlson Comorbidity Index scores.

Conclusion

Older medical patients categorized as high frailty risk (using the HFRS) that are admitted to the ICU are more likely to die than patients with lower frailty risk. Calculating the HFRS at hospital discharge can help identify patients that would benefit from discussions about future ICU care. The HFRS can provide prognostic estimates that can be used to engage in shared decision making between patients and clinicians to help ensure the delivery of care that is concordant with the

patient's values and preferences when patients are readmitted to hospital in the future.

References

1. Krumholz, H.M. Post-hospital syndrome–a condition of generalized risk. The New England journal of medicine. 2013;,368(2):100.
2. Detsky ME, Harhay MO, Bayard DF, et al. Six-Month Morbidity and Mortality among Intensive Care Unit Patients Receiving Life-Sustaining Therapy. A Prospective Cohort Study. Ann Am Thorac Soc. 2017; 14(10): 1562-1570.
3. Ouchi K, Lo Bello J, Moseley E, et al. Long-Term Prognosis of Older Adults Who Survive Emergency Mechanical Ventilation. J Pain Symptom Manage. 2020; 60(5): 1019-1026
4. Hill AD, Fowler RA, Wunsch H, et al. Frailty and long-term outcomes following critical illness: A population-level cohort study. J Crit Care. 2020;62:94-100.
5. Zampieri FG, Iwashyna TJ, Viglianti EM, et al. Association of frailty with short-term outcomes, organ support and resource use in critically ill patients. Intensive Care Med. 2018; 44(9): 1512-1520.
6. Bernacki RE, Block SD; American College of Physicians High Value Care Task Force. Communication about serious illness care goals: a review and synthesis of best practices. JAMA Intern Med. 2014 Dec; 174(12): 1994-2003.
7. Weissman DE, Meier DE. Identifying Patients in Need of a Palliative Care Assessment in the Hospital Setting A Consensus Report from the Center to Advance Palliative Care. Journal of Palliative Medicine 2011; 14: 17–23.
8. Courtright KR, Chivers C, Becker M et al. Electronic health record mortality prediction model for targeted palliative care among hospitalized medical patients: A pilot quasi-experimental study. J Gen Intern Med. 2019; 34(9): 1841-1847.
9. Gilbert T, Neuburger J, Kraindler J, et al. Development and validation of a Hospital Frailty Risk Score focusing on older people in acute care settings using electronic hospital records: an observational study. Lancet. 2018; 391(10132): 1775-1782.
10. Verma AA, Guo Y, Kwan JL, et al. Patient characteristics, resource use and outcomes associated with general internal medicine hospital care: the General Medicine Inpatient Initiative (GEMINI) retrospective cohort study. CMAJ Open. 2017; 5(4): E842-E849.
11. Pasrich SV, Hae JY, Kushnir V et al. Assessing the quality of clinical and administrative data extracted from hospitals: The General Medicine Inpatient Initiative (GEMINI) experience. https://doi.org/10.1101/2020.03.16.20036962
12. McAlister F, van Walravan C. One-year Mortality Risk Score to predict outcomes in elderly hospitalised patients: a retrospective cohort study. BMJ Qual Saf. 2019; 28(4): 284–288.
13. D'agostino RB, Chase W, Belanger A. The appropriateness of some common procedures for testing the equality of two independent binomial populations. The American Statistician. 1988; 42(3): 198-202.

