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Assessing Heuristic Bias During Care for Patients Hospitalized for Heart Failure: Get With The Guidelines-Heart Failure

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Abstract

Background: Heuristic biases are increasingly recognized, and potentially modifiable, contributors to patient care and outcomes. "Left digit bias" is a cognitive bias where continuous variables are categorized by their left-most digit. The impact of this heuristic bias applied to patient age on quality of care in heart failure (HF) has not been explored.

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SUPPLEMENTAL MATERIALS
Table S1

Methods: We examined participants admitted from 2005–2021 in the Get With The Guidelines-HF registry. To create two "naturally randomized" groups, isolating the effect of left digit bias, we dichotomized patients into those discharged within 60 days prior to their 80th birthday (N=4,238) and those discharged within 60 days after their 80th birthday (N=4,329). We performed multivariable logistic regression to assess the association between discharge date relative to 80th birthday and several in-hospital quality metrics and in-hospital outcomes. Among Medicare participants (N=2,759), we performed adjusted Cox regression to analyze the relationship between discharge date and risk of 1-year mortality or readmission.

Results: Among 8,567 patients, 50.4% were female, 73% were non-Hispanic White, and 42.9% had an ejection fraction ≤ 40%. Discharge date relative to 80th birthday was not associated with numerous in-hospital quality metrics or in-hospital outcomes on unadjusted or adjusted logistic regression. Among Medicare beneficiaries, there was no association between discharge date and risk of mortality or readmission at 1-year post-discharge (hazard ratio 1.03, 95% CI 0.95–1.12, p=0.52).

Conclusions: In a large registry of patients hospitalized for HF, we did not detect a left digit bias, with respect to age at discharge, which resulted in differential quality of care or outcomes.

Keywords

heart failure; heuristic bias; hospitalization; age

INTRODUCTION

Acute heart failure (HF) presentations are common in the lifecycle of patients with HF and represent an opportunity to address and improve quality of care.[1, 2] While several studies have highlighted patient and/or hospital specific risk factors associated with quality of care, heuristic biases are increasingly recognized, and potentially modifiable, contributors to patient outcomes.[3, 4] Behavioral heuristics, broadly speaking, are mental "short cuts" that simplify decision making and might alter patterns of care. Additionally, behavioral heuristics can engender natural experiments in medicine that provide an opportunity to assess the value of an intervention. For example, a recent study of patients presenting with non-ST elevation myocardial infarction demonstrated that those presenting within 2 weeks before their 80th birthday were more likely to receive coronary artery bypass surgery than those presenting within 2 weeks after their 80th birthday, despite similar profiles.[3] Specifically, patients slightly older than 80 years may have been perceived to be too "old" or frail to benefit from the procedure, though individuals just 2 weeks younger who were technically <80 years old were similar in presentation. This analysis highlighted the relevance of "left-digit bias" - a cognitive bias where continuous variables are categorized by their left-most digit - to cardiovascular clinical care. Importantly, these slightly younger individuals who underwent surgery did not live longer at 1 year, thereby highlighting the value of this natural randomization to understand the potential importance of the surgery in an older population who may be less represented in trial populations.[3]

The Get With The Guidelines® (GWTG)-Heart Failure (GWTG-HF) registry provides a unique, contemporary opportunity to apply these concepts of cognitive bias to patients presenting with acute HF. Given substantial gaps remain in medical therapy in HF,[5] such analysis could identify a previously unrecognized impediment to guideline directed medical therapy in HF (which could be addressed, for example, through electronic health record alerts).[6–8] The lower achievement rates of guideline directed medical therapy,[5] coupled with the paucity of randomized data among older adults with HF,[9–12] highlight a need to understand the effectiveness of such interventions, particularly in the context of an aging population. We therefore sought to detect whether a heuristic bias, specifically left-digit bias, impacts quality of care for older adults hospitalized for HF, and whether this bias may translate into differences in cardiovascular outcomes.

METHODS

Study data are confidential and cannot be shared according to the terms of the contracts signed between participating hospitals and the American Heart Association, as well as terms governing the use of Medicare claims data. Therefore, the data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure.

Study Population and Design

Details regarding the methodology of GWTG-HF have been previously reported.[13] In brief, GWTG-HF is an ongoing in-hospital quality improvement program which aims to promote adherence to guideline-directed care for patients admitted with HF. Hospitals enroll in GWTG-HF on a voluntary basis and submit detailed clinical information for each consecutive patient admitted with the primary diagnosis of HF using an internet-based Patient Management Tool (Quintiles, Cambridge, MA), where patient data are de-identified. Participating centers in GWTG-HF are required to obtain institutional review board approval for the GWTG-HF protocol and are granted a waiver for informed consent under the common rule. IQVIA (Parsippany, New Jersey) serves as the data collection and coordination center, and the Duke Clinical Research Institute (Durham, NC) serves as the data analysis center.

The starting population for this analysis included patients at least 18 years old who were admitted to and discharged from GWTG-HF hospitals with a primary diagnosis of HF between Jan 1, 2005 to Dec 31, 2021, with <25% missing data on the medical history panel, and non-missing data for sex and age. We then excluded patients without date of birth record (N=48), transferred from another hospital (N=39,835), transferred to a different hospital (N=19,241), and patients who left against medical advice or with missing disposition status (N=200,590). For the purpose of this analysis that examines left-digit bias in relationship to the 80th birthday, we then excluded patients not discharged within 60 days before or after their 80th birthday, leaving 8,567 patients among 558 hospitals for cross-sectional analysis. The rationale for using a 60-day window specifically included maximizing the number of patients within each group to enhance statistical power, while balancing the loss of “natural randomization” by enlarging this window (i.e., the larger the window, the less similar patient groups are to each other). This window was ultimately chosen *a priori*, without examination of the results to influence choice of the window. If participants were discharged on their birthday, we classified them as part of the group that were discharged 60 days after their birthday.

