ABSTRACT

Background: Quality improvement initiatives improve health care delivery but may be resource intensive and disrupt clinical care. An embedded heart failure order set (HFOS) within a computerized physician order-entry system may mitigate these concerns.

Methods: An HFOS, based on proven interventions, was implemented within an existing computerized physician order-entry system in all adult acute-care hospitals in a single Canadian metropolitan city and interrogated between January 1, 2013 and December 31, 2015. The composite of repeat hospitalization or death within 30 days of hospital discharge and hospital length of stay were reported.

Results: In total, 8969 patients were included with mean age 75.6 ± 13.5 years; 4673 (52.1%) were male. The HFOS was used in 731 (8.2%) patients. After analysis of 724 pairs of propensity-score matched patients, use of the HFOS was associated with a 4.0% lower mortality in the next 30 days. In a model that included age, sex, and comorbidities, use of the HFOS was associated with a 11.0% lower risk of all-cause mortality.

Conclusion: Use of an electronic HFOS may improve health care delivery to patients with heart failure.

Original Article

Computerized Electronic Order Set: Use and Outcomes for Heart Failure Following Hospitalization

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ABSTRACT

Background: Given the limited evidence on the appropriate timing of repeat hospitalization or death within 30 days following hospital discharge for patients with heart failure (HF), this study aimed to evaluate the impact of an electronic HF order set (HFOS) on post-discharge outcomes.

Methods: This retrospective cohort study included adult patients with HF discharged from 27 acute-care hospitals in a single Canadian metropolitan city between January 1, 2013, and December 31, 2015. The electronic HFOS included evidence-based therapies and was embedded in the computerized physician order-entry system. Propensity-matched analysis was performed to identify patients with and without HFOS use.

Results: A total of 8,969 patients were included, with 731 (8.2%) using the HFOS. Ablative analysis showed no significant difference in mortality between patients with and without HFOS use (4.0% vs. 4.7%, p = 0.49). However, the use of HFOS was associated with a 4.0% lower risk of readmission or death within 30 days (95% CI: 0.6% to 7.3%, p = 0.01).

Conclusion: Use of an electronic HFOS may improve post-discharge outcomes for patients with HF, including a reduced risk of readmission or death within 30 days after discharge.
matched cohorts, patients with HFOS use experienced a lower median length of stay (8.6 vs 9.4 days, \( P = 0.016 \)) and a trend toward lower composite repeat hospitalization or death (14.5% vs 17.7%, \( P = 0.115 \), hazard ratio 0.79 (0.60–1.05). Patients with HFOS use were more likely to undergo a test for left ventricular ejection fraction (88.6% vs 76.7%, \( P < 0.001 \), and to be referred to a heart failure clinic (48.5% vs 6.3%), with similar rates of discharge prescription of beta-blockers (88.7% vs 86.3) and angiotensin-converting enzyme inhibitors (87.4% vs 89.0%).

Conclusions: Use of a designated HFOS within a computerized physician order-entry system is associated with shorter hospital length of stay without increase in deaths or readmissions. These findings should be confirmed in a prospective controlled trial.

Services included 3 adult acute-care hospitals, which provided community and tertiary care to an approximate 2.4 million people in the greater Calgary area, as well as to southern Alberta. All acute-care centres use the Sunrise Clinical Manager (SCM; Eclypsis Corporation, Boca Raton, FL), an electronic medical record (EMR) with CPOES functionality, for result viewing as well as all order entry, including admission orders, medications, investigations, and care needs. The study was approved by the University of Calgary Institutional Review Board.

**Intervention**

Between November 2008 and September 2009, a multidisciplinary group within the Calgary zone was charged with development and implementation of an HF optimization program. This was an evidence-based set of 11 interventions designed to ensure the use of best practices for hospital inpatients (Supplemental Table S1). These interventions were based on recommendations of the 2008 Canadian Cardiovascular Society Heart Failure Guidelines Focused Update concerning the transition from hospital to home. The central intervention, the electronic HFOS (which included prechecked orders for evidence-based medications for HF—angiotensin-converting enzyme inhibitors, angiotensin receptor antagonists, beta blockers, diuretics, mineralocorticoid receptor antagonists, oral anticoagulants) was created as one of the interventions and contained prechecked orders for the other 10 interventions. Medication reconciliation was not included, as this was the focus of a preexisting initiative.