14. Escobar GJ, Greene JD, Scheirer P, Gardner MN, Draper D, Kipnis P. Risk-adjusting hospital inpatient mortality using automated inpatient, outpatient, and laboratory databases. Med Care. 2008; 46(3): 232–239.
15. Knutzen KE, Sacks OA, Brody-Bizar OC, et al. Actual and Missed Opportunities for End-of-Life Care Discussions With Oncology Patients: A Qualitative Study. JAMA Netw Open. 2021;4(6):e2113193. doi: 10.1001/jamanetworkopen.2021.13193
16. Khandelwal, N. Kross EK, Engelberg RA et al. Estimating the effect of palliative care interventions and advance care planning on ICU utilization: A systematic review. Crit Care Med. 2015; 43(5): 1102-11.
17. Fulmer T, Escobedo M, Berman A, et al. Physicians' Views on Advance Care Planning and End-of-Life Care Conversations. J Am Geriatr Soc. 2018; 66(6): 1201-1205.
18. You JJ, Downar J, Fowler RA, et al. Canadian Researchers at the End of Life Network. Barriers to goals of care discussions with seriously ill hospitalized patients and their families: a multicenter survey of clinicians. JAMA Intern Med. 2015; 175(4): 549-56.
19. Siddiqi N, House AO, Holmes JD. Occurrence and outcome of delirium in medical in-patients: a systematic literature review, Age and Ageing, 2006; 35: 350–364.
20. Halpern SD. Goal-Concordant Care - Searching for the Holy Grail. N Engl J Med. 2019; 381(17): 1603-1606.
21. McNicoll L, Pisani MA, Zhang Y, et al. Delirium in the intensive care unit: occurrence and clinical course in older patients. J Am Geriatr Soc. 2003; 51(5): 591–598.
22. Pisani MA, Friese RS, Gehlbach BK, et al. Sleep in the intensive care unit. Am J Respir Crit Care Med. 2015; 191(7): 731-738.
23. Homberg PR, Fritsche TR, Sader HS, et al. Antimicrobial susceptibility pattern comparisons among intensive care unit and general ward Gram-negative isolates from the Meropenem Yearly Susceptibility Test Information Collection Program (USA). Diagn Microbiol Infect Dis. 2006; 56(1): 57–62.
24. Moreno R, Oeyen S, Öhman CA, et al. The impact of frailty on ICU and 30-day mortality and the level of care in very elderly patients (≥ 80 years). Intensive Care Med. 2017; 43(12): 1820-1828.
25. Oeyen S, Schefold JC, Cecconi M, et al. The contribution of frailty, cognition, activity of daily life and comorbidities on outcome in acutely admitted patients over 80 years in European ICUs: the VIP2 study. Intensive Care Med. 2020; 46(1): 57-69.
26. Hill AD, Fowler RA, Wunsch H, et al. Frailty and long-term outcomes following critical illness: A population-level cohort study. J Crit Care. 2020; 62: 94-100.
27. Zampieri FG, Iwashyna TJ, Viglianti EM, et al. Association of frailty with short-term outcomes, organ support and resource use in critically ill patients. Intensive Care Med. 2018; 44(9): 1512-1520.

28. Wytske G, Marieke Z, Peter D. et al. Changes in frailty among ICU survivors and associated factors: Results of a one-year prospective cohort study using the Dutch Clinical Frailty Scale. Journal of Critical Care. 2020; 55: 184-193.
29. Muscedere J, Waters B, Varambally A, et al. The impact of frailty on intensive care unit outcomes: a systematic review and meta-analysis. Intensive Care Med. 2017; 43(8): 1105–1122.
30. Guidet B, Leblanc G, Simon T, et al. Effect of Systematic Intensive Care Unit Triage on Long-term Mortality Among Critically Ill Elderly Patients in France: A Randomized Clinical Trial. JAMA. 2017;318(15): 1450–1459.
31. Fernando SM, McIsaac, DI, Perry JJ, et al. Frailty and Associated Outcomes and Resource Utilization Among Older ICU Patients With Suspected Infection, Critical Care Medicine. 2019: 47(8); e669-e676.
32. Angus, DC, Barnato, AE, Linde-Zwirble, WT, et al. Use of intensive care at the end of life in the United States: an epidemiologic study. Critical care medicine, 2004;32(3), 638-643.

Acknowledgements

Study design, and analysis was conducted by all authors of the manscript. The first iteration of the manuscript was written primarily by M Detsky with input from all co-authors who provided edits and feedback. Statistical work was primarily done by S Shin with input from M Detsky, A Verma, F Razak and M Fralick. The site leads for data collection include L Lapointe-Shaw, T Tang, S Rawal, J Kwan, A Weinerman, F Razak and A Verma..

