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Patient Factors Linked with Return Acute Healthcare Use in Older Adults by Discharge Disposition

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Abstract

Objectives: Compare patient characteristics by hospital discharge disposition (home without services, with home healthcare (HHC) services, or to post-acute care (PAC) facilities. Examine timing and rates of 30-day healthcare utilization (rehospitalization, emergency department (ED) or observation (OBS) visit) and patient characteristics associated with rehospitalization by discharge location.

Design: Retrospective analysis of hospital administrative and clinical data.

Setting and Participants: 3,294 older adult inpatients discharged home with or without HHC services, or to a PAC facility.

Measurements: Patient-level sociodemographic, and clinical characteristics. Number of and time to occurrences of rehospitalization or ED/OBS visit within 30-days of hospital discharge.

Results: Most rehospitalizations and ED/OBS visits occurred within 14 days from hospital discharge. Patients who returned within 24 hours came mostly from inpatient rehabilitation facilities (IRFs). More intense levels of PAC services were linked with higher rehospitalization risk. However, specific predictors differed by discharge location. Being unemployed, single and having more comorbidities were most associated with rehospitalization in those that went home with or without services while patients rehospitalized from IRFs were younger, with less chronic illness burden, but greater and recent functional decline. Those discharged with HHC services had more return ED/OBS visits.

Conclusions: While sicker patients were referred for more intense levels of PAC services, patients with greater chronic illness burden were still most often rehospitalized. In addition to

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Conflict of Interest

There are no conflicts (or potential conflicts) of interests (financial, personal or otherwise) for any authors.

unique patient differences, rehospitalizations from IRF within 24 hours suggest systems factors are contributory. Most return acute healthcare utilization occurred within 14 days therefore interventions should focus on smoothing transitions to all discharge locations. Since predictors of rehospitalization risk differed by discharge disposition, future research is necessary to study approaches aimed at matching patients' care needs with the most suitable PAC services at the right time.

Keywords

post-acute care; readmission risk; patient discharge; inpatient rehabilitation facility; clinical decision support systems

INTRODUCTION

Consumption of acute healthcare services (i.e., rehospitalization, emergency department (ED) or observation (OBS) visits), within 30-days of hospital discharge, is prevalent,^{1, 2} expensive,³ and potentiates fragmented care hazardous for vulnerable older adults.^{4, 5} Overall rehospitalization rates averaged 15.8% in 2017⁶ and approximately 25% are potentially preventable,⁷ especially if close to hospital discharge.⁸ Effective discharge planning⁹ and high quality post-acute care (PAC)¹⁰ are known to reduce rehospitalizations.

After hospitalization, approximately 40% of Medicare beneficiaries receive PAC services from home healthcare (HHC), skilled nursing facilities (SNFs), or inpatient rehabilitation facilities (IRFs).¹¹ Increasingly aimed at reducing hospital lengths of stays (LOS) and rehospitalizations,¹² PAC services comprise the fastest growing sector of Medicare spending.¹³ There is, however, wide variation in PAC spending,¹⁴ influenced by provider preferences and practice norms.^{15, 16} Despite progress in PAC referral clinical decision support,^{17, 18} discharge decisions are frequently rushed, made close to discharge, and not often based on well-defined criteria.¹⁷ This can lead to delayed or misaligned PAC services resulting in poorer patient outcomes including rehospitalization.¹⁹

There is no known study identifying predictors of rehospitalization risk by discharge disposition. Examination of rates, timing of utilization (as it relates to preventability) and associated patient factors can aid clinicians in making informed and standardized discharge decisions. This study's purpose was to examine rates and timing of post-discharge acute healthcare utilization and patient characteristics associated with utilization by various discharge locations.

METHODS

A secondary analysis was performed using control phase data from a multi-center quasi-experimental study (NR01007674) aimed at measuring the effectiveness of an algorithm to determine need for and type of PAC services.^{17, 18, 20} In this phase, clinicians were blinded to algorithm advice and engaged in *usual* discharge planning practices. Patient-level data were collected from 2 suburban teaching hospitals within the same mid-Atlantic 800-bed health system from May 8, 2015 through September 11, 2015 with an additional 30-days to measure post-discharge acute healthcare utilization.

Eligible patients were age 55 and older, hospitalized for at least 48 hours, discharged alive, and without a primary diagnosis associated with a potentially pre-determined discharge location e.g., fractures (n=3,302). Eight patients were excluded due to missing discharge location yielding a final cohort of 3,294 patients.

Based on the Andersen Behavioral Model of Health Services Use,²¹ this study examines 19 individual-level variables hypothesized to *predispose* one's need for healthcare services, and identify a perceived, or professionally-evaluated *need* for healthcare services (Supplemental Table 1).

Administrative hospital databases supplied admission/discharge dates to compute hospital LOS, comorbidities, employment status, primary diagnoses and the acute healthcare utilization variables: 30-day rehospitalization or return ED/OBS visit. Clinical data extracted from the electronic health record (EHR), included Morse²² (fall risk) and Braden²³ (pressure ulcer) scores, changes in activities of daily living, prior hospitalizations within 6 months, self-rated health, and additional socio-demographic data. Once de-identified, data were transferred via secure files to the parent study team who extensively cleaned the dataset.