Order set implementation began July 2009, initially at the largest hospital, in wards serving a high volume of patients admitted with HF. It became available at all sites by January 2010. Typing “Heart Failure Admission,” “CHF” (for congestive HF), or variations thereof into the EMR dialog box allowed access to the order set at the time of hospital admission or at any point during the hospital stay. Health care providers were informed of the availability of this HFOS via scheduled e-mails from the Information Technology Department. Additionally, the development team members provided lectures to the Internal Medicine, Cardiology, and Hospitalist Services group. Paper notifications were posted on the floors of interest (where 50%–60% of HF patients were admitted), and reminders were incorporated as the screensavers on hospital computers. Finally, unit managers were included in the rollout, and “in-service” sessions were scheduled for staff on at least 2 occasions per floor, with repeat staff meetings to reinforce awareness whenever the monthly compliance rate with daily weight measurements fell below 80%. Compliance with daily weights was defined as the number of days on which weight was documented divided by the number of days in the hospital, for all patients with HF. Between 2010 and 2013, active maintenance of these interventions was not performed. Ultimately, however, use of the order set remained a clinical decision and was left to the most responsible physician in each case and was not randomized.

**Study population**

Patients admitted with a primary or secondary diagnosis of HF between January 1, 2013 and December 31, 2015 were included. All admitting diagnoses were entered into the EMR at the time of admission by the admitting physician and subsequently coded by trained health record personnel in accordance with the International Classifications of Diseases (ICD) 10. Patients were considered to have HF during hospitalization if any codes for HF (ICD 150.x) were listed as primary or secondary diagnoses. Patients under 18 years of age were excluded (n = 118), as were patients on dialysis (n = 35). Patients on renal replacement therapy were excluded because HF admissions may be related to insufficient volume removal during dialysis and a less-developed rationale for HF pharmacotherapy. None of the patients were managed with the HFOS. Only the first hospitalization was included.
for each patient (n = 6837 repeat hospitalizations excluded). Cases were included in the HFOS use group if the order set was activated for that patient at any time during hospitalization.

Data collection and availability

Documented variables from the EMR included patient age and sex, vital signs on admission, treating physician type, and completion of a cardiologist consultation. Prescription of medications at hospital discharge was also included. Comorbid conditions were determined from discharge diagnoses using previously described ICD-10 coding. In all, 36 bid conditions were determined from discharge diagnoses. In an audit of 100 cases, we determined that comorbid conditions were abstracted completely in 73 cases, which was consistent with the previously known completion rate. The Charlson Comorbidity Index was calculated as previously described.

The first recorded laboratory values for each patient were extracted automatically from the EMR, with missing values for levels of sodium (n = 47), creatinine (n = 50), hemoglobin (n = 50), and white blood cells (n = 50) imputed with the population mean value.

Outcomes

The primary outcome was the composite of death and repeat HF hospitalization at 30 days following hospital discharge. Postdischarge outcomes were tracked by linking data from the Sunrise Clinical Manager to the province-wide discharge and admission database (DAD) and vital statistics registry, which include all hospitalizations and deaths for Alberta residents, respectively. Only the first rehospitalization within 30 days was considered for patients with multiple rehospitalizations.

Ancillary measures included use of angiotensin-converting enzyme (ACE) inhibitors/angiotensin receptor blockers and beta-blockers at admission and discharge. Assessment of left ventricular ejection fraction with any modality (echocardiography, radionuclide angiography, cardiac catheterization, or cardiac magnetic imaging) while in the hospital was also recorded. The remaining interventions listed in Supplemental Table S1 were not documented in the EMR and therefore were not included as outcomes.

Statistical analysis

Continuous variables were summarized as mean ± standard deviation and compared with a Student t test or Wilcoxon rank-sum test as appropriate. Categorical variables were summarized as number (proportion) and compared with a \( \chi^2 \) or Fisher exact test, as appropriate.

