ORIGINAL RESEARCH

Dual Healthcare System Use During Episodes of Acute Care Heart Failure Associated With Higher Healthcare Utilization and Mortality Risk

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***Background*—**Individuals receiving cross-system care (dual users) have higher rates of healthcare utilization and worse outcomes for heart failure (HF) and other conditions. Individuals can be dual users or single-system users at different times, though, and little is known about utilization and mortality within discrete episodes of care.

***Methods and Results*—**A retrospective cohort of 3439 patients with 5231 discrete episodes of HF exacerbation were identified between 2007 and 2011. Episodes encompassed the period from 2 weeks before an initial HF emergency department (ED) visit or hospitalization, included any acute care visits within 30 days after initial visit, and ended 30 days after the last acute care visit in the episode chain. All-cause and HF-specific ED visits and hospitalization within 30 days of index visit were analyzed using generalized estimating equations with robust variance. Hazard for death within episodes of acute illness was analyzed using Cox proportional hazards models. In adjusted analyses, dual use acute HF episodes were associated with higher odds of all-cause ED visits (odds ratio 1.61, 95% confidence interval [CI], 1.33, 1.95), HF-specific ED visits, (odds ratio 1.54, 95% CI, 1.12, 2.13), all-cause hospitalization (odds ratio 1.89, 95% CI, 1.50, 2.38), and HF-specific hospitalization (odds ratio 1.62, 95% CI, 1.15–2.30) as compared with Veterans Health Administration–only episodes of acute HF care. Dual use episodes of care were associated with higher hazard for mortality (hazard ratio=1.52, 95% CI 1.07, 2.16) as compared with all–Veterans Health Administration episodes of care.

***Conclusions*—**Episodes of acute HF care spanning across healthcare systems appear to be associated with higher risk of subsequent ED visits, hospitalization, and mortality. **(*J Am Heart Assoc*. 2018;7:e009054. DOI: 10.1161/JAHA.118.009054.)**

Key Words: health services research • heart failure • hospitalization • mortality

Chronic heart failure (HF) is a serious chronic illness with significant morbidity and mortality that affects ≈6.5 million American adults.[1] HF is associated with ≈1.1 million hospitalizations and 3.4 million ambulatory care visits annually.[2] Over 20% of patients hospitalized for HF are rehospitalized within 30 days, and almost a quarter of these patients are seen in an Emergency Department (ED) within 30 days after hospitalization for HF.[3] Within the Veterans Health Administration (VA), HF is also a common cause for hospital admission and potentially avoidable hospital readmission.

While health care delivered across settings is often necessary, especially during instances of acute illness or in areas with limited access to care, emerging evidence suggests that fractured care can be less efficient and less safe.[4–7] Evaluating cross-system care is relevant given Center for Medicare and Medicaid Services penalties enacted through the Affordable Care Act related to all-hospital 30-day readmission rates as well as ongoing Center for Medicare and Medicaid Services Accountable Care Organization demonstration projects in which healthcare organizations manage patient populations while sharing in financial risk with Center for Medicare and Medicaid Services.[8] Dual use is also important in VA in the wake of the Veterans Access, Choice, and Accountability Act of 2014, which significantly increased rates of care for Veterans in community settings.[9]

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Accompanying Tables S1 through S4 are available at http://jaha.ahajournals.org/content/7/15/e009054/DC1/embed/inline-supplementary-material-1.pdf

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Clinical Perspective

What Is New?

- While prior studies have examined so-called dual use in aggregate at the patient level, this study examines healthcare utilization and mortality comparing episodes of care for heart failure experienced in a single healthcare system (Veterans Health Administration) versus episodes of care that occur across healthcare systems.

What Are the Clinical Implications?

- Veterans receiving heart failure care across healthcare systems tend to be sicker with a higher burden of chronic diseases, a marker of higher risk itself.
- When accounting for medical comorbidity and other clinical factors, episodes of cross-system hospital care appear to be associated with higher risk for poor outcomes.

Among patients with HF, ≈19% of hospital readmissions for HF occur at a different hospital the second time around.[10] Within VA, dual healthcare system use (dual use) occurs when Veterans enrolled for VA care also receive care from non-VA providers or healthcare facilities. Dual use is particularly common in the Veteran population where a majority of cardiovascular disease hospitalizations for VA-enrolled patients occur at non-VA facilities.[11] Our research team recently found significantly higher rates of ED visits for HF (adjusted rate ratio 1.15, 95% confidence interval [CI] 1.04–1.27), hospitalization for HF (adjusted rate ratio 1.4, 95% CI, 1.26–1.56), and all-cause hospital readmission after HF hospitalization (1.46, 95% CI, 1.30–1.65) among individuals who were dual users as compared with VA-only users.[12] However, this study and most other studies of dual use to date have focused on dual use at the patient level, categorizing individuals as dual users or single system users.[4,13–15] While this approach is instructive and likely captures long-term risk at the individual level, such analyses may separate the exposure (dual use) from short-term outcomes of interest. In other words, dual use is not a static attribute since an individual may receive single system or dual system care at different points in time along their care continuum. Thus, additional analytic approaches are needed to fully characterize association between acute health care for HF and short-term untoward health outcomes.

An episode of care framework presents 1 alternative to person-level analyses in which healthcare encounters related to an acute illness are grouped together temporally into discrete observations.[16] This approach has been used in the past to analyze healthcare utilization and costs for specific conditions such as diabetes mellitus complications, pneumonia, and asthma, and it has been used to compare costs and efficiency across physicians and health insurance plans.[17–19] Using combined administrative data from VA, Medicare, and a state-level all-payer claims database, we constructed an inclusive cohort of episodes of acute HF care. The primary objective of this study was to analyze differences between single system (all-VA or all non-VA) episodes versus dual use episodes of acute HF care. We hypothesized that dual use episodes of care would be associated with higher subsequent healthcare utilization and mortality.