Acute healthcare utilization rates were computed using Chi-Square proportions and differences by patient characteristics compared using non-parametric (Chi-square, Fisher-Exact, or Kruskal-Wallis) tests as appropriate. The sample was then divided into 3 discharge disposition subsets: (1) Home without Services (40.6%; 1,336/3,294) (2) Home with HHC Services (22.8%; 752/3,294); or (3) PAC facility (SNF or IRF) (36.6%; 1,206/3,294); patient characteristics were compared across discharge disposition using the same non-parametric tests. We identified optimal predictors of rehospitalization via adaptive logistic lasso with cross-validated penalization parameters.^{24, 25} Order of predictive importance was determined by the magnitude of standardized coefficients. Time-to-acute healthcare utilization was examined using Kaplan-Meier survival analysis with log rank tests to compare discharge disposition subsets. A post-hoc secondary analysis examined factors associated with 24-hour rehospitalization. Missing data accounted for <6% of any predictor and was either excluded or coded as a separate categorical level, based on numbers, in the models. Data were managed and analyzed using Stata (Stata/IC Version 16.0, StataCorp, College Station, Texas). The Institutional Review Boards of the University and hospitals approved the study and granted consent waiver.

RESULTS

Patient Characteristics

Differences in Patient Characteristics by Acute Healthcare Utilization—Overall, 15.2% (499/3294) of patients were rehospitalized within 30-days of hospital discharge and were more likely to be unemployed ($P=.005$), have a longer median index LOS (4.1 days vs. 3.3 days; $P=.001$), greater fall risk (52.5 ± 23.2 vs. 47.8 ± 22.7 ; $P<.001$), lower rates of good/excellent health (36.9% vs. 44.7%; $P=.001$), more previous hospitalizations (14.6% vs. 10.6%; $P=.008$), and greater functional decline (except eating ability) ($P=.001$).

Patients returned at a rate of 6.1% (202/3294) for a “treat and release” ED/OBS visit within 30-days of discharge. The only differing characteristic was higher rates of hospitalizations within the past 6 months in those with a return ED/OBS visit (15.4% vs. 10.9%; $P=.03$).

Differences in Patient Characteristics by Discharge Disposition—Of the 1,206 facility patients, 76% (920/1206) were discharged to a SNF, 9% (110/1206) to an IRF, and the remaining 15% (176/1206) to another facility type e.g., transfer to inpatient hospital, long-term care facility. Overall, PAC facility patients were older, and more often widowed or female; 61.2% of females in this sample did not have a spouse/partner versus 32% of males ($P<.001$). Facility patients had greater chronic illness burden evidenced by longer index LOS, higher fall and pressure ulcer risk, more hospitalizations, and greater functional decline. They rated their health at lower levels and less often had a caregiver. Those with more education, employed, and living independently prior to hospitalization, were referred less often to a facility (Table 1). Patients with index hospitalizations for infectious diseases and injuries were more commonly referred to a facility than those who went home with or without services (10.6% vs. 6.4% vs. 5.1%; $P<.001$); those with circulatory system diseases were more often referred for HHC services compared to those who went home without services or to a facility (31.5% vs. 27.0% vs. 21.2%; $P<.001$).

Patient Characteristics Predictive of Rehospitalization—The most important lasso predictor of rehospitalization was level of PAC services; more intense services predicted a higher rehospitalization risk. Stratifying by discharge disposition showed significant differences in predictors of rehospitalization within disposition subgroups (Table 2). Patients discharged to a facility were at higher rehospitalization risk if diagnosed with circulatory disease. Among those who went home with or without services, being unemployed, single and having more comorbidities were linked with higher rehospitalization risk. Those discharged home *without* services were also at greater rehospitalization risk if they had poorer self-rated health, a cancer diagnosis, were older and male.

Acute Healthcare Utilization by Discharge Disposition

Rehospitalizations—Unadjusted 30-day rehospitalization rates differed based on hospital discharge disposition at 19.3% (233/1206; Facility), 16.6% (125/752; HHC), and 10.6% (141/1336; home without services) ($P<.001$). Over 60% (168/266) of all rehospitalizations from home regardless of services, and 74% (172/233) of rehospitalizations from a facility occurred within 14 days. Approximately 40% (106/266) of all rehospitalizations from home, and over 50% (134/233) of facility rehospitalizations occurred within 7 days post-discharge. Differences in time-to-rehospitalization were mostly due to the 36.9% (86/233) of facility rehospitalizations within 24 hours of hospital discharge. Among *all* facility patients, the 7.1% (86/1206) rehospitalized within 24 hours were referred to an IRF. Overall, facility rehospitalization rates appear to plateau slightly between 14 and 20 days but rise again after 20 days (Figure 1).

Return ED Visits or OBS—Unadjusted return ED/OBS visits occurred at rates of 8.8% (66/772; HHC), 6.4% (86/1336; home), and 4.2% (50/1206; Facility) ($P<.001$). At approximately 5–7 days, HHC rates increase with a second rise after 20 days. Regardless

of disposition, more than 50% (126/202) of all return visits occurred within 14 days of discharge. Facility rates plateaued at 14 days and slightly increased again after 20 days (Figure 2).

Post-hoc Analysis of 24-hour Facility Rehospitalizations

Since patients who were rehospitalized within 24-hours returned specifically from an IRF, a post-hoc secondary analysis was conducted to compare these patients with (1) *all* facility patients, and (2) all those rehospitalized from *any* discharge location.

Early Rehospitalizations among All Patients Discharged to a Facility—

Compared to all other facility patients, those rehospitalized within 24 hours from an IRF were younger, better educated, more often employed, and lived independently prior to hospitalization. They had a shorter hospital LOS, fewer hospitalizations, and better self-rated health. However, they were more often discharged on an opioid, had greater fall risk and functional decline during hospitalization (although only toileting and transfer were statistically significant) (Table 3).

