

# Telehealth and Hospitalizations for Medicare Home Healthcare Patients

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**Objective:** To examine the effect of an integrated, clinician-focused telehealth monitoring system on the probability of hospitalization within the first 30-day episode of home healthcare.

**Study Design:** Retrospective, nonexperimental design.

**Methods:** The study sample includes 2009 data from 5873 Medicare beneficiaries receiving home healthcare services through a network of community-based home health agencies operating in Texas and Louisiana. Propensity-score matching was used to control for selection bias. Logistic regression and postestimation parameter simulation were used to assess how the use of an integrated, clinician-focused telehealth monitoring system might affect the probability of hospitalization during the first 30-day episode of home healthcare.

**Results:** The 30-day probability of hospitalization for telehealth and non-telehealth patients was 10.3% and 17.1%, respectively. Patients in the telehealth group had a 7-percentage-point (95% confidence interval 4.2, 9.4) lower probability of hospitalization within the first 30-day episode of home healthcare than those in the non-telehealth group.

**Conclusion:** The use of an integrated, clinician-focused telehealth monitoring system can substantially reduce the 30-day probability of hospitalization for home healthcare patients. Telehealth monitoring systems that integrate skilled clinicians can lead to substantial hospitalization-related cost savings.

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For author information and disclosures, see end of text.

The demand from Medicare beneficiaries for home healthcare is increasing. Approximately 3.2 million Medicare beneficiaries received home health services in 2008, which translated into \$17 billion in expenditures for the Medicare program.<sup>1</sup> Yet, despite the increased demand, the hospitalization rate for home healthcare patients has remained near 30% since 2004, which leads to substantial costs for the Medicare program.<sup>1</sup> Given the high hospitalization rate, the Medicare Payment Advisory Commission has recommended that the Medicare program pay home health agencies using performance-based quality measures.<sup>2</sup> For both home health agencies and Medicare administrators, the problem of how to reduce hospitalization rates to improve quality of care for home healthcare patients continues to be a significant challenge. Moreover, provisions in the Patient Protection and Affordable Care Act (PPACA) of 2010—which call for the development and adoption of value-based and bundled payment systems—will require new community-based health management approaches to reduce hospitalization rates and deliver high-quality, patient-centered care.<sup>3</sup>

Telehealth (“The use of telecommunications and information technology to provide access to health assessment, diagnosis, intervention, consultation, supervision and information across distance<sup>4</sup>”) is a promising solution for cost-effective disease management. There are many different types of telehealth monitoring systems. Most of them include a remote monitoring device to track patient clinical conditions, a transmission system to deliver data from patients to healthcare professionals for assessment and interpretation, and a communication tool (ie, a telephone) to provide consultation or follow-up.

Several studies have used a randomized or pretest and posttest study design to evaluate the effectiveness of telehealth monitoring systems in reducing rehospitalization rates for chronic health conditions, but these studies provided inconclusive findings.<sup>5-17</sup> Meta-analyses have also been conducted to evaluate the effect of telehealth on health outcomes for chronic obstructive pulmonary disease, diabetes, and heart failure. Outcome measures have included hospitalization rates, emergency department visits, mortality, quality of life, and the control of glycosylated hemoglobin (in the case of diabetes). In general, the findings from these studies are consistent with the idea that the use

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of telehealth reduces hospitalization rates, but these studies also show wide variation in the types of telehealth systems and interventions adopted.<sup>18-22</sup> The results from these studies are also difficult to generalize to broad populations. Furthermore, home healthcare patients are referred by physicians and may not be discharged from the hospitals. Whether the use of telehealth reduces the frequency of hospitalization is becoming an increasingly relevant question given the observed increases in the demand for home healthcare services.

The purpose of this study was to examine the effect of an integrated, clinician-focused telehealth monitoring system on the probability of hospitalization within the first 30-day episode of home health services. The study sample included 2009 data from 5873 Medicare beneficiaries receiving home health services through a network of community-based home health agencies operating in the states of Texas and Louisiana. Beginning in 2006, this network implemented a telehealth monitoring system (VitalPartners 365) to track patients' clinical conditions, monitored by skilled registered nurses or registered respiratory therapists who have at least 2 years of experience in the critical care unit of an acute care hospital. A registered nurse assesses each patient's condition within 48 hours after referral by the physician. Then the nurse decides whether telehealth monitoring is appropriate for each patient based on whether patients or their caregivers are able to mentally or physically perform the test from the monitoring device, whether patients have psychiatric disorders or are combative, whether they refuse to use telehealth monitoring, and whether the patient's residence is unsafe.