Table 1. Baseline Patient Characteristics stratified by Hospital Frailty Risk Score

	High N=1,767	**Moderate N=9,464**	**Low N=10,947**
Age, median (IQR)	86 (82, 90)	86 (81, 90)	84 (80, 89)
Sex Male	739 (41.8)	4,327 (45.7)	5,061 (46.2)
From nursing home	662 (37.5)	2,560 (27.0)	1,689 (15.4)
Charlson Comorbidity Index			
0	322 (18.2)	2,135 (22.6)	2,485 (22.7)
1	146 (8.3)	1,231 (13.0)	1,726 (15.8)
2+	1,299 (73.5)	6,098 (64.4)	6,736 (61.5)
LAPS	22 (11, 36)	22 (11, 35)	21 (10, 33)
Day of admission - weekend	464 (26.3)	2,421 (25.6)	2,803 (25.6)
Night admission to hospital	1,341 (75.9)	7,218 (76.3)	8,181 (74.7)
Discharge Diagnosis			
Heart failure	79 (4.5)	778 (8.2)	1,330 (12.1)
COPD	37 (2.1)	319 (3.4)	775 (7.1)
Pneumonia	99 (5.6)	509 (5.4)	593 (5.4)
Urinary Tract Infection	134 (7.6)	684 (7.2)	334 (3.1)
Cognitive Disorders	225 (12.7)	697 (7.4)	342 (3.1)
Sepsis	113 (6.4)	497 (5.3)	336 (3.1)
Aspiration pneumonitis	169 (9.6)	575 (6.1)	354 (3.2)
Gastrointestinal bleed	33 (1.9)	203 (2.1)	314 (2.9)
Renal Failure	38 (2.2)	250 (2.6)	219 (2.0)

P value compares differences across all groups
IQR=Interquartile range
LAPS=Lab and acute physiology score
COPD=chronic obstructive pulmonary disease
Night admission to hospital=between the hours of 1700-8:00
Cognitive Disorders include 'delirium' and 'dementia'

Table 2. Patient outcomes and resource use stratified by Hospital Frailty Risk Score

	High N=1,767	**Moderate N=9,464**	**Low N=10,947**	**P value**
ICU admission (%)	100 (5.7)	566 (6.0)	790 (7.2)	<0.001
Hospital length-of-stay in days, median (IQR)	7.4 (3.6, 15.5)	6.9 (3.5, 14.1)	6.1 (3.9, 12.2)	<0.001
Discharge disposition, n (%)				
Death	461 (26.1)	2167 (22.9)	2205 (20.1)	<0.001
Died with ICU admission	75 (4.2)	317 (3.3)	416 (3.8)	0.086
Died without ICU admission	386 (21.8)	1850 (19.5)	1789 (16.3)	<0.001
Inpatient chronic care[a]	487 (27.6)	2034 (21.5)	1371 (12.5)	<0.001
Inpatient rehabilitation facility	81 (4.6)	479 (5.1)	555 (5.1)	0.673
Home	638 (36.1)	4244 (44.8)	6227 (56.9)	<0.001
Acute care institution	72 (4.1)	413 (4.4)	466 (4.3)	0.838
Other[b]	28 (1.6)	127 (1.3)	123 (1.1)	0.161
Endoscopy, n (%)	73 (4.1)	603 (6.4)	1014 (9.3)	<0.001
Dialysis, n (%)	16 (0.9)	197 (2.1)	238 (2.2)	0.002
Interventional radiology procedures	124 (7.0)	814 (8.6)	945 (8.6)	0.068
Imaging, n (%)				
CT	990 (56.0)	5241 (55.4)	5554 (50.7)	<0.001
MRI	77 (4.4)	596 (6.3)	735 (6.7)	0.001
Ultrasound	455 (25.7)	2508 (26.5)	2866 (26.2)	0.76

P value compares differences across all groups

[a]Inpatient chronic care= nursing homes and complex continuing care institutions

[b]Other includes: Ambulatory Care, Detoxification Centre, Mental Health Unit, Ministry Of Health Internally Used Classification, Health Service Organization (Family Health Organization), Treatment Centre – Addiction

Endoscopy= sigmoidoscopy, colonoscopy, esophago-gastroduedenoscopy, endoscopic retrograde cholangiopancreatography and/or bronchoscopy

CT=computed tomography

MRI=magnetic resonance imaging

Cells with fewer than 5 cases were suppressed to reduce risk of patient reidentification, in line with local privacy policies.