To account for selection bias related to the clinical (non-randomized) decision to use the HFOS, we performed a propensity-score matching analysis. Patients who were not managed with the HFOS were matched to patients managed with the HFOS using 1:1 nearest-neighbor matching, with a caliper of 0.001. The propensity score included the following: year; age; sex; past medical history; admission systolic blood pressure and heart rate; levels of serum creatinine, blood urea nitrogen, serum sodium, and glucose; involvement of cardiology; and medical therapy at admission. Components of the propensity score and their weights are shown in Supplemental Table S3. Distribution of the propensity score in patients who were managed with vs without the HFOS are shown in Supplemental Figure S1. Propensity-score matching was repeated after excluding all patients with >30-day length-of-stay (LOS; termed “limited propensity match” cohort). Matched groups were compared with standardized mean differences, with a difference of >0.10 considered significant.

Associations with clinical outcomes (LOS, 30-day readmission, 30-day all-cause mortality, and a composite of death and rehospitalization at 30 days) were assessed in the overall cohort, the propensity-score matched cohort, and the limited propensity-score matched cohort. Associations with hospital LOS were assessed with ordinal logistic regression. Postdischarge outcomes were assessed only in patients who survived to discharge.

All statistical tests were 2-sided, with \( P < 0.05 \) considered significant. All analyses were performed with STATA version 13 (StataCorp, College Station, TX).

Results

Population characteristics

In total, 8969 patients were included in our study with a mean age of 75.6 ± 13.5 years; 4673 (52.1%) were male. The HFOS was used in 731 (8.2%) patients, with characteristics for the 2 groups shown in Table 1. Patients managed with the HFOS were younger (mean age 74.5 vs 75.6 years, \( P = 0.015 \)) and more likely to have cardiology as an attending or consulting service (77.8% vs 68.3%, \( P < 0.001 \)). The mean Charlson Comorbidity Index was also lower in patients managed with the HFOS (4.7 vs 5.0, \( P < 0.001 \)).

Details of the propensity-score matched cohorts are shown in Table 2. After propensity-score matching, there were no significant residual differences between groups, with both similar mean age (74.6 vs 74.6 years, \( P = 0.983 \)) and proportion of patients having cardiology as an attending or consulting service (77.6% vs 76.7%, \( P = 0.707 \)).

The mean Charlson Comorbidity Index was also similar in patients managed with vs without the HFOS (4.7 vs 4.7, \( P = 0.842 \)).

Inpatient management

Summary of the inpatient management of patients managed with vs without the HFOS in the overall and propensity-score matched cohort are shown in Figure 1. In the overall cohort, patients managed with the HFOS were more likely to have a weight measured on more than 50% of days (94.3% vs 61.6%, \( P < 0.001 \)), have a measurement of left ventricular ejection fraction (LVEF; 88.3% vs 74.6%, \( P < 0.001 \)), and be discharged on a beta-blocker (88.7% vs 76.4%, \( P < 0.001 \)) and an ACE inhibitor (87.4% vs 77.2%, \( P < 0.001 \)). Patients managed with the HFOS were more likely to be referred to a multidisciplinary HF clinic (48.4% vs 5.2%, \( P < 0.001 \)).

In the propensity-score matched cohort, patients managed with the HFOS were more likely to have a weight measured
on ≥50% of days (94.8% vs 68.1%), have a measurement of LVEF (88.6% vs 76.7%, *P* < 0.001), and be referred to the HF clinic (48.5% vs 6.3%, *P* < 0.001). These rates did not significantly vary over the study period.