The telehealth monitoring system at the network of community-based home health agencies we studied includes a remote monitoring device that is placed at each patient's residence, a transmission system that transfers patients' clinical data to the monitoring center at a predetermined time in order to obtain clinical data at the same time each day for monitoring, and a communication system through a standard phone line or a wireless adapter that allows clinicians to communicate with patients and/or their caregivers when necessary. The monitoring device tracks each patient's blood pressure, heart rate, body weight, and oxygen saturation levels. It also has options for a glucometer and a peak flow meter depending on the needs of each individual patient. The monitoring system reminds patients to check their vital signs and helps patients to maintain compliance with their treatment. The clinical data are reviewed by clinicians and if a patient fails to follow the appropriate schedule to check his or her vital signs, then the patient is

### Take-Away Points

An integrated, clinician-focused telehealth monitoring system was effective in reducing the hospitalization rate for Medicare home healthcare patients within the first 30-day home health episode.

- Propensity score matching was used to match patients in telehealth and non-telehealth groups using caliper matching (0.15) without replacement.
- After matching, the hospitalization rate in the non-telehealth group was 7 percentage points higher than the rate in the telehealth group.
- Telehealth monitoring systems that integrate skilled clinicians can lead to substantial hospitalization-related cost savings.

contacted by an administrative person who determines the reason for nontesting and coordinates for retesting. If nontesting is a clinical issue or the results are abnormal, a registered nurse or registered respiratory therapist will assess the patient's condition and provide timely intervention when necessary. In 2009, this network of home health agencies served approximately 1800 Medicare beneficiaries with this telehealth monitoring system.

## METHODS

### Data and Study Design

The current study used a database from a private network of community-based home health agencies as discussed previously. The study design is a retrospective, nonexperimental design, with the patient as the unit of analysis. Propensity-score matching was used to control for selection bias. Logistic regression and postestimation parameter simulation were then used to assess how the telehealth monitoring system might affect the probability of hospitalization during the first 30-day episode of home healthcare. The study sample was composed of Medicare beneficiaries who received home health services. Following previous studies,<sup>23,24</sup> we focused on Medicare patients who were 65 years or older because Medicare patients who are younger than 65 years are often either disabled or have end-stage renal disease; thus, their health needs may be different from those of conventional Medicare patients. Although the Medicare program defines a home health episode as 60 days, patients can receive more than 1 episode of home health services.

We focused on the first 30 days of their first episode of home healthcare for several reasons. First, the majority of home healthcare users are Medicare patients who are likely to have been discharged from hospitals.<sup>25</sup> Rehospitalization costs about \$12 billion a year for the Medicare program, yet 76% of rehospitalizations within 30 days of hospital discharge are preventable through careful follow-up<sup>2</sup>; thus, the hospitalization rate within the first 30 days of the first episode for home care patients presents a significant opportunity for improvement. Second, PPACA calls for greater

accountability of healthcare organizations and hospitals, which will ultimately receive payment reductions if their rehospitalization rate within 30 days is relatively high. Thus, reducing the rehospitalization rate within this period is a key concern not only for the Medicare program, but also for hospitals. Additionally, home health agencies are paid by the episode, adjusted by patients' case-mix weight. If patients receive fewer than 5 skilled visits and are discharged from the home health agency during that episode, home health agencies receive a low utilization payment adjustment from the Medicare program, which pays per visit. The payment amount based on a low utilization payment adjustment is less than the amount based on an episode.<sup>26</sup> As such, the results from this study provide important insights for the Medicare program, home health agencies, and even hospitals.

This study was approved by the Institutional Review Board at University of North Texas Health Science Center.

### Statistical Approach

The dependent variable was dichotomous—whether patients experienced hospitalization within the first 30-day episode of home healthcare. The primary variable of interest was a dummy variable that represented whether a patient used a telehealth monitoring system (coded as 1 if a patient used a telehealth monitoring system and coded as 0 otherwise).

Logistic regression was used for the analysis. Given that patients were assigned to the telehealth or non-telehealth groups based on clinical assessments rather than through random selection, the analytical model was augmented using propensity score matching to take into account the possibility of selection bias.<sup>27-30</sup> The propensity score was the likelihood of a patient being assigned to the telehealth group based on patient conditions, capability of using a remote monitoring device, and patient characteristics. Each patient's primary diagnosis, whether he/she was hospitalized in the 14 days before receiving home healthcare, and the case-mix weight were used as proxy variables for the patient's clinical needs in the propensity-score matching model. The primary diagnosis was included as a set of dummy variables for Alzheimer's disease, cardiac disease, hypertension, chronic obstructive pulmonary disease, and other health conditions that require home healthcare (eg, care for patients after surgery, burn care). Past hospitalization was also coded as a dummy variable (1 if the patient was hospitalized within the 14 days before receiving home healthcare and 0 otherwise). A case-mix weight for an individual patient was a function of clinical conditions such as pain or multiple pressure ulcers, functional status such as

dressing and toileting, and expected service utilization such as the number of therapy visits.<sup>31</sup> A higher case-mix weight meant that the patient required more resources from home health services.