Methods

Data used in this study will not be available for use by other researchers. However, upon request, the methods used in the analysis can be made available for purposes of reproducing the results or replicating the procedure.

Study Population

A state-level cohort of veterans with HF was created by linking multiple patient and administrative files including the VA corporate data warehouse available from VA National Data Systems, VA/Medicare files available from the Veterans Information Resource Center, and the South Carolina Office of Revenue and Fiscal Affairs. The VA corporate data warehouse contains information including dates of service, demographic information, and diagnosis/procedure codes for outpatient visits and inpatient hospitalizations occurring in the VA system. Medicare files including inpatient, outpatient, and carrier files provide similar information for episodes of care reimbursed by the Centers for Medicare and Medicaid Services at non-VA facilities. Under South Carolina law (§44-6-170), all short-term acute care hospitals and licensed freestanding medical centers in the state are required to submit information on hospitalizations, ED visits, outpatient surgeries, imaging, radiation therapy, and other outpatient services to South Carolina Office of Revenue and Fiscal Affairs, which maintains a comprehensive database including diagnostic information, dates of service, hospital charges, and other information. This project was approved by the VA Central Institutional Review Board as well as the Research and Development Committee at the Ralph H. Johnson VA Medical Center. Given the nature of this study, informed consent was not obtained, in keeping with Institutional Review Board regulations.

Subjects were included in a larger cohort (n=203 959) if they were enrolled for care in VA, if they attended at least 1 qualifying primary care appointment at 1 of the 3 VA medical centers serving the state of South Carolina during the study period (2007–2011) and had a primary residence in the state of South Carolina (n=136 244). An episode of care was defined as a string of events beginning 15 days before a first

ED visit or hospitalization (referred to as the index visit) and continuing to 30 days after discharge. If another ED visit or hospitalization occurred during the 30 days after discharge from the index acute care visit, the episode continued until 30 days after the second event or another ED visit or hospitalization occurred. This process was repeated until there were no more acute care events in the episode. Hospitalizations likely to have been elected were not counted as hospital readmissions.[20] We included data from multiple episodes of care per subject up to the 10th episode. Episode numbers >10 and episodes greater than a year in length were deleted from the data set, leaving 335 426 episodes of care available for analysis. A HF (*International Classification of Diseases, Ninth Revision (ICD9)*, 402.01, 402.11, 402.91, 429.3x, 425.xx, and 428.xx) episode of care was defined as an episode having at least 1 HF ED visit, HF hospitalization, HF primary care, or cardiology visit on or within 15 days before the index acute care visit. We further restricted the data set to those ≥65 years old at the time of entry into the cohort, leaving us with 5231 HF episodes of care among 3439 subjects.

Main Exposures of Interest Pertaining to the Episode of Care

Episodes of care were further categorized as to whether the care subjects received within that episode made them a VA-only user, non–VA-only user, or dual users during that episode based on the same criteria as used to determine whether or not an episode was a HF episode of care. Type of first care was defined as ED visit or hospitalization based on where the patient first received care for that episode.

Unit of Analysis and Outcome Measures

The unit of analysis is at the episode level for the utilization outcomes and at the patient level for mortality. An individual patient can have multiple episodes, and outcomes pertain to each episode for the utilization outcomes. Primary outcomes for this analysis were adjusted odds ratios for having an ED visit within 30 days of an index visit; having a heart failure ED visit within 30 days of an index visit; being hospitalized within 30 days of an index visit; and having a HF hospitalization within 30 days of an index visit. Additionally, adjusted hazard ratios were calculated for mortality.

Covariates at the Episode Level

Covariates of interest at the episode level include whether a patient had a primary care visit within 15 days before their index visit or 30 days after their index visit (ie, when the index visit included a hospitalization within the 30 days started at discharge); whether a patient had a cardiology visit within 15 days before their index visit or 30 days after their index visit; and whether the episode was the first, second, third, or fourth (or more) episode a patient had experienced.

Covariates at the Person Level

Covariates of interest at the person level included age; sex; race/ethnicity, classified as non-Hispanic white, non-Hispanic black, Hispanic, and other/missing/unknown; marital status categorized as married, divorced, widowed, never married, unknown; location of residence categorized as urban, rural, highly rural, or missing; and service-connected disability classified as ≥50% or <50%. Service-connected disability is a marker for disease burden, has implications for copayments within VA, and has been used in prior investigations of Veteran patients.[21,22] Comorbidity burden was measured using the van Walraven Elixhauser score[23,24] as well as by examining the total number of episodes and the number of HF episodes a patient contributed to the analysis.

Statistical Analysis

Characteristics of the sample were first examined through univariate analysis. Balance of covariates among the 3 dual use categories (VA only, non-VA only, Dual Use) was assessed using the χ^2 test for categorical variables and F test for continuous variables. Moreover, before outcome models were fitted, univariate association of the dichotomous outcomes (all-cause ED visits and HF-specific ED visits) and mortality with continuous and categorical variables were performed via t test and χ^2 tests, respectively. Then, the models for the relationship between the 2 outcomes with dual use were developed adjusting for a group of predictors (age, race/ethnicity, sex, marital status, service-connected disability, rurality, and van Walraven Elixhauser score). In order to estimate the parameters for the association between the dichotomous outcomes and covariates, we fitted a multivariable logistic regression model using generalized estimating equations accounting for the clustering of episodes by patient using Proc GENMOD in SAS 9.4.[25] Several correlation structures were considered to capture the within-subject correlation of outcomes, and a compound symmetry structure was the best fit. Robust variance was used to make inference. For the mortality outcome, we fitted a multivariable Cox-regression model in a sequential fashion adjusting for domain of covariates (demographic and clinical) using Proc PHREG of SAS 9.4.[26,27] We assessed the tenability of the assumption of proportional hazards for the Cox model using log-log and Kaplan–Meier plots (Figure) and by including a survival-time by covariate interaction (P=0.725) into the model, which all showed that proportional hazards is tenable. For all models,