### Clinical outcomes

Clinical outcomes in patients managed with vs without the HFOS in the overall cohort, the propensity-score matched

### Table 1. Baseline demographic and clinical characteristics

| Characteristic                        | Order set (n = 731) | No order set (n = 8238) | *P*
|--------------------------------------|---------------------|-------------------------|-------
| Age (y)                              | 74.5 ± 13.5         | 75.6 ± 13.5             | 0.015 |
| Male                                 | 395 (54.0)          | 4278 (51.9)             | 0.280 |
| Cardiologist attending/consulting    | 560 (77.8)          | 5623 (68.3)             | < 0.001 |
| Past medical history                 |                     |                         |       |
| Coronary artery disease              | 146 (20.0)          | 1574 (19.1)             | 0.557 |
| Atrial fibrillation                  | 251 (34.3)          | 2715 (33)               | 0.460 |
| Hypertension                         | 372 (50.9)          | 4249 (51.6)             | 0.728 |
| Diabetes mellitus                    | 251 (34.3)          | 2593 (31.5)             | 0.115 |
| Peripheral vascular disease          | 10 (1.4)            | 184 (2.2)               | 0.213 |
| Cerebrovascular disease              | 10 (1.4)            | 260 (3.2)               | 0.004 |
| Chronic kidney disease               | 114 (15.6)          | 1290 (15.7)             | 1.000 |
| COPD                                 | 102 (14.0)          | 1660 (20.2)             | < 0.001 |
| Liver disease                        | 79 (10.8)           | 964 (11.7)              | 0.508 |
| Malignancy                           | 29 (4.0)            | 578 (7.0)               | 0.001 |
| Dementia                             | 18 (2.5)            | 517 (8.7)               | < 0.001 |
| Charlson Comorbidity Index           | 4.7 ± 1.6           | 5.0 ± 1.6               | < 0.001 |
| Charlson Comorbidity Index, median (IQR) | 5 (4–6)            | 5 (4–6)                 | < 0.001 |
| Systolic BP (mm Hg)                  | 126.7 ± 21          | 126.4 ± 21.5            | 0.704 |
| Heart rate (bpm)                     | 82.4 ± 19.4         | 82.4 ± 18.8             | 0.156 |
| Creatinine (μmol/L)                  | 125 ± 83            | 130 ± 116               | 0.279 |
| Sodium (mmol/L)                      | 137 ± 5             | 136 ± 5                 | 0.036 |
| Hemoglobin (g/L)                     | 123 ± 21            | 120 ± 22                | < 0.001 |
| WBC (×10^9/L)                        | 8.8 ± 3.7           | 10.5 ± 14.5             | 0.002 |
| Admission medications                |                     |                         |       |
| Beta-blocker                         | 566 (77.4)          | 5073 (61.6)             | < 0.001 |
| ACE inhibitor/ARB                    | 579 (79.2)          | 4946 (60.0)             | < 0.001 |

Values are n (%) or mean ± standard deviation, unless otherwise indicated. Daily weights expressed as a percentage of available days in the hospital, including day of discharge. ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; BP, blood pressure; bpm, beats per minute; COPD, chronic obstructive pulmonary disease; WBC, white blood cell.