Those returning quickly from an IRF, compared to other facility patients either rehospitalized later or not, had significantly higher incidence of circulatory diseases (37.2% vs. 20.4% vs. 19.2%; $P<.001$) or injuries (36.1% vs. 10.9% vs. 20.3%; $P<.001$). Approximately 84% of patients, returning from an IRF within 24 hours, were rehospitalized only once within 30-days of hospital discharge.

Early Facility Rehospitalizations Compared to All Other Rehospitalizations

—Compared to those rehospitalized after one day (up to 30-days) from *any* location ($n=412$), patients returning within 24 hours from an IRF ($n=86$) were more likely living independently prior to hospitalization ($P<.001$), discharged on an opioid ($P<.001$) with greater fall risk ($P<.001$). They had greater decline in ambulation, bathing, toileting and transfer ability during hospitalization ($P<.001$), more often rated their baseline health as good/excellent ($P=.002$) and had fewer hospitalizations ($P=.02$) (Supplemental Table 2). These patients were more likely originally hospitalized for circulatory diseases (37.1% vs. 27.7%; $P<.001$) or injuries (36.1% vs. 7.3%; $P<.001$).

DISCUSSION

As expected, patients with greater clinical needs (e.g., functional decline, fall risk) and socioeconomic risks (e.g., older, single women without caregivers), were most often discharged to facility-level PAC services. Despite more intensive PAC support, these patients were more frequently rehospitalized (19.3%) than those referred for HHC services (16.6%). In other studies, rehospitalization rates from SNFs ranged between 14.5–22.8%,^{16, 26, 27} and for those receiving HHC services at 18%,²⁸ suggesting our results align with other findings. However, if those patients who returned within 24 hours from an IRF were excluded, HHC rates would exceed those of SNF rehospitalizations consistent with findings from a large study of Medicare beneficiaries.²⁹

Rehospitalized patients, from all discharge locations, had greater evidence of chronic illness burden (i.e., prior hospitalizations, poorer self-rated health), however, predictors of rehospitalization differed by discharge location. Among those who went home without services, patients with greater chronic illness and less support systems i.e., single, unemployed were at higher rehospitalization risk. Conceivably, these patients may not have the resources or the assistance to obtain medications or food thereby potentially worsening not only acute but also comorbid conditions.³⁰

If referred for HHC services, those with a longer hospital LOS, and an infectious disease diagnosis were more likely rehospitalized. However, patients discharged on an opioid were *less* likely to return for an inpatient stay. Possibly opioid use is associated with post-operative care and more intense HHC services hence mitigating risk. If the infectious disease diagnosis was septicemia, patients had greater rehospitalization risk³¹ and potentially were appropriately readmitted due to vigilant HHC services. It is equally plausible these patients would have benefited from a referral for more intensive care in a facility.^{17, 20}

Facility patients were *less* at risk for rehospitalization if they were older or had an infectious disease diagnosis. We did not measure whether patients were receiving end-of-life care which may have lowered risk. Patients discharged with septicemia to a facility may have received more intense monitoring and consistent antibiotic administration thus preventing reinfection, the most common reason for readmission among sepsis survivors.³² Alternatively, patients may have had an infectious disease associated with lower rehospitalization risk. Facility patients were *more* likely rehospitalized if diagnosed with circulatory disease and may have required services beyond those rendered in a particular PAC facility. Most discharging providers are not familiar with the quality of specific facilities which can lead to a mismatch between patient needs and available resources.¹⁶ Moreover, handoffs and information exchange between hospitals and PAC facilities are known to be suboptimal, potentially leading to unsafe transitions between settings.²⁷ Choice of higher quality SNFs is associated with lower rehospitalization rates regardless of the hospital's readmission performance.³³ If facilities are resourced adequately, and providers from hospital and PAC settings are mutually accountable for outcomes through programs e.g., bundled payments and preferred provider networks,^{10, 34} rehospitalizations could be prevented. Effective risk reduction approaches could include collaborative determination of patient discharge readiness, early intensive monitoring of high-risk patients, and comprehensive communication mechanisms between clinicians including shared records (or data exchanges), and telemedicine consults.³⁵

Rehospitalizations from a facility increased at 20 days post-hospitalization. We have no knowledge of how long patients stayed in a PAC facility, but they may have been discharged at 20 days when daily Medicare co-insurance SNF payments begin. The average SNF LOS was 26.5 days in 2015³⁶ which supports the supposition that patients went home before rehospitalization, and further illustrates the importance of managing transitions after PAC discharge.

Consistent with other findings, most rehospitalizations occurred within 14 days post-discharge,³⁷ and similar to another recent study,¹⁶ we found this was especially true for

those discharged to a facility. Our findings demonstrated that patients discharged to an IRF returned more quickly which may be due to system rather than patient-level factors. Early rehospitalizations within 7 days of discharge have double the odds of being potentially preventable, and are more likely associated with hospital factors i.e., premature discharge, and physician decision-making challenges.³⁸ We also determined that most patients who returned within 24 hours from an IRF, did not have another rehospitalization within the 30-day period further suggesting that discharge timing and choice of PAC services are pivotal for avoiding early rehospitalization.