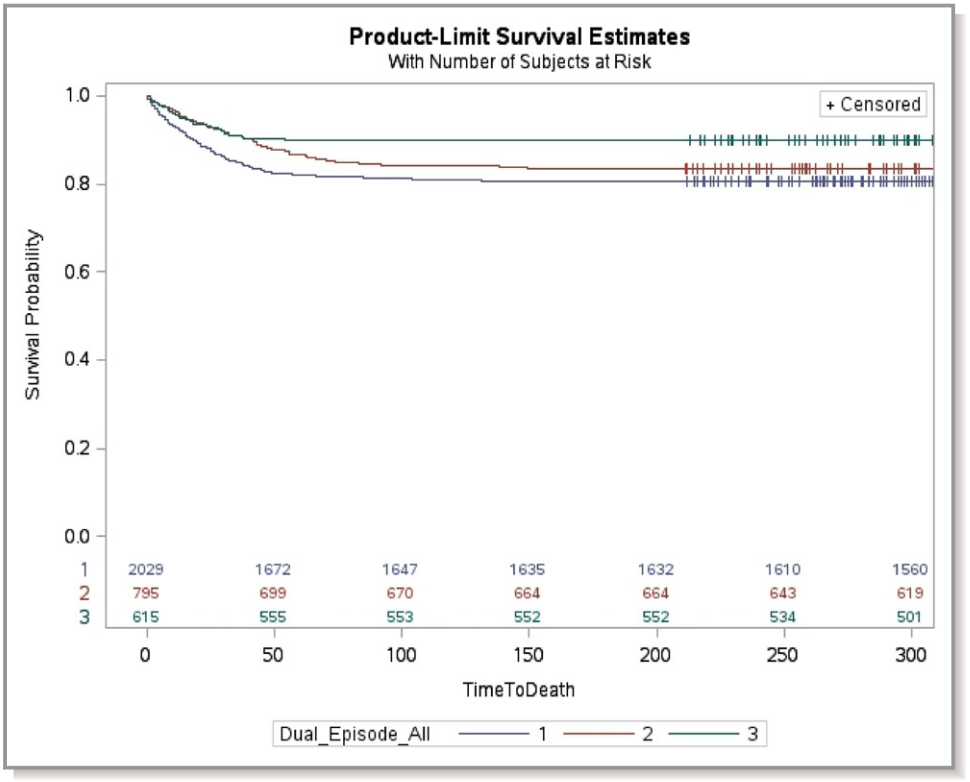

Figure. Kaplan–Meier curve of survival probability over time in days for number of episodes of acute heart failure care. 1 (Green)=VA-only episodes of care; 2 (red)=Dual-use episodes of care; 3 (blue) =Non-VA-only episodes of care. VA indicates Veterans Health Administration.

clinically relevant variables pertaining to the study hypothesis (eg, age) were added and interactions were explored systematically. Model diagnostics were done via residual analysis.

Results

The study cohort consisted of 3439 Veterans age at least 65 years who experienced a total of 5231 HF episodes (Table 1). The mean age of the cohort at enrollment was 77.6 years, 98.9% were males, 79.4% were non-Hispanic white veterans, and 56.5% of patients resided in urban areas. The mean van Walraven Elixhauser comorbidity score was 25.7, indicating a high comorbidity burden with 67.5% of the cohort contributing a single HF episode, 20.2% contributing 2 HF episodes, 7.7% contributing 3 HF episodes, and 4.5% contributing 4 or more HF episodes.

At the level of the episode, 20.2% of all HF episodes had a hospitalization as their index visit, while 79.8% had an ED visit as their index visit (Table 2). Dual use episodes were more likely to be initiated in the hospital (17.4%) than only-VA episodes (13.6%). With respect to primary care, of all HF episodes 30.5% had a primary care visit within 15 days before their index visit, and 43.6% had a primary care visit within 30 days after their index visit. Dual use episodes were more likely to have a primary care visit before as well as after their index visit (43.6% prior; 58.6% after) when compared with only-VA episodes (18.7% prior; 41.8% after). Dual use episodes were also more likely to have a cardiology visit before as well as after their index visit (23.8% prior; 32.2% after) when compared with only-VA episodes (16.7% prior; 26.6% after). Of the episodes that included a hospitalization, the median length of hospitalization was 2.0 for dual use episodes, 3.0 for only non-VA episodes, and 1.0 for only-VA episodes. Of the 5231 HF episodes included, 65.7% were the first episode a patient contributed, 21.4% were the second episode a patient contributed, 8.1% were the third, and 4.8% were the fourth or more episodes a patient contributed.

Focusing on outcomes of interest, 32.7% of dual use episodes resulted in an ED visit within 30 days of the index visit as compared with 23.0% of only-VA episodes and 20.8% of only non-VA episodes (Table 2). Similarly, hospitalization within 30 days of an index visit was more likely for dual use episodes (22.9%) than only-VA episodes (13.7%) and only non-VA episodes (17.7%).

Table 3 shows the adjusted odds ratio (OR) estimates for site of episode (ie, comparing dual use and non-VA-only episodes to VA-only episodes) and type of first care (ie, comparing hospitalization to ED visit episodes) for a number

Table 1. Patient Characteristics Among Those Who Had Acute HF Episodes of Care

Characteristic	Patients (N=3439)
Age, mean (y)*	77.6
Male, %	98.9
Race/ethnicity, %	
Non-Hispanic white	79.4
Non-Hispanic black	19.6
Hispanic	0.3
Other	0.7
Marital status, %	
Married	67.4
Divorced	10.0
Widowed	16.4
Never married	4.4
Unknown	1.8
Service-connected disability, %	
≥50%	13.9
Rurality, %	
Urban	56.5
Rural	40.4
Highly rural	0.3
Missing	2.8
van Walraven Elixhauser Score, mean	25.7
Comorbidities, %	
Cancer	28.9
Cardiovascular disease	89.3
Chronic pulmonary disease	72.1
Congestive heart failure	98.5
Depression	31.4
Diabetes mellitus	63.0
Hypertension	98.8
Hypothyroidism	23.3
Liver disease	9.6
Lung conditions	30.3
Neurologic disorders	24.2
Obesity	26.7
Peripheral vascular disease	47.2
Psychoses	10.7
Substance abuse	10.4
Other†	92.3