### Table 2. Population characteristics in matched cohort

| Characteristic                        | Order set (n = 724) | No order set (n = 724) | Standardized difference |
|--------------------------------------|---------------------|-------------------------|--------------------------|
| Age (y)                              | 74.6 ± 13.5         | 74.6 ± 13.6             | -0.001                   |
| Male                                 | 391 (54.0)          | 387 (53.5)              | -0.011                   |
| Cardiologist attending/consulting    | 562 (77.6)          | 555 (76.7)              | -0.023                   |
| Coronary artery disease              | 143 (19.8)          | 134 (18.5)              | -0.032                   |
| Atrial fibrillation                  | 248 (34.3)          | 252 (34.8)              | 0.012                    |
| Hypertension                         | 366 (50.6)          | 375 (51.8)              | 0.025                    |
| Diabetes mellitus                    | 248 (34.3)          | 234 (32.3)              | -0.041                   |
| Peripheral vascular disease          | 10 (1.4)            | 7 (1)                   | -0.038                   |
| Cerebrovascular disease              | 10 (1.4)            | 12 (1.7)                | 0.023                    |
| Chronic kidney disease               | 114 (15.8)          | 114 (15.8)              | 0.000                    |
| COPD                                 | 102 (14.1)          | 102 (14.1)              | 0.000                    |
| Liver disease                        | 79 (10.9)           | 79 (10.9)               | 0.000                    |
| Malignancy                           | 29 (4.0)            | 26 (3.6)                | -0.022                   |
| Dementia                             | 25 (3.5)            | 23 (3.2)                | -0.015                   |
| Charlson Comorbidity Index           | 4.7 ± 1.6           | 4.7 ± 1.6               | -0.010                   |
| Systolic BP (mm Hg)                  | 126.7 ± 21          | 126.3 ± 20.8            | -0.019                   |
| Heart rate (bpm)                     | 82 ± 19             | 83 ± 19                 | 0.025                    |
| Creatinine (μmol/L)                  | 126 ± 83            | 127 ± 116               | 0.009                    |
| Sodium (mmol/L)                      | 137 ± 5             | 137 ± 4                 | -0.033                   |
| Hemoglobin (g/L)                     | 123.2 ± 20.7        | 122.7 ± 21.5            | -0.021                   |
| WBC (×10^9/L)                        | 8.8 ± 3.6           | 8.7 ± 3.5               | -0.020                   |
| Admission medications                |                     |                         |                          |
| Beta-blocker                         | 563 (77.8)          | 562 (77.6)              | -0.003                   |
| ACE inhibitor/ARB                    | 573 (79.1)          | 576 (79.6)              | 0.010                    |

Values are n (%) or mean ± standard deviation, unless otherwise indicated. Daily weights expressed as a percentage of available days in the hospital, including day of discharge. ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; BP, blood pressure; bpm, beats per minute; COPD, chronic obstructive pulmonary disease; WBC, white blood cell.
cohort, and the limited propensity-score matched cohort are shown in Table 3. In total, 734 (8.2%) patients died in the hospital, and an additional 200 (2.2%) died within 30 days of discharge. Additionally, 812 (8.1%) patients were readmitted for HF within 30 days of discharge.

Associations between use of the HFOS and clinical outcomes are shown in Figure 2. In the overall cohort, mean hospital LOS was lower in patients managed with the HFOS (13.6 vs 19.1 days, \( P < 0.001 \) and median 8.4 vs 10.0 days, \( P = 0.001 \)). Additionally, all-cause mortality within 30 days of discharge (including in-hospital deaths) was lower in patients managed with vs without the HFOS (4.5% vs 10.9%, \( P < 0.001 \)).

The differences in hospital LOS (mean stay: 13.6 vs 16.3 days, \( P = 0.016 \); median: 8.6 vs 9.4 days, \( P = 0.016 \)) and all-cause mortality (4.4% vs 7.2%, \( P = 0.032 \)) were also seen in the propensity-score matched cohort. Similar results were seen in the limited propensity-score matched cohort (excluding patients with LOS > 30 days). There were no differences in 30-day repeat hospitalization (10.2% vs 10.8%, \( P = 0.77 \)). There was also no difference in urgent readmissions for HF (defined as readmission through the emergency department) between the propensity-score matched patients managed with vs without the HFOS (6.8% vs 6.9%, \( P = 0.54 \)).

Discussion

In this study, the use of a comprehensive, standardized electronic HFOS was associated with a reduction in mean and median LOS as well as 30-day mortality in patients admitted with HF. In addition, a nearly significant, strong trend toward lower 30-day composite repeat hospitalization for HF and mortality was observed. The use of an HFOS was also associated with an increased likelihood of assessment of LVEF, use of daily weights, and referral to a multidisciplinary HF clinic. Use of evidence-based medications (ACE/angiotensin receptor blocker /beta-blockers) was lower in the overall cohorts; however, it was extremely high and not different between groups in the propensity-score matched analysis. To our knowledge, these data represent the first evidence of HF outcome improvements in a Canadian hospital setting. Importantly, shorter hospital LOS and reduced early mortality rates were not derived at the expense of repeat hospitalization for HF, which has a lower incidence in Canada than in other
jurisdictions and may lead to actual reduction of inpatient treatment costs for HF. The current results support ongoing study of the expansion of this approach to a wider patient population.