To obtain longitudinal data for analysis of post-discharge rates of readmission and all-cause mortality, GWTG-HF registry data were linked with claims from Centers for Medicare and Medicaid Services (CMS) from January 1, 2005 through December 31st, 2018 among patients at least 65 years old (starting N=5,743).[14] We excluded those 1) whom we were unable to link to CMS data, 2) with non-index admissions, 3) who died during index hospitalization, 4) who were discharged to hospice care, or 5) who were not fee for service eligible at discharge, leaving 2,759 patients among 420 hospitals for the analysis of post-discharge outcomes.

Clinical Characteristics and Outcome Variables

Detailed patient-level information on demographics, insurance, medical history, medications, vital signs, length of stay, admission and discharge laboratory testing, ejection fraction (EF), discharge treatment and counseling, discharge destination, and in-hospital mortality were collected.

For cross-sectional outcome assessment, GWTG-HF has detailed several achievement and reporting measures that include general in-hospital quality metrics (i.e., deep venous thrombosis prophylaxis), HF-specific guideline directed medications or devices at discharge, smoking cessation counseling, vaccination, and timely post-discharge follow-up. Additionally, a defect-free composite quality score has been constructed, which is a process measure among eligible patients that includes following: angiotensin-converting enzyme (ACE) inhibitor/angiotensin receptor blocker (ARB)/angiotensin-receptor neprilysin-inhibitor (ARNI) at discharge; evidence-based beta-blocker at discharge; assessment of left ventricular function; and post-discharge follow-up appointment within 7 days.

In longitudinal analysis, we also analyzed post-discharge outcomes in the subgroup of Medicare beneficiaries measured at 30 days and 1 year, including all-cause hospitalization or all-cause mortality. If a patient had multiple hospitalizations logged in the registry, only the first hospitalization was considered for analysis. All-cause mortality was based upon death dates in Medicare denominator files and readmission based on Medicare inpatient claims using diagnostic-related group codes.[14]

Statistical Analysis

Cross-Sectional Analysis—To confirm “pseudo-randomization” between groups, baseline patient characteristics were described in the study population, stratified by date of discharge relative to 80th birthday (60 days before versus after 80th birthday). Counts and proportions for categorical variables and median with 25th and 75th percentiles for continuous variables were reported. Differences between groups were assessed using the chi-square test for categorical variables and the Wilcoxon rank sum tests for continuous variables. We also calculated absolute standard differences between groups, which GWTG analyses have previously used to indicate clinically significant differences (>10%) between groups.[15]

In cross-sectional analyses, we evaluated disparities in quality of care stratified by date of discharge relative to 80th birthday using logistic regression. Given a slight imbalance of a few covariates between these groups in Table 1, both unadjusted and adjusted odds ratios for these cross-sectional outcomes are presented. Covariates in the adjusted analyses included prior myocardial infarction, atrial fibrillation/flutter, and hyperlipidemia (in addition to age at discharge, which was different between groups by study design). Missing medical history values were imputed to “no”. Laboratory values of serum sodium and estimated glomerular filtration rate were not imputed or included as covariates given their missingness. We also conducted a falsification analysis investigating the rates of achievement of the defect-free composite score 60 days before and after the 78th, 79th, 80th, 81st, and 82nd birthdays to investigate for “discontinuity” at the 80th birthday that would imply a left-digit bias.

Longitudinal Analyses—In longitudinal analyses, we used Cox proportional hazard models to examine the association between patient discharge relative to birthday and key clinical outcomes (30-day and 1-year all-cause readmission rates, 30-day and 1-year mortality, and a composite of readmission or mortality at 30-day and 1-year post-discharge). Unadjusted and adjusted hazard ratios (using covariates identified above) were similarly reported for these key clinical outcomes.

A two-sided p-value ≤ 0.05 was considered statistically significant. The Duke Clinical Research Institute performed all analyses using SAS software version 9.4 (SAS Institute, Cary, North Carolina).

RESULTS

Characteristics of Study Participants

Descriptive characteristics of the study sample are displayed in Table 1. A total of 8,567 patients met the inclusion criteria, of whom half (50.4%) were female and 73% were non-Hispanic White. Comorbidities were typical of patients presenting with acute HF, including hypertension (87%), coronary artery disease (57%), atrial fibrillation/flutter (53%), and diabetes mellitus (49%). The admission blood pressure was mildly elevated (median 136, 25th-75th percentile 119–157, mmHg) and the median body mass index was 29.0 (25th-75th percentile 24.8–34.6) kg/m^2. The median (25th-75th percentile) left ventricular EF was 48% (30–59%), and 43% of the cohort had an EF≤ 40%. Characteristics were overall well-balanced between these two naturally-randomized groups, with minor exceptions (prior myocardial infarction, atrial fibrillation/flutter, hyperlipidemia, estimated glomerular filtration rate, and serum sodium; p<0.05 for these comparisons). Supplementary Table 1 shows further descriptive characteristics of these two study groups as well as the absolute standard differences between groups. The only significant difference between groups (defined by an absolute standardized difference >10%) was the prevalence of atrial fibrillation/flutter (absolute standardized difference = 10.6%).