HF indicates heart failure.
*Age at entry into the cohort.
†AIDS, anemias, coagulopathy, fluid electrolyte disorder, peptic ulcer disease, renal failure, rheumatoid arthritis, and weight loss.

of outcomes of interest. All models were adjusted for age, race/ethnicity, sex, marital status, service-connected disability, rurality, and van Walraven Elixhauser score. Focusing on the outcome ED visits within 30 days, the odds of an ED visit within 30 days was higher for dual use episodes than VA-only episodes (OR=1.61 [95% CI, 1.33, 1.95]). For our second exposure of interest, the odds of an ED visit within 30 days was lower comparing hospitalization to ED visit as type of first care (OR=0.70 [95% CI, 0.58, 0.83]). When the outcome is limited to HF ED visits within 30 days, results are similar. The odds of a HF ED visit within 30 days was higher in dual user episodes than VA-only episodes (OR=1.54 [95% CI, 1.12, 2.13]), but lower when the type of first care was a hospitalization as compared with an ED visit (OR=0.70 [95% CI, 0.52, 0.95]). Focusing on the outcome hospitalizations within 30 days, the odds of a hospitalization within 30 days was higher in dual user episodes than VA-only episodes (OR=1.89 [95% CI, 1.50, 2.38]) and trended toward significantly higher when the type of first care was a hospitalization as compared with an ED visit (OR=1.18 [95% CI, 0.99, 1.41]). When the outcome is limited to HF hospitalization within 30 days, results are similar. The odds of a HF hospitalization within 30 days were higher in dual use episodes than VA-only episodes (OR=1.62 [95% CI, 1.15, 2.30]), and again trended toward significantly higher when the type of first care was a hospitalization as compared with an ED visit (OR=1.16 [95% CI, 0.88, 1.52]).

Table 4 shows the adjusted hazard ratio (HR) estimates for site of episode (ie, comparing dual use and non-VA-only episodes to VA-only episodes) and type of first care (ie, comparing hospitalization to ED visit episodes) for all-cause mortality adjusted for age, race/ethnicity, sex, marital status, service-connected disability, rurality, and van Walraven Elixhauser score. The sequential models for the mortality analysis are reported in Table S1. Hazard ratios (HR) indicate that the risk of mortality is higher following a non-VA-only episode (HR=1.89 [95% CI, 1.29, 2.77]) as well as dual use episode (HR=1.52 [95% CI, 1.07, 2.16]) when compared with VA-only episodes of care. The risk of mortality was similar whether the type of first care was hospitalization or ED visit (HR=0.96 [95% CI, 0.78, 1.18]). Tables S2 through S4 depict results of additional analyses testing the association between site of episode and type of first care with mortality among all patients (Table S2) as well as the subset of patients surviving more than 30 days (Tables S3 and S4). Results were similar to those presented in Table 4.

Discussion

Our study is one of the first to analyze dual healthcare system use at the episode of care level for patients with acute HF exacerbation. We observed that dual use episodes (those

Table 2. Characteristics of HF Episodes at the Episode Level

	Only VA Episode (N=1007)	Only Non-VA Episode (N=2978)	Dual Use Episode (N=1246)	All HF Episodes (N=5231)	*P* Value
Index visit, %					
ED visit	86.4	76.4	82.6	79.8	<0.0001
Hospitalization	13.6	23.6	17.4	20.2	
Primary care visit, %					
Prior (15 d)	18.7	29.0	43.6	30.5	<0.0001
After (30 d)	41.8	37.9	58.6	43.6	<0.0001
Cardiology visit, %					
Prior (15 d)	16.7	20.6	23.8	20.6	0.0002
After (30 d)	26.6	30.9	32.2	30.4	0.01
ED visit (within 30 d), %	23.0	20.8	32.7	24.0	<0.0001
Hospitalization (within 30 d), %	13.7	17.7	22.9	18.2	<0.0001
Days hospitalized index visit (mean, median)*	1.8, 1	4.9, 3	3.7, 2	3.7, 2	<0.0001
Episode N (%)					
First	60.8	67.7	65.1	65.7	0.002
Second	23.3	20.7	21.4	21.4	
Third	9.5	7.5	8.3	8.1	
Fourth or more	6.4	4.1	5.3	4.8	

ED indicates Emergency Department; HF, heart failure; VA, Veterans Health Administration.
*N for only VA episode=593, only non-VA episode=870, dual user episode=422, and all HF episodes=1885. *P* values are based on χ^2 tests, using proc freq, for categorical variables and *F* test, using proc glm, for days hospitalized index visit.

spanning across VA and non-VA facilities) were associated with higher rates of subsequent visits to EDs, higher rates of subsequent hospitalization, and higher risk for mortality as compared with VA-only visits. These findings differ slightly from an earlier study by Ajmera and colleagues that analyzed the impact of dual use on ambulatory care sensitive hospitalizations including HF and did not find significant differences in rates of ambulatory care sensitive hospitalization. However, our findings add to evidence on the association between dual use measured at the individual level and increased healthcare utilization as well as adverse outcomes. For example, Jia and colleagues observed higher hospital readmission rates and mortality among dual users after stroke, and Tarlov and colleagues observed higher mortality among dual users of colon cancer care.[28,29] More recently, Bolden and colleagues found that dual system care was associated with lower likelihood of wound healing in patients with chronic pressure ulcer.[30]

What are the potential mechanisms by which dual use leads to higher rates of acute healthcare utilization and mortality, and how might these impacts be mitigated? Clearly, patient preference plays a role in choice for site of health care. In qualitative interviews, we observed that consistent dual users were more likely to express dissatisfaction with VA access to care and care coordination.[31] Such patients risk fractured outpatient care, though. Dual use has been associated with duplicative testing and poorer hemoglobin A1c control among patients with diabetes mellitus, and similar mechanisms could apply to HF care.[4,5] It is also true that patients may not always get to choose where they receive urgent or emergent care for HF. Especially for rural Veterans, travel to VA facilities may not be possible when acutely ill, and many municipalities require ambulances to deliver patients to the nearest acute care facility regardless of patient preference. We have also observed that many dual users of HF care were inadvertent 1-time non-VA users for these reasons.[31] Risks related to fractured care may accrue to these Veterans, nevertheless.