Patients rehospitalized early from an IRF, looked very differently than all other patients in the study. When compared to other facility patients, they were younger, better educated, employed, living independently, with a shorter index LOS. When compared to those rehospitalized from any location *and* all that went to a facility, they had much less *chronic* illness burden. They did, however, have greater functional decline, higher fall risk, and were more often discharged on an opioid. Given these factors and since patients were predominantly diagnosed with circulatory disease, or injuries, it suggests their health status changed suddenly. Similar to other findings, functional decline,^{16, 39} and clinical instability at hospital discharge,⁴⁰ were significantly associated with rehospitalization risk from a facility. More specifically, in studies of unplanned rehospitalizations from an IRF, poor function at discharge was associated with greater rehospitalization risk.^{41, 42}

Given their younger age, it is possible these patients requested an earlier hospital discharge, and an IRF placement if they did not perceive other levels of facility care appealing. It is equally plausible that if clinically eligible, discharging providers referred these patients for more intensive IRF care, since they were younger, employed, and perceived more readily able to follow instructions given their higher educational level or cognitive ability.

Patients who returned for an ED/OBS visit had no differences in patient characteristics except for more previous hospitalizations. In a study of ED use in older aged patients, each additional hospitalization nearly quadrupled the risk for ED/OBS return (3.78 (95% CI: (2.53, 5.65))).⁴³ In our study, patients referred for HHC services were more likely to return for an ED/OBS visit within 5–7 days. Despite referral, it is conceivable that some patients may not have received timely or adequate numbers of nursing visits,⁴⁴ or seen a clinician before returning to the ED.⁴⁵ Two recent studies with heart failure and sepsis survivors show the value of early nursing and outpatient provider follow-up in significantly reducing 30-day readmissions from HHC.^{46, 47} Furthermore, it is plausible that the quality of HHC services was suboptimal,⁴⁸ or that caregivers were inadequately prepared to render assistance at home.⁴⁹ It is also possible that patients refused HHC services; Topaz et al. found that 28% of patients refuse PAC services and subsequently had twice the odds of 30- and 60-day rehospitalizations.⁵⁰ Alternatively, perhaps HHC patients appropriately utilized ED/OBS services circumventing worse sequelae.

Although we identified significant predictive risk factors, since this was an observational study, we cannot make causal inferences and there is always the risk of unmeasured bias confounding findings. Since the measurement of discharge disposition was based on referral status at discharge, we could not ascertain whether patients actually received the

recommended services or arrived at the PAC facility. We did not have data available to assess the contribution of other important factors (i.e., physical therapy assessments, insurance type), although most patients were likely Medicare beneficiaries. We do not know how many were dually-eligible for Medicaid, but the study hospitals are located in fairly affluent areas. We also were unable to measure when and how often patients received HHC services, if they had seen a provider before returning to the ED or returned for acute services in another hospital (although neither of these hospitals are referral centers). Although no differences in healthcare utilization were observed based on race or ethnicity, the sample population was predominantly white. We could not reliably identify *readmission* diagnoses for our secondary analysis of 24-hour rehospitalizations from a PAC facility.

In conclusion, patients with higher illness burden were more commonly referred for PAC services but rehospitalizations were more frequent and occurred sooner in those discharged to a facility especially IRFs. This suggests that patients may have required greater provision of healthcare services than available and were likely sent back to acute care due to systems issues with transitions between hospitals and IRF settings in particular. Because our post-hoc analyses were only exploratory, future research aimed at studying early rehospitalizations from a facility is warranted.

In this study, we examined patient characteristics not readily available in claims data to explore factors associated with return acute care utilization. These results have implications for future research aimed at refining risk prediction and analyzing patient outcomes in different PAC settings. Hospitals and PAC providers should also consider these factors within clinical decision support tools to best match patients' care needs with PAC services^{17, 18, 20} and to communicate these factors to the next level of care. Given the Medicare Payment Advisory Commission's proposal of a unified PAC prospective payment system, it will be especially critical to judiciously utilize higher cost services.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. Zuckerman RB, Sheingold SH, Orav EJ, Ruhter J, Epstein AM. Readmissions, Observation, and the Hospital Readmissions Reduction Program. *N Engl J Med*. 2016;374(16):1543–51. [PubMed: 26910198]
2. Vashi AA, Fox JP, Carr BG, D'Onofrio G, Pines JM, Ross JS, et al. Use of hospital-based acute care among patients recently discharged from the hospital. *Jama*. 2013;309(4):364–71. [PubMed: 23340638]