Association of Discharge Date with Quality Metrics and In-Hospital Outcomes

Table 2 shows unadjusted rates of implementation of several quality metrics as well as in-hospital outcomes by date of discharge relative to 80th birthday; the corresponding odds ratios are displayed in Table 3 and Figure 1. Discharge 60 days prior to 80th birthday was used as the reference group. After adjustment for minor imbalances noted in the two groups identified in Table 1, most metrics did not differ between groups. Of the few metrics that were differentially associated, discharge within 60 days after 80th birthday was associated with a modestly higher odds of discharge on evidence-based beta-blocker (OR 1.28, 95% CI 1.05–1.56, p=0.01) and receipt of discharge instructions (OR 1.38, 95% CI 1.09–1.76, p=0.009). Figure 2 shows similar percentage achievement of the defect-free composite score relative to discharge date among those hospitalized around their 78th-82nd birthdays, without evidence of a discontinuity implying a “left digit” bias at the 80th birthday.

Association of Discharge Date with 30 Day and 1 Year Outcomes

Among the 2,759 registry participants with longitudinal data, hazard ratios for 30-day and 1-year clinical outcomes, stratified by date of discharge relative to 80th birthday, are shown in Table 4. All-cause readmission, mortality, and a composite of these outcomes were very similar between groups at both 30 days and 1 year. Specifically, there was no association between discharge date and the combined outcome with up to 1 year of follow-up (adjusted hazard ratio 1.03, 95% CI 0.95–1.12, p=0.52). Figure 3 demonstrates near overlap of Kaplan Meier event curves with up to 1 year of follow-up (log-rank p=0.61).

DISCUSSION

In a large, national registry of patients hospitalized for HF, we did not find evidence that a specific type of cognitive bias, left-digit bias, affected the quality of care or outcomes for patients near their 80th birthday. Specifically, we found no association between discharge date relative to 80th birthday and patient-level quality metrics or in-hospital outcomes. In a subgroup of Medicare patients with available longitudinal data, we similarly found no association between discharge date relative to the 80th birthday and 30-day and 1-year event rates, including death, readmission, or a combined outcome. To our knowledge, this analysis is the first to evaluate such a bias in older adults with HF and provides reassuring data in the consistency of care quality among this highly-complex, high-risk patient population. In addition, these findings suggest that the known associations between aging and decreased guideline-directed medical therapy prescriptions in contemporary studies may be attributable to factors beyond ageism or the cognitive bias studied here.

The optimal strategy to improve quality of care in HF in older adults involves a multifactorial approach. The present analysis was undertaken to understand whether an “orthogonal” risk factor, namely a heuristic (“left digit”) bias, might contribute to worse quality of care received in some patients. Studies have repeatedly demonstrated the relevance of cognitive failures to clinical care, particularly in the form of “intuitive” processing (a form of “automated” reasoning).[3, 16] Despite several effective treatments in HF (particularly in HF with reduced EF, though also recently in HF with preserved EF), implementation into clinical practice is still underutilized among eligible patients.[5, 17] As such, it is conceivable that the lower adoption of such treatment strategies could partially relate to subconscious perception of frailty among older patients, framed by the “left digit” of their age. In addition, large outcome-based trials have generally studied patients significantly younger than the group here (with an average enrollment age in the mid 60s in recent trials in HF with reduced EF and low 70s in HF with preserved EF),[18, 19] and clinicians could be hesitant to prescribe guideline-directed medical treatments to older patients.[20] The burgeoning role of the electronic health record to improve quality of care, which could mitigate such a bias, underscores the value of understanding the presence of this heuristic bias.[7] As GWTG-HF represents a quality improvement program, which has previously been demonstrated to be associated with improved care quality and reduced disparities in care, may have diminished any potential heuristic bias.

Our results are overall reassuring and demonstrate no clear bias exists within the studied scope of this registry-based analysis. Specifically, the use of guideline directed medical therapy was comparable between arms. The overall lack of difference observed in the present study versus a previous study in patients evaluated for cardiac surgery demonstrating this bias may relate to the enhanced perceptions regarding risk with surgical treatments. A few metrics even suggested slightly improved quality of care in those discharged within 60 days after their 80th birthday. This could even suggest enhanced vigilance in the care of older patients. However, a holistic interpretation of these findings would suggest that these small differences are likely due to chance, given the lack of concordance in several other metrics. A falsification analysis to determine whether any differences existed in those with birthdays around the 78th, 79th, 81st, and 82nd birthdays likewise yielded similarly null results. Unsurprisingly, these two groups had nearly identical outcomes up to 1 year of follow-up. Thus, while cognitive errors are pervasive in medicine,[21] our analysis does not suggest that this studied left-digit bias significantly contributes to worse quality of care in older adults hospitalized with HF.

Our study had several limitations. Our study was limited to patients hospitalized at participating GWTG-HF hospitals, which is a voluntary quality improvement program dedicated to improving outcomes for patients admitted with HF. Therefore, our results may not be generalizable to patients hospitalized at non-participating hospitals. In addition, GWTG-HF is an inpatient HF registry, and therefore the relevance of a left-digit bias in outpatient care must be examined separately. Further, medications on discharge were considered dichotomous variables, as doses of medications were not captured. Finally, we may have been underpowered to detect some differences in quality of care between groups.

In conclusion, in a large study of older patients hospitalized with HF across the United States, we did not detect a left digit bias, with respect to age at discharge, that resulted in differential quality of care or outcomes. Our results are reassuring in the care provided to a vulnerable and high-risk patient population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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PERSPECTIVES

What is new?