To the extent that HF is an ambulatory care–sensitive condition, one might posit that dual users actually have increased access to primary and specialty care early in HF exacerbations that could be protective. In fact, we observed fairly high rates of primary care and cardiology clinic visits within the 2 weeks before index acute care events across all episode types, with the highest rates in the dual use category. Thus, more clinic visits did not appear to mitigate ED visit and hospitalization rates in our sample. Similarly, early clinic follow-up after hospitalization has been associated with lower risk for hospital readmission among patients with HF and other high-risk patient groups.[32–34] However, we observed

Table 3. ORs and 95% CIs for the Association Between Site of Episode and Type of First Care for Relevant Utilization Outcomes

	OR	95% CI
Outcome—ED visits within 30 d		
Site of episode		
VA	1.00	…
Non-VA	0.88	0.74–1.05
Dual use	1.61	1.33–1.95
Type of first care		
ED visit	1.00	…
Hospitalization	0.70	0.58–0.83
Outcome—HF ED visits within 30 d		
Site of episode		
VA	1.00	…
Non-VA	0.92	0.68–1.24
Dual use	1.54	1.12–2.13
Type of first care		
ED visit	1.00	…
Hospitalization	0.70	0.52–0.95
Outcome—hospitalizations within 30 d		
Site of episode		
VA	1.00	…
Non-VA	1.36	1.09–1.68
Dual use	1.89	1.50–2.38
Type of first care		
ED visit	1.00	…
Hospitalization	1.18	0.99–1.41
Outcome—HF hospitalizations within 30 d		
Site of episode		
VA	1.00	…
Non-VA	1.12	0.80–1.55
Dual use	1.62	1.15–2.30
Type of first care		
ED visit	1.00	…
Hospitalization	1.16	0.88–1.52

Adjusted for age, race/ethnicity, sex, marital status, service-connected disability, rurality, and van Walraven Elixhauser score. CI indicates confidence interval; ED, Emergency Department; HF, heart failure; OR, odds ratio; VA, Veterans Health Administration.

high rates of postdischarge follow-up within 30 days of hospitalization for HF in all episode types, with highest rates in dual use episodes. Nevertheless, in our sample dual use episodes of care were associated with higher unadjusted ED visit rates after index acute care visits and higher unadjusted hospital readmission rates as compared with VA-only and all non-VA episodes care. It is possible that increased access to care provided more opportunities for providers to observe the high symptom burden in such patients, a finding previously reported.[35]

Table 4. Association Between Site of Episode and Type of First Care With Mortality

	HR	95% CI	Raw Mortality Rate (%)
Site of episode			
VA	1.00	…	10.24
Non-VA	1.89	1.29–2.77	19.57
Dual use	1.52	1.07–2.16	16.48
Type of first care			
ED visit	1.00	…	17.30
Hospitalization	0.96	0.78–1.18	16.74

Adjusted for age, race/ethnicity, sex, marital status, service-connected disability, rurality, and van Walraven Elixhauser score. CI indicates confidence interval; ED, Emergency Department; HR, hazard ratio; VA, Veterans Health Administration.

Several lines of evidence document poor communication and information exchange between inpatient and outpatient healthcare providers, and this effect is likely magnified in care delivered across healthcare systems.[36] For instance, hospital discharge summaries are frequently unavailable at the time of first hospital follow-up, and deficiencies in timeliness and quality exist.[37] Within the VA healthcare system, records from outside hospital facilities must be optically scanned into a separate area of the electronic health record not readily visible to VA providers, and similar challenges exist in sharing information from VA to the community.[38] Improved efforts toward information exchange are clearly warranted. While some patient-focused strategies such as the VA's Blue Button program show promise, the breadth of dissemination and impact of such programs are not yet clear.[39,40]

Medication errors and medication-related adverse events are another powerful contributor to poor care transitions, and these may be more likely to occur during cross-system episodes of care.[41,42] Several investigators have described challenges in medication prescribing between VA healthcare providers and community providers.[43,44] Gellad and colleagues recently analyzed opioid prescribing among Veterans dually enrolled in VA pharmacy benefits and Medicare Part D, and they observed that 26% of patients prescribed buprenorphine had overlapping prescriptions across programs and that 11% of patients had overlapping benzodiazepine prescriptions.[7] In addition, Thrall and colleagues recently analyzed care coordination and medication reconciliation among high-risk transplant patients receiving cross-system care.[45] They found very high rates of overlapping care for chronic comorbid conditions and discrepancies in medication regimens across systems as well as instances of inadequate

immunosuppressant drug monitoring. These findings complement observations by other investigators that highlight high rates of incomplete postdischarge diagnostic evaluations and follow-up of abnormal laboratory values after hospital discharge.[46]

Our study should be interpreted with attention to certain limitations. First, this observational study used administrative data sets, which are subject to the inherent limitations including possible endogeneity between our exposure (dual use) and the error term for our utilization outcomes of interest. Accordingly, we have been careful not to assume a direct causal relationship between dual use and increased ED visits and hospitalizations. We also controlled for variations in known likely confounders at the patient level and at the episode level, including type of first acute care (ie, ED visit or hospitalization), though it is possible that unobserved variables associated with likelihood of dual use episodes and our outcomes of interest could have confounded our results. Our study was performed on a sample of predominantly male Veterans receiving care in 1 Southern state. Thus, care should be taken in generalizing our findings to female Veterans with HF or to other geographic regions. Third, it must be acknowledged that the timeframes we selected before and after index encounters for acute HF care were somewhat arbitrary. Some healthcare encounters may have been incorrectly included or excluded from a given episode of HF care, and manipulation of timeframes could conceivably alter results. However, the timeframes we chose were slightly more restrictive than those used in a prior study of acute episodes of pneumonia such that we were less likely to include encounters unrelated to a given HF exacerbation.[18] Finally, patients who were high utilizers may have been more likely to experience dual system use.