### Table 3. Clinical outcomes for patients managed with vs without the HF order set

| Overall | Order set used (n = 731) | No order set (n = 8238) | P  |
|---------|--------------------------|------------------------|----|
| Hospital LOS (d) | 13.6 ± 18.0 | 19.1 ± 32.6 | < 0.001 |
| Hospital LOS (d), median | 8.4 | 10.0 | < 0.001 |
| 30-day readmissions for HF | 74 (10.6) | 693 (9.5) | 0.312 |
| 30-day all-cause mortality | 33 (4.5) | 901 (10.9) | < 0.001 |
| 30-day readmission for HF or all-cause mortality | 107 (14.6) | 1594 (19.4) | 0.002 |

| Propensity-score matched | Order set used (n = 724) | No order set (n = 724) | P  |
|--------------------------|--------------------------|------------------------|----|
| Hospital LOS (d) | 13.6 ± 18.0 | 16.3 ± 22.9 | 0.016 |
| Hospital LOS (d), median | 8.6 | 9.4 | 0.016 |
| 30-day readmissions for HF | 74 (10.2) | 78 (10.8) | 0.797 |
| 30-day all-cause mortality | 32 (4.4) | 52 (7.2) | 0.032 |
| 30-day readmission for HF or all-cause mortality | 105 (14.5) | 128 (17.7) | 0.115 |

| Limited propensity-score matched, excluding LOS > 30 days | Order set used (n = 657) | No order set (n = 657) | P  |
|----------------------------------------------------------|--------------------------|------------------------|----|
| Hospital LOS (d) | 9.5 ± 6.2 | 10.3 ± 6.7 | 0.020 |
| 30-day readmission for HF | 67 (10.2) | 62 (9.4) | 0.711 |
| 30-day all-cause mortality | 32 (4.9) | 95 (7.2) | 0.001 |
| 30-day readmission for HF or all-cause mortality | 98 (14.9) | 122 (18.6) | 0.089 |

Values are n (%) or mean ± standard deviation, unless otherwise indicated. All-cause mortality includes both in-hospital and postdischarge mortality. HF, heart failure; LOS, length of stay.

* Calculated using survivors at hospital discharge.

Comparison to literature

Use of multimodal interventions to reduce repeat hospitalization is not new. Data from nonrandomized studies

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**Figure 2.** Association between heart failure order set use and clinical outcomes. In the limited propensity-score matched cohort, patients with a > 30-day length of stay were excluded. CI, confidence interval.
involving clinical pathway and/or order set have suggested improved outcomes for a variety of populations, including hospitalized HF patients.6,6,8,20,22 Ballard et al. showed that the use of a paper-based HFOS decreased in-hospital, but not 30-day, mortality in a propensity-score matched analysis.12 Implementation of a CPOES within EMRs has been associated with fewer preventable adverse events due to medication errors and improved physician adherence to disease-specific process measures.6,23 There is evidence that CPOES use may also improve patient outcomes.1,2,4,22 We expand on the findings of Krive et al., by demonstrating improvement in clinical outcomes with use of an electronic HFOS after correcting for factors leading to utilization of the HFOS. Unfortunately, outcome data from randomized clinical trials of HFOS implementation and from the Canadian health care settings are lacking.26

More specifically, studies of various sizes, ranging from 48 to 2875 identified cases, show that use of a CPOES is associated with consistent reductions in hospital LOS and short-term mortality, but not with repeat hospitalization.6,8,12,13 Key performance metrics for HF, such as ACE/angiotensin receptor blocker or beta-blocker therapy, in general were not statistically improved when correction for baseline characteristics, including treating physician and cardiology involvement, was performed. In contrast, nonmedical interventions, such as documentation of LVEF and measurement of daily weights, were consistently improved in the setting of CPOES usage.