- While several cognitive biases can affect patient care, we did not identify a heuristic bias with respect to age that resulted in differential quality of care or outcomes among patients hospitalized with heart failure.
- The known associations between aging and decreased guideline-directed medical therapy in contemporary studies may be attributable to factors beyond ageism or cognitive bias.

What are the clinical implications?

- There are several barriers to optimal implementation of care for HF patients. Reassuringly, we did not identify that a left-digit bias with respect to age impacted quality of care or outcomes.
- This finding implies that further work to identify other actionable avenues to improve quality of care in this vulnerable population is needed.

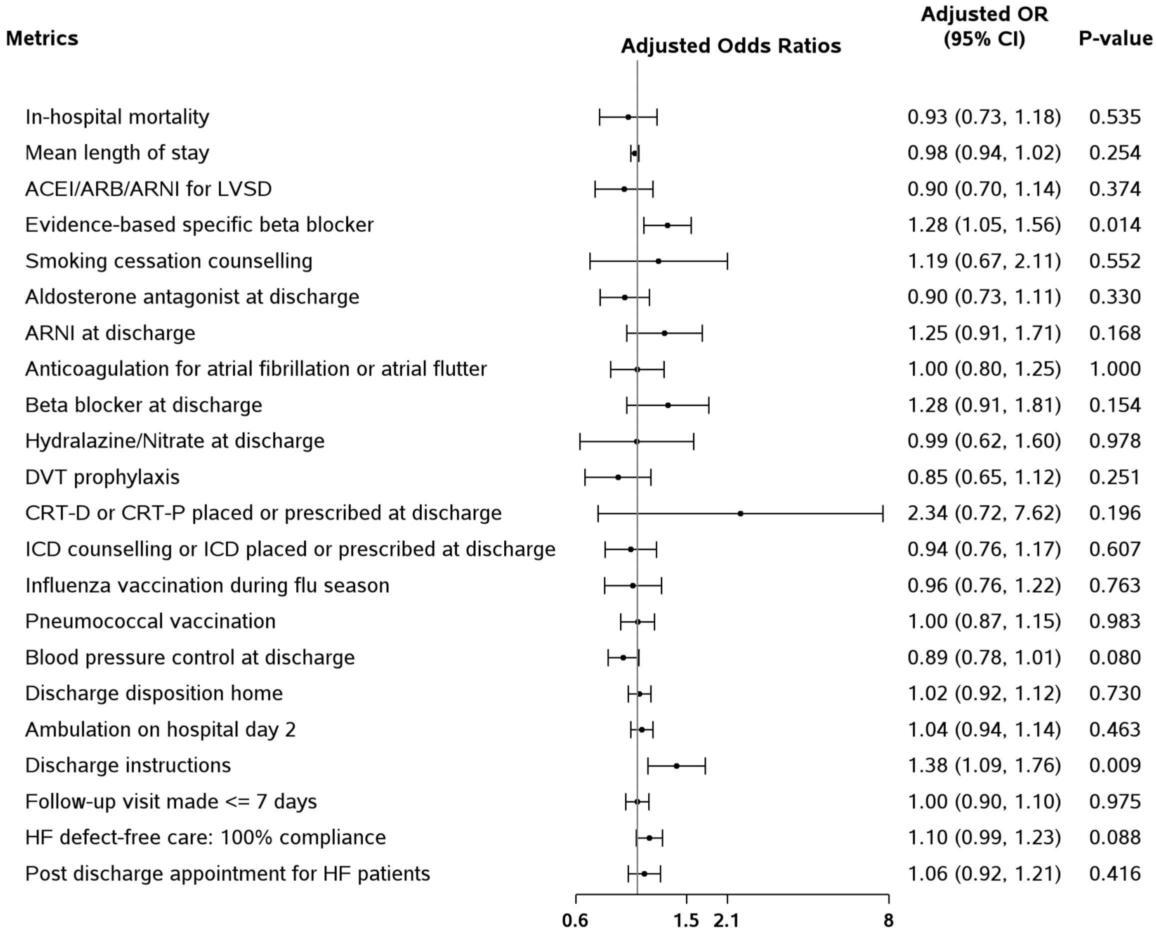

Figure 1: Forest plot of adjusted odds of in-hospital mortality and quality of care metrics among patients discharged 60 days before versus after their 80th birthday

The adjusted odds ratios by quality metric or discharge disposition are shown here in a forest Plot, noting few statistically significant differences observed between groups. The referent arm is discharge within 60 days prior to 80th birthday. Odds ratios are adjusted for age at discharge, prior MI, atrial fibrillation/flutter, and hyperlipidemia. Error bars denote 95% confidence intervals. ACE-I, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin-receptor neprilysin-inhibitor; CRT-D, cardiac resynchronization therapy-defibrillator; CRT-P, cardiac resynchronization therapy-pacemaker; DVT, deep vein thrombosis; ICD, internal cardioverter-defibrillator; LVSD, left ventricular systolic dysfunction.