We expect that our findings will be of interest to healthcare practitioners and policymakers within and outside the VA system. Within VA, the Veterans Access Choice and Accountability Act of 2014 and its associated Veterans Choice Program have significantly increased the care of Veterans in the community, and there is recognition of the challenges that dual use presents.[47] For example, the VA Office of Community Care is currently piloting programs designed to identify community-hospitalized Veterans in real time and to better coordinate care for these Veterans as they reintegrate into the VA system (Greenstone L. Personal communication, November 30, 2016). Community healthcare systems are also more acutely focused on coordination of care across facilities. In 2016, almost 80% of US hospitals received penalties for high hospital readmission rates for target conditions including HF through the Center for Medicare and Medicaid Services Hospital Readmission Reduction Program.[48] Also, the recent Medicare Access and Chip Reauthorization Act mandates expanded merit-based incentive payments and alternative payment models that encourage longitudinal care across place and time.[49–51] If cross-system care is associated with higher rates of subsequent ED visits, hospitalizations, and mortality, these initiatives may be beneficial. However, individual programs must address care coordination, information sharing, medication safety, and follow-up care across healthcare systems as described above. Additional research is needed to identify optimal models of care across systems, including studies that focus on patient-reported outcomes of satisfaction with care and impressions of care quality.

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Disclosures

None.

References

1. Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R, de Ferranti SD, Floyd J, Fornage M, Gillespie C, Isasi CR, Jimenez MC, Jordan LC, Judd SE, Lackland D, Lichtman JH, Lisabeth L, Liu S, Longenecker CT, Mackey RH, Matsushita K, Mozaffarian D, Mussolino ME, Nasir K, Neumar RW, Palaniappan L, Pandey DK, Thiagarajan RR, Reeves MJ, Ritchey M, Rodriguez CJ, Roth GA, Rosamond WD, Sasson C, Towfighi A, Tsao CW, Turner MB, Virani SS, Voeks JH, Willey JZ, Wilkins JT, Wu JH, Alger HM, Wong SS, Muntner P. Heart disease and stroke statistics—2017 update: a report from the American Heart Association. *Circulation*. 2017;135:e146–e603.
2. Heidenreich PA, Trogdon JG, Khavjou OA, Butler J, Dracup K, Ezekowitz MD. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. *Circulation*. 2011;123:933–944.
3. Goodman DC, Fisher ES, Chang C-H. *After hospitalization: a Dartmouth Atlas report on post-acute care for Medicare beneficiaries*. The Dartmouth Atlas of Healthcare. Hanover, NH: Dartmouth college; 2011. Available at: http://www.dartmouthatlas.org/downloads/reports/Post_discharge_events_092811.pdf.
4. Helmer D, Sambamoorthi U, Shen Y, Tseng CL, Rajan M, Tiwari A, Maney M, Pogach L. Opting out of an integrated healthcare system: dual-system use is associated with poorer glycemic control in veterans with diabetes. *Prim Care Diabetes*. 2008;2:73–80.
5. Maciejewski ML, Wang V, Burgess JF Jr, Bryson CL, Perkins M, Liu CF. The continuity and quality of primary care. *Med Care Res Rev*. 2013;70:497–513.
6. Thorpe JM, Thorpe CT, Gellad WF, Good CB, Hanlon JT, Mor MK, Pleis JR, Schleiden LJ, Van Houtven CH. Dual health care system use and high-risk prescribing in patients with dementia: a national cohort study. *Ann Intern Med*. 2017;166:157–163.
7. Gellad WF, Zhao X, Thorpe CT, Thorpe JM, Sileanu FE, Cashy JP, Mor M, Hale JA, Radomski T, Hausmann LR, Fine MJ, Good CB. Overlapping buprenorphine, opioid, and benzodiazepine prescriptions among veterans dually enrolled in Department of Veterans Affairs and Medicare Part D. *Subst Abuse*. 2017;38:22–25.
8. Chen C, Ackerly DC. Beyond ACOs and bundled payments: Medicare's shift toward accountability in fee-for-service. *JAMA*. 2014;311:673–674.
9. West AN, Charlton ME, Vaughan-Sarrazin M. Dual use of VA and non-VA hospitals by veterans with multiple hospitalizations. *BMC Health Serv Res*. 2015;15:431.
10. Nasir K, Lin Z, Bueno H, Normand SL, Drye EE, Keenan PS, Krumholz HM. Is same-hospital readmission rate a good surrogate for all-hospital readmission rate? *Med Care*. 2010;48:477–481.