3. Fingar K, Washington R. Readmissions for Four High-Volume Conditions, 2009–2013. Healthcare Cost & Utilization Project. Agency for Healthcare Research and Quality. Statistical Brief #196. November 2015:1–17. <https://www.hcup-us.ahrq.gov/reports/statbriefs/sb196-Readmissions-Trends-High-Volume-Conditions.pdf>. Accessed December 18, 2017. 2015.
4. Naylor MD, Stephens C, Bowles KH, Bixby MB. Cognitively Impaired Older Adults: From Hospital To Home: An exploratory study of these patients and their caregivers. *AJN The American Journal of Nursing*. 2005;105(2):52–61.
5. Krumholz HM, Merrill AR, Schone EM, Schreiner GC, Chen J, Bradley EH, et al. Patterns of hospital performance in acute myocardial infarction and heart failure 30-day mortality and readmission. *Circ Cardiovasc Qual Outcomes*. 2009;2(5):407–13. [PubMed: 20031870]
6. Medicare Payment Advisory Commission. Mandated report: The effects of the Hospital Readmissions Reduction Program. In: Report to Congress: Medicare and the Health Care Delivery System. 62018: 14–15. http://www.medpac.gov/docs/default-source/reports/jun18_medpacreporttocongress_sec.pdf?sfvrsn=0 Accessed October 14, 2019.
7. van Walraven C, Bennett C, Jennings A, Austin PC, Forster AJ. Proportion of hospital readmissions deemed avoidable: a systematic review. *CMAJ*. 2011;183(7):E391–402. [PubMed: 21444623]
8. Goldfield NI, McCullough EC, Hughes JS, Tang AM, Eastman B, Rawlins LK, et al. Identifying potentially preventable readmissions. *Health Care Financ Rev*. 2008;30(1):75–91. [PubMed: 19040175]
9. Auerbach AD, Kripalani S, Vasilevskis EE, Sehgal N, Lindenauer PK, Metlay JP, et al. Preventability and Causes of Readmissions in a National Cohort of General Medicine Patients. *JAMA Intern Med*. 2016;176(4):484–93. [PubMed: 26954564]
10. McHugh JP, Foster A, Mor V, Shield RR, Trivedi AN, Wetle T, et al. Reducing Hospital Readmissions Through Preferred Networks Of Skilled Nursing Facilities. *Health Aff (Millwood)*. 2017;36(9):1591–8. [PubMed: 28874486]
11. Medicare Payment Advisory Commission. Post-acute care: The Congress and CMS must act to implement recommended changes to PAC payments. In: Report to Congress: Medicare Payment Policy. 32017: 185–193. http://medpac.gov/docs/default-source/reports/mar17_entirereport.pdf. Accessed January 4, 2018.
12. Burke RE, Juarez-Colunga E, Levy C, Prochazka AV, Coleman EA, Ginde AA. Rise of post-acute care facilities as a discharge destination of US hospitalizations. *JAMA Intern Med*. 2015;175(2):295–6. [PubMed: 25437642]
13. Mechanic R. Post-acute care—the next frontier for controlling Medicare spending. *New England Journal of Medicine*. 2014;370(8):692–4.
14. Newhouse JP, Garber AM. Geographic variation in Medicare services. *New England Journal of Medicine*. 2013;368(16):1465–8.
15. Mor V, Intrator O, Feng Z, Grabowski DC. The revolving door of rehospitalization from skilled nursing facilities. *Health Aff (Millwood)*. 2010;29(1):57–64. [PubMed: 20048361]
16. Burke RE, Whitfield EA, Hittle D, Min SJ, Levy C, Prochazka AV, et al. Hospital Readmission From Post-Acute Care Facilities: Risk Factors, Timing, and Outcomes. *J Am Med Dir Assoc*. 2016;17(3):249–55. [PubMed: 26715357]
17. Bowles KH, Ratcliffe SJ, Naylor MD, Holmes JH, Keim SK, Flores EJ, editors. Nurse generated EHR data supports post-acute care referral decision making: Development and validation of a two-step algorithm. *AMIA Annual Symposium Proceedings*; 2017: American Medical Informatics Association.
18. Bowles KH, Ratcliffe SJ, Holmes JH, Keim S, Potashnik S, Flores E, et al. Using a Decision Support Algorithm for Referrals to Post-Acute Care. *Journal of the American Medical Directors Association*. 2019;20(4):408–13. [PubMed: 30414821]
19. Holland DE, Bowles KH. Standardized discharge planning assessments: impact on patient outcomes. *J Nurs Care Qual*. 2012;27(3):200–8. [PubMed: 22437249]
20. Keim SK, Bowles KH, editors. Comparison of algorithm advice for post-acute care referral to usual clinical decision-making: examination of 30-day acute healthcare utilization. *AMIA Annual Symposium Proceedings*; 2017: American Medical Informatics Association.