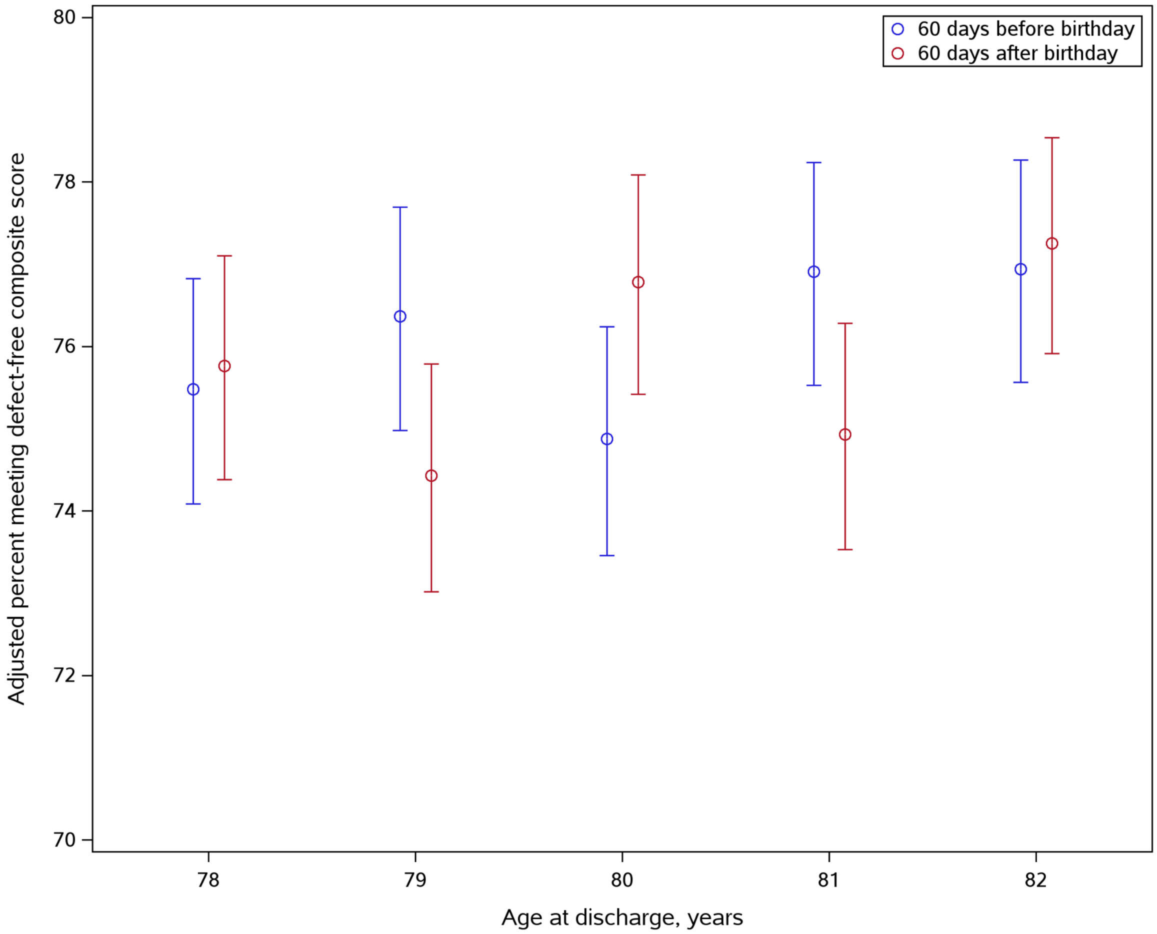

Figure 2: Plot of adjusted percent of patients meeting defect-free composite score among patients discharged 60 days before vs. after their 78th, 79th, 80th, 81st, and 82nd birthdays

Overall, the percentages of patients discharged 60 days prior to their birthday meeting the defect-free composite score was similar to those discharged 60 days after their birthday. Error bars denote 95% confidence intervals. Estimates are adjusted for age at discharge, prior MI, atrial fibrillation/flutter, and hyperlipidemia. Defect-free composite score includes process measures including angiotensin-converting enzyme (ACE) inhibitor/angiotensin receptor blocker (ARB)/angiotensin-receptor neprilysin-inhibitor (ARNI) at discharge, evidence-based beta-blocker at discharge, assessment of left ventricular function, and post-discharge follow-up appointment within 7 days.