11. Weeks WB, West AN, Wallace AE, Fisher ES. Comparing the characteristics, utilization, efficiency, and outcomes of VA and non-VA inpatient care provided to VA enrollees: a case study in New York. *Med Care*. 2008;46:863–871.
12. Axon RN, Gebregziabher M, Everett CJ, Heidenreich P, Hunt KJ. Dual health care system use is associated with higher rates of hospitalization and hospital readmission among veterans with heart failure. *Am Heart J*. 2016;174:157–163.
13. Carey K, Montez-Rath ME, Rosen AK, Christiansen CL, Loveland S, Ettner SL. Use of VA and Medicare services by dually eligible veterans with psychiatric problems. *Health Serv Res*. 2008;43:1164–1183.
14. Liu CF, Bolkan C, Chan D, Yano EM, Rubenstein LV, Chaney EF. Dual use of VA and non-VA services among primary care patients with depression. *J Gen Intern Med*. 2009;24:305–311.
15. Petersen LA, Byrne MM, Daw CN, Hasche J, Reis B, Pietz K. Relationship between clinical conditions and use of Veterans Affairs health care among Medicare-enrolled veterans. *Health Serv Res*. 2010;45:762–791.
16. Rosen AK, Mayer-Oakes A. Episodes of care: theoretical frameworks versus current operational realities. *Jt Comm J Qual Improv*. 1999;25:111–128.
17. Candrilli SD, Meyers JL, Boye K, Bae JP. Health care resource utilization and costs during episodes of care for type 2 diabetes mellitus-related comorbidities. *J Diabetes Complications*. 2015;29:529–533.
18. Landsman PB, Smith DG, Fendrick AM. Healthcare utilization in community-acquired pneumonia episodes of care: a comparison across the continuum of managed care. *Med Care*. 2009;47:1084–1090.
19. Rosen AK, Mayer-Oakes A. Developing a tool for analyzing medical care utilization of adult asthma patients in indemnity and managed care plans: can an episodes of care framework be used? *Am J Med Qual*. 1998;13:203–212.
20. Krumholz HM, Wang Y, Mattera JA, Han LF, Ingber MJ, Roman S, Normand SL. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with heart failure. *Circulation*. 2006;113:1693–1701.
21. Egede LE, Gebregziabher M, Hunt KJ, Axon RN, Echols C, Gilbert GE, Mauldin PD. Regional, geographic, and racial/ethnic variation in glycemic control in a national sample of veterans with diabetes. *Diabetes Care*. 2011;34:938–943.
22. Egede LE, Gebregziabher M, Hunt KJ, Axon RN, Echols C, Gilbert GE, Mauldin PD. Regional, geographic, and ethnic differences in medication adherence among adults with type 2 diabetes. *Ann Pharmacother*. 2011;45:169–178.
23. Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, Saunders LD, Beck CA, Feasby TE, Ghali WA. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care*. 2005;43:1130–1139.
24. van Walraven C, Austin PC, Jennings A, Quan H, Forster AJ. A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data. *Med Care*. 2009;47:626–633.
25. Fitzmaurice GM, Laird NM, Ware JH. *Applied Longitudinal Analysis*. Hoboken, NJ: Wiley-Interscience; 2004.
26. Lin DY. Cox regression analysis of multivariate failure time data: the marginal approach. *Stat Med*. 1994;13:2233–2247.
27. Kalbfleisch JD, Prentice RL. *The Statistical Analysis of Failure Time Data*. Hoboken, NJ: John Wiley & Sons, Inc.; 2002.
28. Jia H, Zheng Y, Reker DM, Cowper DC, Wu SS, Vogel WB, Young GC, Duncan PW. Multiple system utilization and mortality for veterans with stroke. *Stroke*. 2007;38:355–360.
29. Tarlov E, Lee TA, Weichle TW, Durazo-Arvizu R, Zhang Q, Perrin R, Bentrem D, Hynes DM. Reduced overall and event-free survival among colon cancer patients using dual system care. *Cancer Epidemiol Biomarkers Prev*. 2012;21:2231–2241.
30. Bouldin ED, Littman AJ, Wong E, Liu CF, Taylor L, Rice K, Reiber GE. Medicare-VHA dual use is associated with poorer chronic wound healing. *Wound Repair Regen*. 2016;24:913–922.
31. Pope CA, Davis BH, Wine LL, Nemeth LS, Axon RN. A triangulated qualitative study of veteran decision-making to seek care during heart failure exacerbation: implications of dual health system use. *Inquiry*. 2018;55:46958017751506.
32. Misky GJ, Wald HL, Coleman EA. Post-hospitalization transitions: examining the effects of timing of primary care provider follow-up. *J Hosp Med*. 2010;5:392–397.
33. Hernandez AF, Greiner MA, Fonarow GC, Hammill BG, Heidenreich PA, Yancy CW, Peterson ED, Curtis LH. Relationship between early physician follow-up and 30-day readmission among Medicare beneficiaries hospitalized for heart failure. *JAMA*. 2010;303:1716–1722.
34. Gavish R, Levy A, Dekel OK, Karp E, Maimon N. The association between hospital readmission and pulmonologist follow-up visits in patients with COPD. *Chest*. 2015;148:375–381.
35. Weinberger M, Oddone EZ, Henderson WG. Does increased access to primary care reduce hospital readmissions? Veterans Affairs Cooperative Study Group on Primary Care and Hospital Readmission. [see comment]. *N Engl J Med*. 1996;334:1441–1447.
36. Coleman EA, Williams MV. Executing high-quality care transitions: a call to do it right. *J Hosp Med*. 2007;2:287–290.
37. Kripalani S, LeFevre F, Phillips CO, Williams MV, Basaviah P, Baker DW. Deficits in communication and information transfer between hospital-based and primary care physicians: implications for patient safety and continuity of care. *JAMA*. 2007;297:831–841.
38. Gellad WF. The Veterans Choice Act and dual health system use. *J Gen Intern Med*. 2016;31:153–154.
39. Bouhaddou O, Bennett J, Teal J, Pugh M, Sands M, Fontaine F, Swall M, Dhar S, Mallia T, Morgan B, Cromwell T. Toward a virtual lifetime electronic record: the Department of Veterans Affairs experience with the Nationwide Health Information Network. *AMIA Annu Symp Proc*. 2012;2012:51–60.
40. Turvey CL, Klein DM, Witry M, Klutts JS, Hill EL, Alexander B, Nazi KM. Patient education for consumer-mediated HIE. A pilot randomized controlled trial of the Department of Veterans Affairs Blue Button. *Appl Clin Inform*. 2016;7:765–776.
41. Forster AJ, Clark HD, Menard A, Dupuis N, Chernish R, Chandok N, Khan A, van Walraven C. Adverse events among medical patients after discharge from hospital. *CMAJ*. 2004;170:345–349.
42. Cua YM, Kripalani S. Medication use in the transition from hospital to home. *Ann Acad Med Singapore*. 2008;37:136–136.
43. Gellad WF, Cunningham FE, Good CB, Thorpe JM, Thorpe CT, Bair B, Roman K, Zickmund SL. Pharmacy use in the first year of the Veterans Choice Program: a mixed-methods evaluation. *Med Care*. 2017;7(suppl 1):S26–S32.
44. Stroupe KT, Smith BM, Bailey L, Adas J, Gellad WF, Suda K, Huo Z, Tully S, Burk M, Cunningham F. Medication acquisition by veterans dually eligible for Veterans Affairs and Medicare Part D pharmacy benefits. *Am J Health Syst Pharm*. 2017;74:140–150.
45. Thrall SA, Egede LE, Taber DJ. Ambulatory care coordination issues with dual use veteran organ transplant recipients. *Prog Transplant*. 2017;27:187–191.
46. Roy CL, Poon EG, Karson AS, Ladak-Merchant Z, Johnson RE, Maviglia SM, Gandhi TK. Patient safety concerns arising from test results that return after hospital discharge. *Ann Intern Med*. 2005;143:121–128.
47. Gellad WF, Zhao X, Thorpe CT, Mor MK, Good CB, Fine MJ. Dual use of Department of Veterans Affairs and Medicare benefits and use of test strips in veterans with type 2 diabetes mellitus. *JAMA Intern Med*. 2015;175:26–34.
48. Boccuti C, Casillas G. Aiming for fewer hospital U-turns: the Medicare Hospital Readmission Reduction Program. Issue Brief. San Francisco, CA: Kaiser Family Foundation; 2017. Available at: https://www.kff.org/medicare/issue-brief/aiming-for-fewer-hospital-u-turns-the-medicare-hospital-readmission-reduction-program/.
49. Clough JD, McClellan M. Implementing MACRA: implications for physicians and for physician leadership. *J Am Med Assoc*. 2016;315:2397–2398.
50. Williams KA Sr, Casale PN, Oetgen WJ. A micro view of MACRA: how the ACC and NCDR will help members navigate radical changes ahead. *J Am Coll Cardiol*. 2015;66:2675–2677.
51. Farmer SA, Darling ML, George M, Casale PN, Hagan E, McClellan MB. Existing and emerging payment and delivery reforms in cardiology. *JAMA Cardiol*. 2017;2:210–217.