Table 3. Patient outcomes and resource use for ICU admitted patients stratified by Hospital Frailty Risk Score

	High N=100	Moderate N=566	Low N=790	P value
ICU length-of-stay in days, median (IQR)	4.0 (2.0, 8.8)	3.3 (1.6, 7.0)	3.2 (1.4, 7.0)	0.137
Hospital length-of-stay in days, median (IQR)	14.99 (6.9, 27.4)	13.9 (6.9, 30.8)	13.6 (6.6, 26.5)	0.351
Discharge disposition, n (%)				
Death	75 (75.0)	317 (56.0)	416 (52.7)	<0.001
Inpatient chronic care[a]	8 (8.0)	66 (11.7)	59 (7.5)	0.028
Inpatient rehabilitation facility	<=5	33 (5.8)	40 (5.1)	0.482
Acute care hospital	<=5	27 (4.8)	52 (6.6)	0.348
Home	8 (8.0)	119 (21.0)	217 (27.5)	<0.001
Other[b]	<=5	<=5	6 (0.8)	0.952
Endoscopy, n (%)	10 (10.0)	106 (18.7)	150 (19.0)	0.085
Dialysis, n (%)	6 (6.0)	47 (8.3)	69 (8.7)	0.647
Interventional procedures	26 (26.0)	151 (26.7)	170 (21.5)	0.078
Imaging, n (%)				
CT	68 (68.0)	372 (65.7)	502 (63.5)	0.549
MRI	12 (12.0)	53 (9.4)	68 (8.6)	0.525
Ultrasound	49 (49.0)	255 (45.1)	326 (41.3)	0.186

P value compares differences across all groups
[a]Inpatient chronic care= nursing homes and complex continuing care institutions
[b]Other includes: Health Service Organization (Family Health Organization)
Inpatient chronic care= nursing homes and complex continuing care institutions
Endoscopy= sigmoidoscopy, colonoscopy, esophago-gastroduedenoscopy, endoscopic retrograde cholangiopancreatography and/or bronchoscopy
CT=computed tomography
MRI=magnetic resonance imaging
Cells with fewer than 5 cases were suppressed to reduce risk of patient reidentification, in line with local privacy policies.

Table 4. Patient Outcomes and Resource Use for non-ICU Admitted Patients Stratified by Hospital Frailty Risk Score

	High N=1,667	**Moderate N=8,898**	**Low N=10,157**	**P value**
Hospital length-of-stay in days, median (IQR)	7.03 [3.56, 14.86]	6.63 [3.42, 13.55]	5.77 [2.86, 11.31]	<0.001
Discharge disposition, n (%)				
Death	386 (23.2)	1850 (20.8)	1789 (17.6)	<0.001
Inpatient chronic care[a]	479 (28.7)	1968 (22.1)	1312 (12.9)	<0.001
Inpatient rehabilitation facility	78 (4.7)	446 (5.0)	515 (5.1)	0.794
Acute care institution	67 (4.0)	386 (4.3)	414 (4.1)	0.627
Home	630 (37.8)	4125 (46.4)	6010 (59.2)	<0.001
Other[b]	27 (1.6)	123 (1.4)	117 (1.2)	0.17
Endoscopy, n (%)	63 (3.8)	497 (5.6)	864 (8.5)	<0.001
Dialysis, n (%)	10 (0.6)	150 (1.7)	169 (1.7)	0.003
Interventional procedures	98 (5.9)	663 (7.5)	775 (7.6)	0.04
Imaging, n (%)				
CT	922 (55.3)	4869 (54.7)	5052 (49.7)	<0.001
MRI	65 (3.9)	543 (6.1)	667 (6.6)	<0.001
Ultrasound	406 (24.4)	2253 (25.3)	2540 (25.0)	0.681