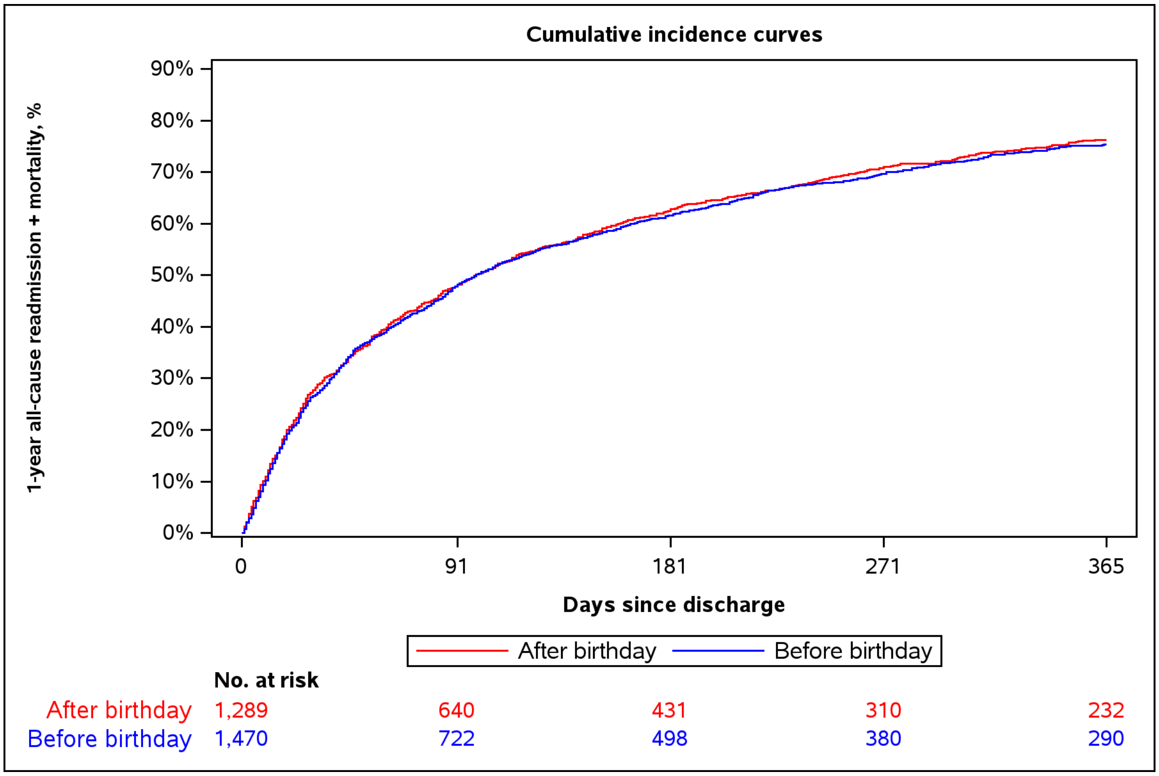

Figure 3: Kaplan-Meier incidence curves of the 1-year all-cause readmission or mortality among patients discharged 60 days before versus after their 80th birthday

Kaplan-Meier curves are depicted for 2,759 participants with longitudinal data, stratified by discharge 60 days before and after 80th birthday.

Table 1.

Baseline characteristics of study participants, stratified by date of discharge relative to 80th birthday.

	Overall (N=8,567)	Discharged 1–60 days before birthday (N=4,238)	Discharged 0–60 days after birthday (N=4,329)	P-Value
Demographics				
Female Sex	4,320 (50.4%)	2,116 (49.9%)	2,204 (50.9%)	0.3628
Race/Ethnicity				0.6259
Non-Hispanic White	6,273 (73.3%)	3,126 (73.8%)	3,147 (72.8%)	
Non-Hispanic Black	1,144 (13.4%)	545 (12.9%)	599 (13.9%)	
Hispanic	697 (8.1%)	349 (8.2%)	348 (8.0%)	
Asian	189 (2.2%)	88 (2.1%)	101 (2.3%)	
Other (includes UTD)	256 (3.0%)	127 (3.0%)	129 (3.0%)	
Insurance status				0.4085
Private/HMO/Other	1,560 (23.9%)	756 (23.5%)	804 (24.2%)	
Medicaid	560 (8.6%)	291 (9.1%)	269 (8.1%)	
Medicare	2,857 (43.8%)	1,381 (43.0%)	1,476 (44.5%)	
Medicare – Private/HMO/Other	1,516 (23.2%)	766 (23.8%)	750 (22.6%)	
No Insurance/Not Documented/UTD	36 (0.6%)	18 (0.6%)	18 (0.5%)	
Medical History				
Hypertension	7,281 (86.8%)	3,595 (86.6%)	3,686 (86.9%)	0.6370
Coronary artery disease	4,743 (56.5%)	2,364 (56.9%)	2,379 (56.1%)	0.4443
Prior MI	1,835 (21.9%)	949 (22.9%)	886 (20.9%)	0.0298
Peripheral vascular disease	1,165 (13.9%)	555 (13.4%)	610 (14.4%)	0.1768
Smoking in the prior year	615 (7.3%)	281 (6.7%)	334 (7.8%)	0.0559
COPD/Asthma	3,141 (37.4%)	1,543 (37.2%)	1,598 (37.7%)	0.6187
Atrial fibrillation/flutter	4,449 (53.0%)	2,312 (55.7%)	2,137 (50.4%)	<0.0001
Renal insufficiency	2,379 (28.3%)	1,155 (27.8%)	1,224 (28.9%)	0.2859
ICD (ICD only or CRT-D)	2,019 (24.1%)	1,010 (24.3%)	1,009 (23.8%)	0.5712
CRT-D or CRT-P	708 (8.4%)	363 (8.7%)	345 (8.1%)	0.3180
Stroke/TIA	1,546 (18.4%)	770 (18.5%)	776 (18.3%)	0.7737
Diabetes	4,069 (48.5%)	2,026 (48.8%)	2,043 (48.2%)	0.5750
Hyperlipidemia	5,494 (65.5%)	2,674 (64.4%)	2,820 (66.5%)	0.0424
Admission vitals and labs (or closest to admission)				
Ejection fraction, (median)	48.0 (30.0–59.0)	48.0 (30.0–58.0)	50.0 (30.0–60.0)	0.2991
Ejection fraction ≤ 40	3,671 (42.9%)	1,832 (43.2%)	1,839 (42.5%)	0.4848
Heart rate	80.0 (70.0–94.0)	80.0 (69.0–94.0)	80.0 (70.0–94.0)	0.6046
SBP, mmHg	136.0 (119.0–157.0)	136.0 (119.0–157.0)	137.0 (119.0–157.0)	0.6692
BMI, kg/m2	29.0 (24.8–34.6)	29.1 (24.8–34.6)	29.0 (24.8–34.6)	0.9080
Weight, kg	82.0 (69.0–98.0)	82.0 (69.0–98.0)	82.3 (69.0–98.0)	0.7283
eGFR (using 2021 CKD-EPI), mg/dL	45.8 (30.2–64.7)	45.8 (30.2–68.3)	45.8 (30.0–64.3)	0.0125
Serum sodium, mEq/L	138.0 (135.0–141.0)	138.0 (135.0–141.0)	139.0 (136.0–141.0)	0.0059
Hemoglobin, g/dL	11.4 (10.0–12.9)	11.5 (10.0–12.8)	11.4 (10.0–12.9)	0.9287