21. Andersen R, Newman JF. Societal and individual determinants of medical care utilization in the United States. *The Milbank Memorial Fund Quarterly Health and Society*. 1973;95–124. [PubMed: 4198894]
22. Morse JM, Morse RM, Tylko SJ. Development of a scale to identify the fall-prone patient. *Canadian Journal on Aging/La Revue canadienne du vieillissement*. 1989;8(04):366–77.
23. Bergstrom N, Braden B, Kemp M, Champagne M, Ruby E. Predicting pressure ulcer risk: a multisite study of the predictive validity of the Braden Scale. *Nursing research*. 1998;47(5):261–9. [PubMed: 9766454]
24. Tibshirani R. Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society: Series B (Methodological)*. 1996;58(1):267–88.
25. Zou H. The adaptive lasso and its oracle properties. *Journal of the American statistical association*. 2006;101(476):1418–29.
26. Ouslander JG, Diaz S, Hain D, Tappen R. Frequency and diagnoses associated with 7- and 30-day readmission of skilled nursing facility patients to a nonteaching community hospital. *J Am Med Dir Assoc*. 2011;12(3):195–203. [PubMed: 21333921]
27. Vasilevskis EE, Ouslander JG, Mixon AS, Bell SP, Jacobsen J, Saraf AA, et al. Potentially Avoidable Readmissions of Patients Discharged to Post-Acute Care: Perspectives of Hospital and Skilled Nursing Facility Staff. *Journal of the American Geriatrics Society*. 2017;65(2):269–76. [PubMed: 27981557]
28. Xiao R, Miller JA, Zafirau WJ, Gorodeski EZ, Young JB. Impact of home health care on health care resource utilization following hospital discharge: a cohort study. *The American journal of medicine*. 2018;131(4):395–407. e35. [PubMed: 29180024]
29. Werner RM, Coe NB, Qi M, Konetzka RT. Patient outcomes after hospital discharge to home with home health care vs to a skilled nursing facility. *JAMA internal medicine*. 2019;179(5):617–23. [PubMed: 30855652]
30. Calvillo-King L, Arnold D, Eubank KJ, Lo M, Yunyongying P, Stieglitz H, et al. Impact of social factors on risk of readmission or mortality in pneumonia and heart failure: systematic review. *J Gen Intern Med*. 2013;28(2):269–82. [PubMed: 23054925]
31. Jones TK, Fuchs BD, Small DS, Halpern SD, Hanish A, Umscheid CA, et al. Post-Acute Care Use and Hospital Readmission after Sepsis. *Ann Am Thorac Soc*. 2015;12(6):904–13. [PubMed: 25751120]
32. Singh A, Bhagat M, George SV, Gorthi R, Chaturvedula C. Factors Associated with 30-day Unplanned Readmissions of Sepsis Patients: A Retrospective Analysis of Patients Admitted with Sepsis at a Community Hospital. *Cureus*. 2019;11(7).
33. Mor V, Rahman M, McHugh J. Accountability of hospitals for Medicare beneficiaries' postacute care discharge disposition. *JAMA internal medicine*. 2016;176(1):119–21. [PubMed: 26595256]
34. Zhu JM, Patel V, Shea JA, Neuman MD, Werner RM. Hospitals using bundled payment report reducing skilled nursing facility use and improving care integration. *Health Affairs*. 2018;37(8):1282–9. [PubMed: 30080469]
35. Rahman M, Gadbois EA, Tyler DA, Mor V. Hospital–Skilled Nursing Facility Collaboration: A Mixed-Methods Approach to Understanding the Effect of Linkage Strategies. *Health services research*. 2018;53(6):4808–28. [PubMed: 30079445]
36. Medicare Payment Advisory Commission. Skilled Nursing Facility Services. In: Report to Congress: Medicare Payment Policy. 32017: 197–221. http://medpac.gov/docs/default-source/reports/mar17_entirereport.pdf. Accessed January 4, 2018.
37. Dharmarajan K, Hsieh AF, Lin Z, Bueno H, Ross JS, Horwitz LI, et al. Diagnoses and timing of 30-day readmissions after hospitalization for heart failure, acute myocardial infarction, or pneumonia. *Jama*. 2013;309(4):355–63. [PubMed: 23340637]
38. Graham KL, Auerbach AD, Schnipper JL, Flanders SA, Kim CS, Robinson EJ, et al. Preventability of early versus late hospital readmissions in a national cohort of general medicine patients. *Annals of internal medicine*. 2018;168(11):766–74. [PubMed: 29710243]
39. Morandi A, Bellelli G, Vasilevskis EE, Turco R, Guerini F, Torpilliesi T, et al. Predictors of rehospitalization among elderly patients admitted to a rehabilitation hospital: the role of

- polypharmacy, functional status, and length of stay. *J Am Med Dir Assoc.* 2013;14(10):761–7. [PubMed: 23664484]
40. Ouslander JG, Naharci I, Engstrom G, Shutes J, Wolf DG, Rojido M, et al. Hospital transfers of skilled nursing facility (SNF) patients within 48 hours and 30 days after SNF admission. *Journal of the American Medical Directors Association.* 2016;17(9):839–45. [PubMed: 27349621]
41. Fisher SR, Graham JE, Krishnan S, Ottenbacher KJ. Predictors of 30-Day Readmission Following Inpatient Rehabilitation for Patients at High Risk for Hospital Readmission. *Phys Ther.* 2016;96(1):62–70. [PubMed: 26359271]
42. Ottenbacher KJ, Karmarkar A, Graham JE, Kuo Y-F, Deutsch A, Reistetter TA, et al. Thirty-day hospital readmission following discharge from postacute rehabilitation in fee-for-service Medicare patients. *Jama.* 2014;311(6):604–14. [PubMed: 24519300]
43. Naughton C, Drennan J, Treacy P, Fealy G, Kilkenny M, Johnson F, et al. The role of health and non-health-related factors in repeat emergency department visits in an elderly urban population. *Emerg Med J.* 2010;27(9):683–7. [PubMed: 20581390]
44. O'Connor M, Bowles KH, Feldman PH, St Pierre M, Jarrin O, Shah S, et al. Frontloading and intensity of skilled home health visits: a state of the science. *Home Health Care Serv Q.* 2014;33(3):159–75. [PubMed: 24924484]
45. Hernandez AF, Greiner MA, Fonarow GC, Hammill BG, Heidenreich PA, Yancy CW, et al. Relationship between early physician follow-up and 30-day readmission among Medicare beneficiaries hospitalized for heart failure. *JAMA.* 2010;303(17):1716–22. [PubMed: 20442387]
46. Murtaugh CM, Deb P, Zhu C, Peng TR, Barron Y, Shah S, et al. Reducing Readmissions among Heart Failure Patients Discharged to Home Health Care: Effectiveness of Early and Intensive Nursing Services and Early Physician Follow-Up. *Health Serv Res.* 2017;52(4):1445–72. [PubMed: 27468707]
47. Deb P, Murtaugh CM, Bowles KH, Mikkelsen ME, Khajavi HN, Moore S, et al. Does Early Follow-Up Improve the Outcomes of Sepsis Survivors Discharged to Home Health Care? *Medical care.* 2019;57(8):633–40. [PubMed: 31295191]
48. Wang Y, Spatz ES, Tariq M, Angraal S, Krumholz HM. Home Health Agency Performance in the United States: 2011–15. *J Am Geriatr Soc.* 2017;65(12):2572–9. [PubMed: 28960228]
49. Chase J-AD, Russell D, Rice M, Abbott C, Bowles KH, Mehr DR. Caregivers' Experiences Regarding Training and Support in the Post-Acute Home Health-Care Setting. *Journal of Patient Experience.* 2009;2374373519869156.
50. Topaz M, Kang Y, Holland DE, Ohta B, Rickard K, Bowles KH. Higher 30-day and 60-day readmissions among patients who refuse post acute care services. *Am J Manag Care.* 2015;21(6):424–33. [PubMed: 26168063]

