Telehealth Factors for Predicting Hospital Length of Stay

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ABSTRACT

Identifying older adults with heart failure at risk for hospital readmission is challenging, and risk prediction models may be improved with inclusion of telehealth factors. In the current study, demographic, clinical, telehealth, and use data for emergency department (ED) presentations, hospitalizations, and length of stay (LOS) were collected from the records of 187 Veterans with heart failure participating in a 90-day Care Coordination Home Telehealth program between September 2007 and September 2013. Heart failure–related ED visits were 17.6% and 18.2% required hospitalization with an average LOS of 7 days (range = 1 to 38 days). Binary logistic regression models failed to predict likelihood of an ED presentation or hospitalization. Poisson regression models significantly predicted hospital LOS on the factors of telehealth alerts, nurse response to alerts, advancing age, and chronic renal disease. Data collected from one telehealth program significantly contributed to heart failure–related risk prediction models and should be included in future models. [Journal of Gerontological Nursing, xx(x), xx-xx.]

Heart failure–related hospital readmission among older adults is approximately 20% at 30 days and 34% at 90 days after initial discharge (Allen, Smoyer Tomic, Smith, Wilson, & Agodoa, 2012; Jencks, Williams, & Coleman, 2009). Identified behaviors contributing to worsening heart failure include patient nonadherence to medication, diet, and physical activity recommendations; and lack of recognition of change in dyspnea, fatigue, or edema symptoms (Reeder, Ercole, Peek, & Smith, 2015). Home-based telehealth monitoring has been shown to favorably improve health care behaviors and may contribute toward decreasing preventable hospital readmissions (Peek...
et al., 2014). Although telehealth programs are the most widely studied form of home-based technology (Kotb, Cameron, Hsieh, & Wells, 2015), risk models developed for predicting likelihood of heart failure–related hospital readmission do not routinely include telehealth program data (Krumholz et al., 2016; Zai et al., 2013).

AIM
The aim of the current study was to (a) report heart failure–related emergency department (ED) presentations, hospitalizations, and inpatient length of stay (LOS) among older Veterans during their initial 90 days of telehealth program participation, and (b) develop unique telehealth factors to include in prediction models that may inform likelihood of risk for heart failure–related hospital readmission among telehealth participants.

METHOD
Design, Sample, and Telehealth and Medical Record Measures
While adhering to protection of human subject guidelines and receiving institutional review board approval, the electronic telehealth and medical records of older Veterans were queried to identify individuals participating in the Care Coordination Home Telehealth program specifically for heart failure at one New England Veterans Health Administration (VHA) between September 2007 and September 2013. The study sample comprised records from 187 participants meeting the following inclusion criteria: diagnosed with heart failure, age ≥60 years, residing at a private residence, evaluated as oriented to place and time prior to telehealth program participation, and using a wireless scale and telehealth device connected to the home telephone service. Exclusion criteria were Veterans in a clinical trial or documented on the telehealth evaluation form as memory impaired or having a limited life expectancy.

Characteristics Data
Demographic, clinical history, and heart failure–related health care use (i.e., ED presentations, hospitalizations, LOS) data were extracted from the electronic medical record (EMR). Data were not collected for health care use unrelated to heart failure or from other settings.

Telehealth Alert Data
The first 90 days of telehealth submission data were extracted from the electronic telehealth record for physiological measures of heart rate, systolic blood pressure, diastolic blood pressure, and weight. Participant telehealth submission data were collected each day for response to self-rated health status prompts (i.e., adherence to medication, diet, physical activity; symptoms of dyspnea, fatigue, edema) displayed on the telehealth device. Each data point was flagged as being within either normal or alert range. It was anticipated that not all participants would remain in the program throughout the review period. For each participant, total telehealth alert days were identified from all sessions, with at least one submission measuring within alert range. The factor of telehealth alerts was constructed from number of telehealth alert days divided by number of days of program participation.

Timely Nurse Response Data
Progress note documentation by nurses monitoring participants’ telehealth submissions were identified within the EMR throughout the review period. Timely nurse response was credited when documentation was signed by the monitoring nurse within 24 workday hours of an alert day and included mention of at least one alert-range telehealth data point within the progress note. The factor of timely nurse response was constructed from number of days of nurse documentation (within 24 workday hours after at least one alert) divided by total alerting days.

Data Analysis
The telehealth and medical records were linked and de-identified by participant number, and statistical analyses were performed using SPSS version 23.0. Descriptive statistics were used to characterize data placed in the models, including demographic and clinical measures common to heart failure evaluations (Zai et al., 2013), factors of telehealth alerts and timely nurse response, and binary (need or no need) health care use of ED presentations or hospitalizations, as well as inpatient LOS.

Binary logistic regressions within SPSS were conducted using a probability cutoff of 0.3 (Tsai et al., 2013) as the predictive value for uses. Listed factors were placed in models for predicting likelihood of ED presentations and hospitalizations; odds ratios (OR) and 95% confidence intervals (CIs) were reported for each factor. The same factors were placed in Poisson log linear regression models to identify factors associated with risk for heart failure–related ED presentations and hospitalizations ≥1 day; incidence rate ratios (IRR) and 95% CIs were reported for each factor. A p value <0.05 was considered significant. Power analysis was evaluated using the G*Power V.3.1 program (Faul, Erdfelder, Buchner, & Lang, 2009). In an a priori analysis of Poisson regression with 95% power and a 0.05 alpha, there was sufficient power to identify factors significantly contributing to predicting hospital LOS.