Supplemental Material

Table S1. Hazard Ratio estimates and 95% CI for Dual Use.

Variable	Model 1	Model 2	Model 3
	HR (95% CI)	HR (95% CI)	HR (95% CI)
Non-VA Only	2.01 (1.54-2.62)	1.84 (1.40-2.42)	1.89 (1.29-2.77)
Dual Use	1.62 (1.20-2.19)	1.53 (1.13-2.08)	1.52 (1.07-2.16)
VA Only	1.00	1.00	1.00
Hospitalization			0.96 (0.78-1.18)
ED Visit			1.00
Age (years)		1.04 (1.03-1.06)	1.04 (1.03-1.06)
Non-Hispanic White		1.00	1.00
Non-Hispanic Black		0.87 (0.69-1.09)	0.83 (0.66-1.05)
Hispanic and Other		1.06 (0.47-2.41)	1.02 (0.45-2.31)
Female		1.15 (0.59-2.26)	1.18 (0.60-2.34)
Male		1.00	1.00
Married		1.00	1.00
Separated or Divorced		1.14 (0.84-1.54)	1.17 (0.86-1.58)
Widowed		1.25 (1.02-1.54)	1.27 (1.03-1.57)
Never Married		0.95 (0.61-1.48)	0.96 (0.61-1.51)
Unknown		1.16 (0.65-2.06)	1.14 (0.64-2.02)
Service Connected Disability $\geq$50%			1.34 (1.07-1.68)
Urban		1.00	1.00
Rural and Highly Rural		0.98 (0.83-1.16)	0.99 (0.84-1.18)
Unknown		1.08 (0.67-1.74)	1.12 (0.70-1.80)
Van Walraven Elixhauser Score			1.01 (1.01-1.02)
Interaction of Dual Use with Survival Time			1.00 (1.00-1.00)

Table S2. Association between site of episode and type of first care with mortality among all patients (utilization variables included).

	Hazard Ratio	95% CI
Site of Episode		
VA	1.00	---
Non-VA	2.29	1.56-3.37
Dual Use	1.52	1.07-2.14
Type of First Care		
ED Visit	1.00	---
Hospitalization	1.23	0.91-1.65

Adjusted for age, race/ethnicity, sex, marital status, service connected disability, rurality, van Walraven Elixhauser score, ED visit utilization, and hospitalization utilization.

Table S3. Association between site of episode and type of first care with mortality among patients that survived for more than 30 days.

	Hazard Ratio	95% CI
Site of Episode		
VA	1.00	---
Non-VA	1.71	0.55-5.32
Dual Use	2.91	1.29-6.55
Type of First Care		
ED Visit	1.00	---
Hospitalization	1.53	1.11-2.11

Adjusted for age, race/ethnicity, sex, marital status, service connected disability, rurality, and van Walraven Elixhauser score.

Table S4. Association between site of episode and type of first care with mortality among patients that survived for more than 30 days (utilization variables included).

	Hazard Ratio	95% CI
Site of Episode		
VA	1.00	---
Non-VA	2.76	0.87-8.79
Dual Use	2.48	1.07-5.72
Type of First Care		
ED Visit	1.00	---
Hospitalization	1.94	1.30-2.89

Adjusted for age, race/ethnicity, sex, marital status, service connected disability, rurality, van Walraven Elixhauser score, ED visit utilization, and hospitalization utilization.