P value compares differences across all groups

[a]Inpatient chronic care= nursing homes and complex continuing care institutions

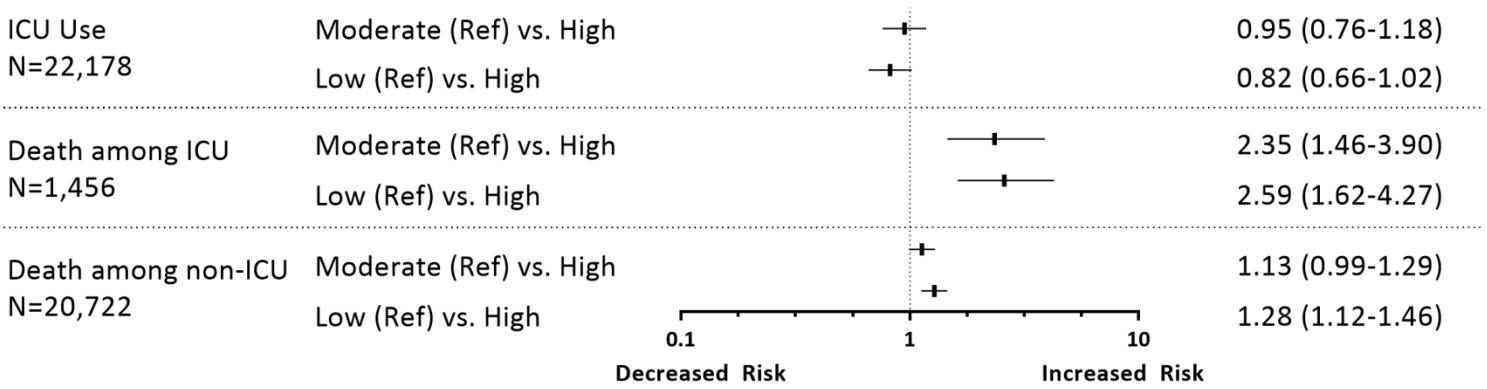
[b]Other includes: Ambulatory Care, Acute Detoxification Centre, Mental Health Unit, Ministry Of Health Internally Used Classification, Health Service Organization (Family Health Organization), Treatment Centre – Addiction

Inpatient chronic care= nursing homes and complex continuing care institutions

Endoscopy= sigmoidoscopy, colonoscopy, esophago-gastroduedenoscopy, endoscopic retrograde cholangiopancreatography and/or bronchoscopy