RESULTS
Demographics and Clinical History
Records of 187 older adult Veterans were included in analyses. Mean participant age was 73.9 years (SD = 9.73 years, range = 60 to 93 years). Most participants were male (97.9%), non-Hispanic
(96.3%), White (87.7%), and educated at the high school level or above (82.4%), and more than one third were currently married (39.6%). Most had hypertension (93.6%) and left ventricular ejection fraction (LVEF) ≥40% identified as heart failure preserved ejection fraction (70.1%). Factors investigated as possible predictors of heart failure–related health care use included demographics (i.e., age in years, marital status, education); clinical data (i.e., LVEF, presence or absence of hypertension, chronic renal disease, prior myocardial infarction or stroke); and telehealth data (i.e., telehealth alerts, timely nurse response).

**ED Presentations**

During the study period, 17.6% of participants had a heart failure–related ED presentation. In binary logistic regression, a test of the full model with all factors against a constant-only model was not statistically significant, indicating that the factors as a set did not reliably distinguish participants at greater risk for a heart failure–related ED presentation ($\chi^2 = 12.7, p = 0.24$ with $df = 10$).

**Hospitalization and Hospital Length of Stay**

During the study period, 18.2% of participants required ≥1 consecutive days of heart failure–related inpatient hospital care, with 29 participants experiencing hospital readmission as a result of an ED presentation ($n = 24$) or primary care presentation ($n = 5$) at the VHA facility. In the binary logistic regression model, a test of the full model with all factors against a constant-only model was not statistically significant ($\chi^2 = 16.2, p = 0.09$ with $df = 10$), indicating that the factors as a set did not reliably distinguish between participants with or without risk for a heart failure–related hospitalization. Mean inpatient hospital LOS was 7 days ($SD = 7.59$ days, range = 1 to 38 days), with 64.7% of participants staying <7 days (Figure).

In Poisson regression analysis, the full predictor model represented a statistically significant improvement in fit over the null model ($p < 0.001$). Hospital LOS was likely to increase among participants with presence of telehealth alerts (IRR = 1.006, $p < 0.035$); presence of nurse response to alerts (IRR = 1.013, $p < 0.001$); chronic renal disease (IRR = 1.78, $p < 0.001$); or advancing age (IRR = 1.01, $p < 0.001$). A reduction in hospital LOS was seen among participants with heart failure–reduced ejection fraction (IRR = 0.40, $p < 0.001$), and those without hypertension (IRR = 0.13, $p < 0.005$). Among demographic variables, there was a reduction in hospital LOS for currently married participants (IRR = 0.54, $p < 0.001$) compared to widowed, divorced, or never married participants; and those graduating from high school or additional vocational training (IRR = 0.71, $p < 0.04$) or with any college (IRR = 0.49, $p < 0.001$) compared to those without a high school diploma. The Table shows the final model incidence rate ratio estimates for hospital LOS.

**DISCUSSION**

Rates of heart failure–related health care use in the current study are similar to findings in the literature among those receiving heart failure care within the same health care system across multiple presentations (Axon, Gebregziabher, Everett, Heidenreich, & Hunt, 2016; McClellan, 2013). With the development of telehealth factors, the current descriptive study extends the advancing field of model work to predict heart failure–related health care use. Specifically, the factor of telehealth alerts may capture a possible change in the health status of the participant, and timely nurse response may reflect real-time evaluation of the participant's health status.

In the Poisson regression model for predicting LOS, current study models did not reveal significant predictors. ED presentations by older adults with heart failure are often characterized by a variety of complaints, including increasing dyspnea, fatigue, edema, pain, or uncertainty of worsening heart failure or other comorbidities (Krumholz et al., 2016; Meyer, Kiernan, McManus, & Shih, 2014).
telehealth factors significantly contributed to predicting an extended hospital LOS. Prior studies have used large administrative datasets with factors that likely fail to reflect actual health status of older adults with heart failure (Kripalani, Theobald, Anctil, & Vasilevskis, 2014). Telehealth factors may be a more practical clinical predictor of risk for health care use.

**LIMITATIONS**

The current study was a descriptive study, with the limitation of using retrospective telehealth data collected from systems connected to the home telephone service. The factor of timely nurse response was not meant to reflect that the documenting nurse made contact with or provided care to the participant, or made contact with the participant’s health care provider. Although it may be possible that participation in the telehealth program decreased health care use, the current study’s findings may also be attributable to factors not included in the risk models. Another limitation was the absence of measures reflecting heart failure–related ED presentations prior to participation in the telehealth program. An ED presentation within the previous 12 months for treatment of heart failure symptoms is a significant predictor of risk for another ED presentation (Au et al., 2012), including among Veterans with chronic disease (Doran, Raven, & Rosenheck, 2013). Finally, the current study’s measures did not include descriptions of ED presentations or inpatient hospital stays that were not identified as heart failure–related but may have provided additional information.

**IMPLICATIONS**

Larger studies are needed to explore the factors of telehealth alerts and nurse response to establish the extent to which they contribute to predicting risk for health care use. Identifying telehealth factors that consistently and accurately reflect clinical change in telehealth participants increases opportunity for early interventions that may decrease the need for heart failure–related health care use.

**CONCLUSION**

Telehealth factors were unique and significant predictors for heart failure–related hospital LOS. To increase prediction of risk for heart failure–related ED presentations or hospitalizations, more robust telehealth factors reflecting change in health status are needed. By improving health care use risk models among telehealth participants, researchers may have a significant influence on identifying measures reflecting health status change prior to the need for emergent care.

**REFERENCES**