	Overall (N=8,567)	Discharged 1–60 days before birthday (N=4,238)	Discharged 0–60 days after birthday (N=4,329)	P-Value
BUN, mg/dL	27.0 (18.0–40.0)	26.0 (18.0–39.0)	27.0 (19.0–40.0)	0.1547
Discharge vitals and labs (or closest to discharge)				
Heart rate	74.0 (66.0–85.0)	74.0 (65.0–85.0)	75.0 (66.0–85.0)	0.1178
SBP, mmHg	122.0 (108.0–137.0)	121.0 (108.0–136.0)	122.0 (109.0–138.0)	0.2057
BMI, kg/m2	28.4 (24.2–33.8)	28.4 (24.2–33.9)	28.4 (24.2–33.7)	0.8869
Weight, kg	80.7 (67.0–95.2)	80.0 (67.0–95.0)	81.0 (67.0–95.7)	0.7435
eGFR (using 2021 CKD-EPI), mg/dL	45.8 (30.2–64.7)	47.1 (31.4–65.4)	45.5 (30.0–64.3)	0.0026
BNP, pg/mL	706.0 (343.0–1512)	668.0 (339.0–1452)	743.0 (346.0–1558)	0.2524
Serum sodium, mEq/L	138.0 (136.0–141.0)	138.0 (135.0–141.0)	138.0 (136.0–141.0)	0.0009
BUN, mg/dL	30.0 (21.0–43.0)	29.0 (21.0–43.0)	30.0 (21.0–44.0)	0.2470
In hospital outcomes				
Median Length of stay (among patients discharged alive)	4.0 (2.0–6.0)	4.0 (2.0–6.0)	4.0 (2.0–6.0)	0.0790
Discharge Disposition				0.7710
In-hospital mortality	278 (3.2%)	144 (3.4%)	134 (3.1%)	
Home	6,093 (71.1%)	2,998 (70.7%)	3,095 (71.5%)	
Hospice (home or health care facility)	409 (4.8%)	208 (4.9%)	201 (4.6%)	
Other health care facility	1,787 (20.9%)	888 (21.0%)	899 (20.8%)	

Continuous variables presented as median (25^{th}-75^{th} percentile)

BMI, body mass index; BNP, b-type natriuretic peptide; BUN, blood urea nitrogen; COPD, chronic obstructive pulmonary disease; CRT, cardiac resynchronization therapy; eGFR, estimated glomerular filtration rate; HMO, health maintenance organization; ICD, internal cardioverter-defibrillator; SBP, systolic blood pressure; TIA, transient ischemic attack; DVT, deep venous thrombosis; UTD, unable to determine.

Table 2.

In-hospital quality of care metrics, stratified by date of discharge relative to 80th birthday

	Overall (N=8,567)	Discharged 1–60 days before birthday (N=4,238)	Discharged 0–60 days after birthday (N=4,329)
GWTG-HF achievement/quality/reporting measures (percent compliance) among patients discharged alive			
ACEI/ARB/ARNI for LVSD	1,724 (83.6%)	870 (84.1%)	854 (83.2%)
Evidenced-based specific beta blocker	2,386 (82.6%)	1,156 (80.8%)	1,230 (84.4%)
Smoking cessation counselling	492 (89.3%)	221 (88.0%)	271 (90.3%)
Aldosterone antagonist at discharge	655 (38.4%)	335 (39.3%)	320 (37.4%)
ARNI at discharge	190 (11.4%)	88 (10.4%)	102 (12.4%)
Anticoagulation for atrial fibrillation or atrial flutter	3,219 (89.3%)	1,631 (89.4%)	1,588 (89.2%)
Beta blocker at discharge	2,744 (95.0%)	1,351 (94.4%)	1,393 (95.5%)
Hydralazine/nitrate at discharge	95 (23.2%)	46 (23.1%)	49 (23.3%)
DVT prophylaxis	3,025 (90.5%)	1,495 (91.3%)	1,530 (89.6%)
CRT-D or CRT-P placed or prescribed at discharge	29 (40.3%)	11 (32.4%)	18 (47.4%)
ICD counselling or ICD placed or prescribed at discharge	1,127 (64.3%)	579 (64.9%)	548 (63.7%)
Influenza vaccination during flu season	2,593 (86.5%)	1,270 (86.4%)	1,323 (86.6%)
Pneumococcal vaccination	5,154 (79.4%)	2,524 (79.4%)	2,630 (79.3%)
Blood pressure control at discharge	3,944 (76.3%)	1,931 (77.6%)	2,013 (75.2%)
Discharge disposition home	6,340 (74.0%)	3,126 (73.8%)	3,214 (74.2%)
Ambulation on hospital day 2	4,728 (56.6%)	2,339 (56.4%)	2,389 (56.7%)
Discharge instructions	4,330 (93.2%)	2,111 (92.0%)	2,219 (94.3%)
Follow-up visit made ≤7 days	3,992 (55.9%)	1,970 (55.6%)	2,022 (56.2%)
HF defect-free care: 100% compliance	5,798 (75.7%)	2,825 (74.7%)	2,973 (76.6%)
Post discharge appointment for HF patients	4,367 (76.3%)	2,140 (75.8%)	2,227 (76.9%)

ACE-I, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin-receptor neprilysin-inhibitor; CRT-D, cardiac resynchronization therapy-defibrillator; CRT-P, cardiac resynchronization therapy-pacemaker; DVT, deep vein thrombosis; HF, heart failure; ICD, internal cardioverter-defibrillator; LVSD, left ventricular systolic dysfunction.