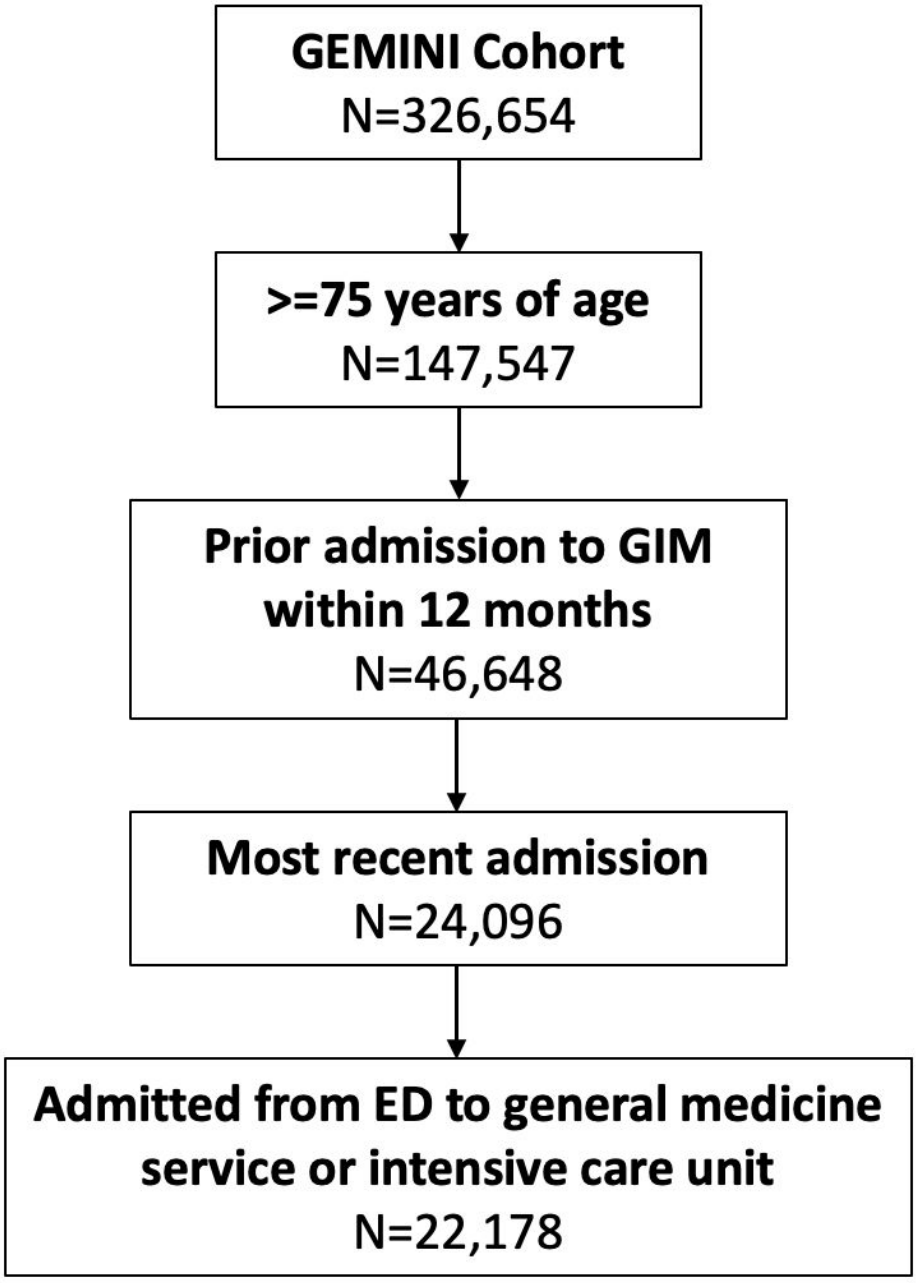
CT=computed tomography

MRI=magnetic resonance imaging



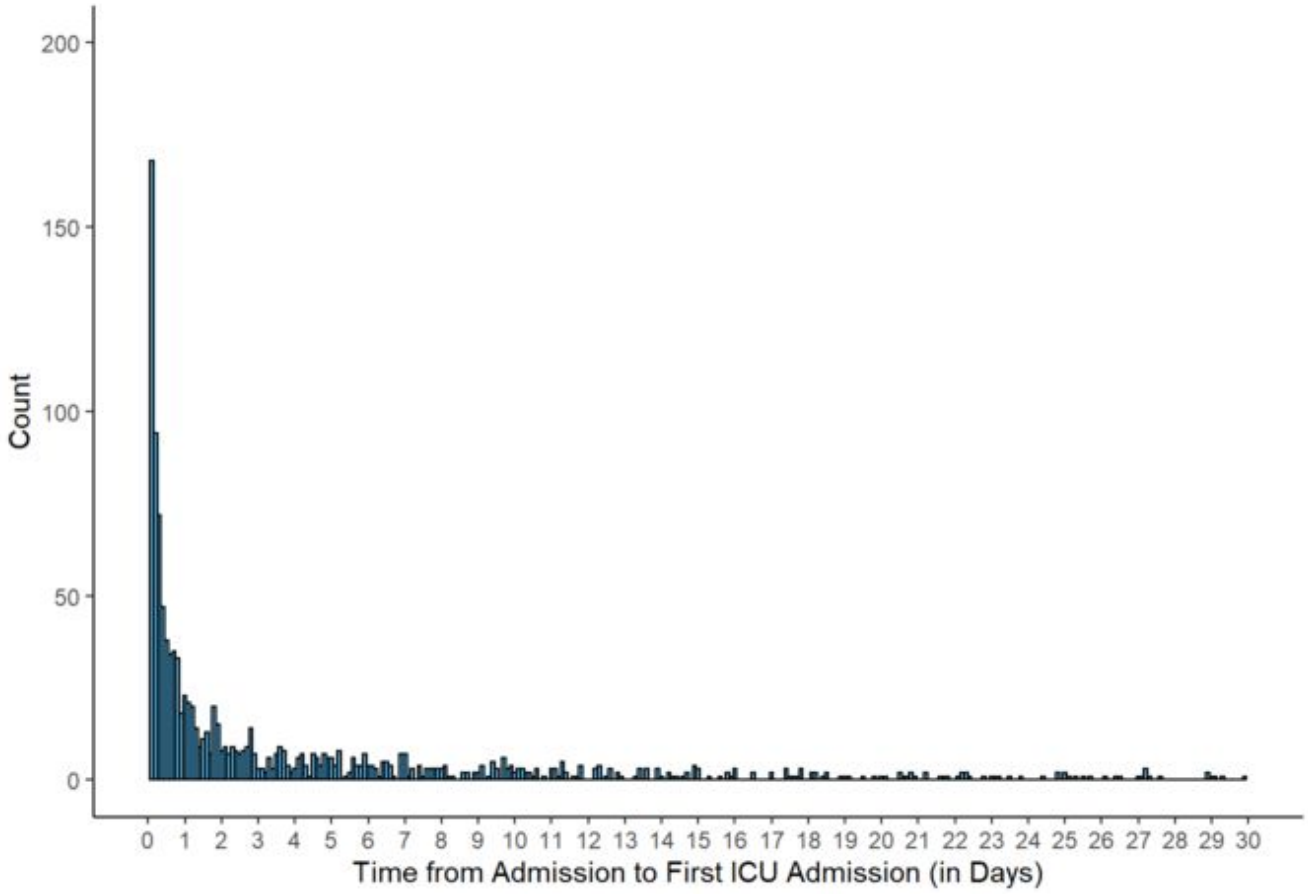
Supplementary Online Content

eFigure 1. Hospitalizations in the GEMINI COHORT



GEMINI= General Medicine Inpatient Initiative

eFigure 2. Day of ICU admission during hospitalization (n=1,456)



Note that 52 patients were admitted to ICU after 30 days.

eTable 1. Comparing Included vs. Excluded Patients in the Cohort

	Included N=22,178	Excluded N=125,369	P value
Age (median and interquartile range)	85.00 [81.00, 90.00]	84.00 [80.00, 89.00]	<0.001
Sex Male	10127 (45.7)	55745 (44.5)	0.001
From nursing home	4911 (22.1)	19911 (15.9)	<0.001
Charlson Comorbidity Index			<0.001
0	4942 (22.3)	40837 (32.6)	
1	3103 (14.0)	20004 (16.0)	
2+	14133 (63.7)	64528 (51.5)	
LAPS	21.00 [11.00, 34.00]	18.00 [7.00, 31.00]	<0.001
Day of admission – weekend	5688 (25.6)	32285 (25.8)	0.748
Night time admission to hospital	16740 (75.5)	95566 (76.2)	0.016
Most common discharge diagnosis			<0.001
Aspiration pneumonitis	1098 (5.0)	3032 (2.4)	<0.001
Stroke	470 (2.1)	5336 (4.3)	0.258
COPD	1131 (5.1)	6166 (4.9)	0.001
Fluid and electrolyte disorders	460 (2.1)	3089 (2.5)	0.589
Gastrointestinal hemorrhage	550 (2.5)	3190 (2.5)	<0.001
Heart failure	2187 (9.9)	9598 (7.7)	<0.001
Neurocognitive disorders	1264 (5.7)	6290 (5.0)	<0.001
Pneumonia	1201 (5.4)	7728 (6.2)	<0.001
Sepsis	946 (4.3)	3428 (2.7)	0.755
Urinary tract infection	1152 (5.2)	6579 (5.2)	<0.001