Although we identified a significant reduction in 30-day mortality with use of the HFOS, we did not identify a reduction in 30-day readmission for HF. Patients managed with or without HFOS had shorter hospital LOS, and potentially had more residual congestion as a result.6,12,20,22 Sud et al. and others previously demonstrated that short LOS was an independent risk factor for re-admission.20 We also note that the lower mean LOS, coupled with lower mortality and similar 30-day readmission rates, would also translate into a greater number of days alive and out of hospital over the study period. Additionally, the lower 30-day mortality rate left a larger proportion of patients at risk for readmission (survivor bias). It is reassuring to note that in our study, lower LOS was observed, but not at the expense of increased repeat hospitalization and/or mortality, resulting in a higher number of days alive and out of the hospital, an increasingly used post-discharge outcome.20 Lastly, this may be a result of the relatively small sample size and event rate (152 hospitalizations) in the propensity-score matched groups.

Regardless, the results of the present study are quite consistent with existing data on the impact of using an HFOS, aside from a lower usage rate (8.2% vs rates approaching 80%).6 This rate may have occurred due to an initial strategy of limited introduction of this CPOES to selected hospital wards, with little additional resources for dissemination coupled with inability to mandate usage. It is difficult to speculate on the potential impact of full implementation. Given that processes included in the CPOES are widely accepted discharge interventions, heterogeneity in usage rates of discharge tools is well described, difficult to solve, and requires further study.30,31

Strengths and limitations

This study considers an order set within a fully integrated CPOES, which permitted highly accurate data extraction, complete follow-up, and linkage to external databases. We included many consecutive cases (8969) over a prolonged period of time and were able to propensity-score match 724 CPOES cases for 25 variables, including specialist involvement in care.

Although all inpatient records from a single metropolitan Canadian city were included, limitations in data availability were nevertheless present. These included inability to determine actual LVEF, and listing of drug intolerances or reasons for medication use/non-use or earlier patient intolerance, a known limitation of electronic order sets.3 These and other variables either were not available (natriuretic peptides were available for <10% of the cohort) or were documented on the supplementary, paper-based charts, which were not formally audited in total. Consequently, variables known to affect outcomes, such as LVEF and serum B-type natriuretic peptide values, were not included. This study is nonrandomized and observational, with all the attendant potential bias this entails. Although many important clinical variables were well balanced in the matched groups, it is highly likely that several unmeasured confounders were present.

The lack of randomization allows for only a hypothesis-generating conclusion. Further, we cannot attribute any difference in outcomes to any specific mechanism of benefit, although we did observe increased use of nonpharmacologic, evidence-based therapies advocated within the HFOS, including documentation of LVEF, daily weight, and referral of high-risk patients to specialty HF clinics. We did not note any change in rate of daily weight or LVEF measurement over time in the HFOS group over the study period, which may have reflected a steady state of behavior. We did not more closely examine treatment behaviours, such as use of diuretic or other ancillary therapies. In addition, changes in clinical practice, such as introduction of angiotensin-neprilysin receptor inhibitors for HF with low LVEF are likely to have occurred following the study period. We were therefore, regrettably, not able to evaluate the HFOS as a tool to affect uptake of new treatments, which may have provided further insights as to the overall effectiveness of these treatments, especially given the potential for early reduction in hospitalization. We did not prospectively collect costing data, which would have informed a potential cost—benefit analysis.

In addition, the CPOES introduction was targeted primarily to locations where a high concentration of patients with HF would be found, and no formal effort was made to maintain or improve use over time, which likely led to the low usage rate, possibly among those with interest in HF. Thus, our findings may not be widely applicable to the generalist provider segment. Reasons for non-use of the order set were not recorded, and so we do not know if non-use was due to lack of awareness of the HFOS, patient factors, or other physician factors.
Conclusions

Use of a standardized, electronic HFOS for care of patients admitted to the hospital with HF was associated with shorter LOS and lower rates of death at 30 days. These results raise the possibility of savings in inpatient HF treatment costs and support the further expansion and rigorous studies designed to determine which components of the HFOS are most important in reducing adverse outcomes for patients admitted to the hospital with HF, and how they may be applied more broadly in the Canadian health care system. Additionally, given the potential clinical benefits of this intervention, barriers to widespread utilization should be identified and addressed.

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Disclosures

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Supplementary Material
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