Figure 1.
30-day Rehospitalization by Discharge Disposition

Figure 2.
30-day Return ED Visits & OBS by Discharge Disposition

Table 1.**Patient Characteristics and Rehospitalization Rates by Hospital Discharge Disposition**

Overall Control Sample (N=3294)		Home (N=1336)	HHC (N=752)	Facility (N=1206)	P Value [*]
Characteristics		Means (SD) [Range] or n (%)			
Age	75.9 (11.4) [55–106]	71.8 (10.8) [55–103]	76.1 (10.6) [55–101]	80.4 (10.6) [55–106]	<.001
Gender [†]					
Male	1553 (47.1)	676 (50.7)	376 (50.0)	501 (41.5)	<.001
Female	1738 (52.8)	658 (49.2)	375 (50.0)	705 (58.5)	
Race [†]					
White	2818 (85.6)	1120 (86.8)	636 (84.6)	1062 (88.1)	<.001
Black	391 (11.9)	171 (12.8)	103 (13.7)	117 (9.7)	
Other	73 (2.2)	41 (3.1)	9 (1.2)	23 (1.9)	
Ethnicity [†]					
Hispanic	31 (0.9)	20 (1.5)	6 (0.8)	5 (0.4)	.016
Non-Hispanic	3237 (98.3)	1303 (97.5)	739 (98.3)	1195 (99.1)	
Marital Status [†]					
Married/Partnered	1643 (49.9)	750 (56.2)	434 (57.7)	459 (38.1)	<.001
Single/Widowed	1476 (44.8)	519 (38.8)	280 (37.2)	677 (56.2)	
Education [†]					
Some High School	1757 (53.3)	631 (47.2)	396 (52.7)	730 (60.5)	<.001
Post High School	1421 (43.1)	672 (50.3)	325 (43.2)	424 (35.2)	
Employment [†]					
Employed	501 (15.2)	331 (24.8)	111 (14.8)	59 (4.9)	<.001
Not Employed	377 (11.5)	162 (12.1)	66 (8.8)	149 (12.4)	
Retired	2299 (69.8)	803 (60.1)	548 (72.9)	948 (78.6)	
Living Situation [†]					
Independent	2527 (76.7)	1166 (87.3)	662 (88.0)	699 (58.0)	<.001
ALF/Facility	691 (21.0)	142 (10.6)	68 (9.0)	481 (39.9)	
# Comorbidities	3.17 (1.9) [0 – 14]	3.1 (1.8) [0–14]	3.1 (1.8) [0–11]	3.3 (2.0) [0–14]	.06
LOS (days)	4.9 (4.8) [1–82]	3.3 (2.2) [1–21]	4.5 (3.6) [1–29]	6.9 (6.5) [1–82]	<.001
Median	3.6	2.8	3.4	4.9	
Fall Risk Score (< 45=High Risk)	48.5 (22.8) [0 – 125]	37.5 (17.8) [0–110]	48.2 (20.3) [0–115]	60.8 (23.0) [0–125]	<.001
Braden Score (15–18=At Risk) (19–23=Low Risk)	18.8 (2.9) [7 – 23]	20.4 (2.0) [8–23]	19.3 (2.2) [10–23]	16.6 (2.9) [7–23]	<.001
Self-Health [†]					
Excellent/Good	1433 (43.5)	742 (55.5)	362 (48.1)	330 (27.4)	<.001
Average	1070 (32.4)	395 (30.0)	229 (30.5)	446 (37.0)	
Fair/Poor	759 (23.0)	194 (14.5)	153 (20.4)	412 (34.2)	

Overall Control Sample (N=3294)		Home (N=1336)	HHC (N=752)	Facility (N=1206)	<i>P</i> Value [*]
Characteristics		Means (SD) [Range] or n (%)			
Prior hosp 6 mos [†]					
None	2049 (62.2)	916 (68.6)	465 (61.8)	668 (55.4)	<.001
One	1168 (35.5)	397 (29.7)	277 (36.9)	494 (41)	
Caregiver					
Yes	2511 (76.2)	1057 (79.1)	582 (77.4)	872 (72.3)	<.001
No	783 (23.8)	279 (20.9)	170 (22.6)	334 (27.7)	
Opioid [†]					
No	2452 (74.4)	1061 (79.4)	503 (66.9)	888 (73.6)	<.001
Yes	800 (24.3)	260 (19.5)	238 (31.7)	302 (25.0)	
Decline in:					
Ambulation [†]	1387 (42.1)	259 (19.4)	352 (46.8)	776 (64.3)	<.001
Bathing [†]	1019 (30.9)	164 (12.3)	234 (31.1)	621 (51.5)	<.001
Eating [†]	457 (13.9)	44 (3.3)	66 (8.8)	347 (28.8)	<.001
Toileting [†]	1181 (35.9)	212 (15.9)	264 (35.1)	705 (58.5)	<.001
Transfer [†]	1323 (40.2)	240 (18.0)	348 (46.3)	735 (61.0)	<.001
Readmission Rate	499 (15.2)	141 (10.6)	125 (16.6)	233 (19.3)	<.001

Abbreviations: ALF, assisted living facility; LOS, length of stay; hosp, hospitalization; mos, months;

^{*} p-values for difference across discharge disposition (calculated using Chi-square, Fisher Exact or Kruskal-Wallis Tests)

[†] Numbers may not add to 100% if unknowns excluded

Table 2.