LAPS=Lab and acute physiology score
COPD=chronic obstructive pulmonary disease
Night time admission=between 1700-8:00

eTable 2. Adjusted Odds Ratios Hospital Frailty Risk Score and ICU Admission

Predictor	Adjusted OR (95% CI)	p
Intercept	7.29 (3.07 – 17.37)	<0.001
Moderate Frailty	1.05 (0.85 – 1.32)	0.655
Low Frailty	1.22 (0.98 – 1.52)	0.081
Age	0.94 (0.93 – 0.95)	<0.001
Sex – Male	1.28 (1.15 – 1.43)	<0.001
Day of Admission - Weekend	0.96 (0.85 – 1.09)	0.526
Time of Admission - Night	0.84 (0.75 – 0.95)	0.005
LAPS	1.02 (1.02 – 1.03)	<0.001
Hospital – A	0.44 (0.35 – 0.54)	<0.001
Hospital – B	0.91 (0.73 – 1.13)	0.407
Hospital – C	0.46 (0.36 – 0.57)	<0.001
Hospital – D	1.00 (0.84 – 1.20)	0.969
Hospital – E	0.85 (0.68 – 1.06)	0.143
Hospital – F	0.98 (0.80 – 1.20)	0.847

LAPS=Lab and acute physiology score
Reference levels include frailty (high), sex (female), and Charlson comorbidity index (0)

eTable 3. Adjusted Odds Ratios for Hospital Frailty Risk Score and Death Among Patients Admitted to the ICU

Predictor	Adjusted OR (95% CI)	p
Intercept	0.29 (0.05 – 1.74)	0.176
Moderate Frailty	0.43 (0.26 – 0.69)	0.001
Low Frailty	0.39 (0.23 – 0.62)	<0.001
Age	1.02 (1.00 – 1.04)	0.024
Sex – Male	1.14 (0.92 – 1.41)	0.236
Day of Admission - Weekend	1.15 (0.90 – 1.48)	0.270
Time of Admission - Night	1.23 (0.97 – 1.57)	0.082
LAPS	1.01 (1.00 – 1.02)	0.001
Hospital – A	1.18 (0.77 – 1.80)	0.453
Hospital – B	0.50 (0.32 – 0.75)	0.001
Hospital – C	0.94 (0.60 – 1.48)	0.804
Hospital – D	0.90 (0.63 – 1.27)	0.543
Hospital – E	0.98 (0.64 – 1.50)	0.919
Hospital – F	0.77 (0.52 – 1.15)	0.206

LAPS=Lab and acute physiology score
Reference levels include frailty (high), sex (female), and Charlson comorbidity index (0)

eTable 4. Adjusted Odds Ratios for Hospital Frailty Risk Score and Death Among Patients Not Admitted to the ICU

Predictor	Adjusted OR (95% CI)	p
Intercept	0.01 (0.00 – 0.01)	<0.001
Moderate Frailty	0.89 (0.78 – 1.01)	0.070
Low Frailty	0.78 (0.68 – 0.89)	<0.001
Age	1.03 (1.03 – 1.04)	<0.001
Sex – Male	1.22 (1.13 – 1.31)	<0.001
Day of Admission - Weekend	1.04 (0.96 – 1.13)	0.321
Time of Admission - Night	0.81 (0.75 – 0.88)	<0.001
LAPS	1.04 (1.04 – 1.04)	<0.001
Hospital – A	0.68 (0.59 – 0.79)	<0.001
Hospital – B	1.35 (1.15 – 1.59)	<0.001
Hospital – C	1.18 (1.02 – 1.37)	0.024
Hospital – D	1.21 (1.05 – 1.39)	0.007
Hospital – E	1.70 (1.46 – 1.99)	<0.001
Hospital – F	1.92 (1.66 – 2.22)	<0.001

LAPS=Lab and acute physiology score
Reference levels include frailty (high), sex (female), and Charlson comorbidity index (0)