Table 3.

Odds ratios comparing quality of care metrics received according to discharge date relative to 80th birthday

	Unadjusted odds ratio (95% CI)	P-Value	Adjusted odds ratio (95% CI)*	P-Value
In-hospital mortality	0.91 (0.72, 1.15)	0.4345	0.93 (0.73, 1.18)	0.5350
Mean length of stay	0.98 (0.94, 1.01)	0.2064	0.98 (0.94, 1.02)	0.2542
ACEI/ARB/ARNI for LVSD	0.93 (0.73, 1.18)	0.5386	0.90 (0.70, 1.14)	0.3736
Evidenced-based specific beta blocker	1.29 (1.06, 1.58)	0.0113	1.28 (1.05, 1.56)	0.0142
Smoking cessation counselling	1.20 (0.68, 2.12)	0.5253	1.19 (0.67, 2.11)	0.5524
Aldosterone antagonist at discharge	0.92 (0.75, 1.13)	0.4254	0.90 (0.73, 1.11)	0.3295
ARNI at discharge	1.24 (0.91, 1.70)	0.1725	1.25 (0.91, 1.71)	0.1677
Anticoagulation for atrial fibrillation or atrial flutter	0.97 (0.78, 1.21)	0.7996	1.00 (0.80, 1.25)	0.9995
Beta blocker at discharge	1.27 (0.90, 1.79)	0.1691	1.28 (0.91, 1.81)	0.1542
Hydralazine/Nitrate at discharge	1.01 (0.63, 1.61)	0.9809	0.99 (0.62, 1.60)	0.9779
DVT prophylaxis	0.81 (0.61, 1.06)	0.1215	0.85 (0.65, 1.12)	0.2509
CRT-D or CRT-P placed or prescribed at discharge	1.86 (0.68, 5.06)	0.2526	2.34 (0.72, 7.62)	0.1960
ICD counselling or ICD placed or prescribed at discharge	0.96 (0.78, 1.19)	0.7191	0.94 (0.76, 1.17)	0.6073
Influenza vaccination during flu season	0.96 (0.75, 1.21)	0.7127	0.96 (0.76, 1.22)	0.7632
Pneumococcal vaccination	0.99 (0.86, 1.14)	0.9120	1.00 (0.87, 1.15)	0.9834
Blood pressure control at discharge	0.88 (0.77, 1.00)	0.0468	0.89 (0.78, 1.01)	0.0800
Discharge disposition home	1.03 (0.93, 1.13)	0.5909	1.02 (0.92, 1.12)	0.7298
Ambulation on hospital day 2	1.04 (0.95, 1.15)	0.3846	1.04 (0.94, 1.14)	0.4635
Discharge instructions	1.37 (1.08, 1.74)	0.0106	1.38 (1.09, 1.76)	0.0088
Follow-up visit made <= 7 days	0.99 (0.90, 1.10)	0.9067	1.00 (0.90, 1.10)	0.9748
HF defect-free care: 100% compliance	1.10 (0.98, 1.23)	0.0923	1.10 (0.99, 1.23)	0.0876
Post discharge appointment for HF patients	1.05 (0.92, 1.20)	0.4839	1.06 (0.92, 1.21)	0.4165

The referent group is date of discharge within 60 days prior to 80th birthday, and the comparator group is date of discharge within 60 days after 80th birthday.

*Adjusted for age at discharge, prior MI, atrial fibrillation/flutter, and hyperlipidemia.

ACE-I, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin-receptor neprilysin-inhibitor; CRT-D, cardiac resynchronization therapy-defibrillator; CRT-P, cardiac resynchronization therapy-pacemaker; DVT, deep vein thrombosis; HF, heart failure; ICD, internal cardioverter-defibrillator; LVSD, left ventricular systolic dysfunction.

Table 4.

Hazard ratios for 30-day and 1-year clinical outcomes by date of discharge relative to 80th birthday

	Unadjusted hazard ratio (95% CI)	P-Value	*Adjusted hazard ratio (95% CI)	P-Value
30-day all-cause readmission	1.03 (0.89, 1.20)	0.7030	1.03 (0.89, 1.20)	0.6694
30-day mortality	1.18 (0.87, 1.59)	0.2989	1.18 (0.87, 1.60)	0.2806
30-day all-cause readmission or mortality	1.05 (0.91, 1.21)	0.4851	1.06 (0.92, 1.22)	0.4449
1-year all-cause readmission	1.00 (0.91, 1.10)	0.9847	1.00 (0.92, 1.10)	0.9241
1-year mortality	1.04 (0.91, 1.19)	0.5210	1.05 (0.92, 1.20)	0.4501
1-year all-cause readmission or mortality	1.02 (0.94, 1.11)	0.5937	1.03 (0.95, 1.12)	0.5193

The referent group is date of discharge within 60 days prior to 80th birthday, and the comparator group is date of discharge within 60 days after 80th birthday.

*Adjusted for age at discharge, prior MI, atrial fibrillation/flutter, and hyperlipidemia.