Lasso Predictors of Rehospitalization within Hospital Discharge Disposition subgroups by Order of Predictive Importance*

Order	Home without Services (n=1292 [^])	HHC Services (n=752)	Facility Care (n=1206)
1	Poorer Self-Health (+)	<u>Employment Status:</u> Employed (–) Unemployed (+) Retired (+)	Age (–)
2	Skin Disease Dx (–)	LOS (+)	Infectious Disease Dx (–)
3	Ill-defined Dx (–)	Infectious Disease Dx (+)	Circulatory Disease Dx (+)
4	<u>Employment Status:</u> Employed (–) Unemployed (+) Retired (–)	Opioid (–)	
5	Single (+)	Single (+)	
6	Male (+)	# Comorbidities (+)	
7	Age (+)		
8	# Comorbidities (+)		
9	Neoplasm Dx (+)		

Abbreviations: Dx, diagnosis; LOS, length of stay; #, number of.

* Predictions associated with increased risk of readmission shown as (+);

Predictions associated with decreased risk of readmission shown as (–);

Order of predictive importance based on magnitude of standardized coefficients.

[^] Number of patients included in the lasso models due to missing data.

Table 3.

Patient Characteristics by Rehospitalization Status across Facility (N=1206)

Characteristics	No Rehosp (N=973)	24hr Rehosp (N=86)	>1 day-30d Rehosp (N=147)	P value [*]
	Means (SD) [Range] or n (%)			
Age	81.0 (10.3)[55–106]	75.5 (11.4)[55–96]	79.1(11.2)[55–98]	<.001
Gender [†]				
Male	399 (41.0)	37 (43.0)	65 (44.2)	.731
Female	574 (59.0)	49 (57.0)	82 (55.8)	
Race [†]				
White	867 (89.1)	75 (87.2)	120 (81.6)	.132
Black	84 (8.6)	9 (10.5)	24 (16.3)	
Other	19 (2.0)	2 (2.3)	2 (1.4)	
Ethnicity [†]				
Hispanic	5 (.51)	0	0	.301
Non-Hispanic	965 (99.2)	85 (98.8)	145 (98.6)	
Marital Status [†]				
Married/Partnered	361 (37.1)	44 (51.2)	54 (36.7)	.027
Single/Widowed	560 (57.6)	38 (44.2)	79 (53.8)	
Education [†]				
Some High School	599 (61.6)	39 (45.4)	92 (62.6)	.013
Post High School	332 (34.1)	45 (52.3)	47 (32.0)	
Employment Status [†]				
Employed	43 (4.4)	13 (15.1)	3 (2.0)	<.001
Not employed	115 (11.8)	8 (9.3)	26 (17.7)	
Retired	775 (79.7)	64 (74.4)	109 (74.2)	
Living Arrangement [†]				
Independent	559 (57.5)	75 (87.2)	65 (44.2)	<.001
ALF/Facility	392 (40.3)	10 (11.7)	79 (53.7)	
# Comorbidities	3.3 (2.8)[0–14]	3.3 (1.7)[1–9]	3.4(2.0)[1–12]	.103
LOS (days)	6.8 (6.4) [1–81.9]	6.0(4.8) [1.9–28.0]	7.9 (7.7) [1.1–50]	<.001
Median	4.9	4.3	5.2	
Fall Risk Score (< 45=High Risk)	60.6 (23.1) [0–125]	66.9 (23.4) [10–110]	58.7 (21.7) [0–110]	<.001
Braden Score (15–18=At Risk) (19–23=Low Risk)	16.6 (3.0) [7–23]	17.9 (2.1) [13–22]	16.3 (2.7) [9–21]	<.001
Self-Rated Health [†]				
Excellent/Good	264 (27.1)	44 (51.2)	22 (15.0)	<.001
Average	364 (37.4)	28 (32.6)	54 (36.7)	
Fair/Poor	329 (33.8)	13 (15.1)	70 (47.6)	

Characteristics	No Rehosp (N=973)	24hr Rehosp (N=86)	>1 day-30d Rehosp (N=147)	<i>P</i> value [*]
	Means (SD) [Range] or n (%)			
Prior hosp. 6 mos. [†]				
None	541 (55.6)	62 (72.1)	65 (44.2)	.001
One	391 (40.2)	24 (27.9)	79 (53.7)	
Opioid [†]				
No	727 (74.7)	51 (59.3)	110 (74.8)	.009
Yes	231 (23.7)	35 (40.7)	36 (24.5)	
Caregiver				
Yes	699 (71.8)	63 (73.3)	110 (74.8)	.736
No	274 (28.2)	23 (26.7)	37 (25.2)	
Decline in:				
Ambulation [†]	619 (63.6)	68 (79.1)	89 (60.5)	.073
Bathing [†]	491 (50.5)	57 (66.3)	73 (50.0)	.17
Eating [†]	286 (29.4)	21 (24.4)	40 (27.2)	.893
Toileting [†]	568 (58.4)	62 (72.1)	75 (51.0)	.031
Transfer [†]	587 (60.3)	67 (77.9)	81 (55.1)	.017

Abbreviations: Rehosp., rehospitalization; ALF, assisted living facility; LOS, length of stay; hosp., hospitalization; mos., months

^{*} p-values calculated using Chi-square, Fisher Exact or Kruskal-Wallis Tests

[†] Numbers may not add to 100% if unknowns excluded