Patient age and a dummy variable for whether patients lived alone were used as proxy variables for the ability to use a remote monitoring device. For instance, patients who are younger are more likely to be capable of using a remote monitoring device than patients who are older. Additionally, patients who live with caregivers are more likely to receive help from them; thus, these patients may be more likely to use a remote monitoring device than patients living without caregivers. Finally, patient characteristics such as sex and race/ethnicity were included because these characteristics are likely to be related to differences in preferences for the use of telehealth monitoring systems.

A propensity score was constructed for each patient and was then used to match patients in the telehealth and non-telehealth groups using caliper matching (0.15) without replacement.<sup>32,33</sup> Postestimation parameter simulation was used to quantify how the use of the telehealth monitoring system was related to the probability of hospitalization. Statistical simulation allowed for the consideration of both estimation uncertainty (not knowing the exact values of the parameters in the logistic regression model) and fundamental uncertainty (the stochastic component of the logistic regression model). The first step was to draw 1000 samples from a multivariate normal distribution with a mean equal to the vector of estimated parameters and the variance equal to the variance-covariance matrix. Antithetical simulations were used to ensure that the mean of the simulated parameters was equal to the estimated parameters obtained from the logistic regression model.<sup>34</sup> The effect of the telehealth monitoring system was analyzed by setting the value of the binary variable of telehealth to 0 and 1, and then generating 1000 probability estimates. The median difference in the probability estimates was used to obtain the estimated effect of the telehealth monitoring system on the probability of hospitalization. The 1000 probability point estimates also were used to generate 95% confidence intervals by sorting these estimates from lowest to highest and using the 25th and 75th values as lower and upper bounds.

## RESULTS

The total number of Medicare patients whose date of start for home health services fell in 2009 was 6947. In order to reduce potential bias due to measurement error, we excluded from the study the observations with missing values for sex and out-of-range values for case-mix weight (the

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lowest case-mix weight was 0.5827 and the highest case-mix weight was 3.4872). After excluding 1074 observations, the total number of observations was 5873 before data were matched: 1349 patients in the telehealth group and 4524 patients in the non-telehealth group. After propensity score matching, the telehealth and non-telehealth groups both included 1349 patients.

**Table 1** presents the variables before matching. The differences in sample means between the telehealth and non-telehealth groups for age, sex, race/ethnicity, and whether patients lived alone were not statistically significant ( $P > .05$ ). The numbers of patients who were hospitalized within 14 days before they received home healthcare were significantly different between the telehealth and non-telehealth groups ( $P < .01$ ). For chronic health conditions, patients with heart disease and chronic obstructive pulmonary disease were more likely to be in the telehealth group ( $P < .01$  for both health conditions), which has been commonly found in the literature.<sup>5-16</sup> On the other hand, patients with Alzheimer's disease were less likely to use telehealth ( $P < .01$ ). It may be that many Alzheimer's patients are not able to appropriately use the remote telehealth monitoring device unless they live with caregivers. Additionally, patients with other health conditions were less likely to use the telehealth monitoring system. Most patients included in this group had nonchronic health conditions and only required services such as physical therapy after hip surgery or wound care; thus, this group of patients were less likely to need a telehealth monitoring system. There were no statistically significant differences in the proportions of patients with hypertension or diabetes between the telehealth and non-telehealth groups ( $P > .05$ ).

After propensity score matching, the differences between the telehealth and non-telehealth groups with respect to patient characteristics, whether patients lived alone, whether patients experienced hospitalization within the 14 days prior to home healthcare, case-mix weight, and all chronic health conditions became statistically insignificant, as shown in **Table 2** ( $P > .05$ ). Thus, the telehealth and non-telehealth groups were comparable in terms of the observable characteristics included in the study.

**Table 3** presents the results from the postestimation parameter simulation—based on a logistic regression model—for the

**Table 1. Descriptive Statistics for the Telehealth and Non-Telehealth Groups Before Matching**

Variable	Telehealth (n = 1349)		Non-Telehealth (n = 4524)		P (t test or $\chi^2$ test)
	Mean	SD	Mean	SD	
Age, y	78.70	7.56	78.53	7.95	.49
Female, %	65.23	47.64	64.68	47.80	.71
White, %	69.24	46.17	67.02	47.02	.13
Live alone, %	28.17	45.00	27.54	44.68	.65
Case-mix weight	1.84	0.90	1.63	0.82	<.01
Past hospitalization, %	54.26	49.84	49.62	50.00	<.01
Alzheimer's disease, %	0.90	9.39	2.54	15.74	<.01
Heart disease, %	35.87	47.98	16.75	37.35	<.01
Hypertension, %	15.57	36.27	16.40	37.03	.47
Diabetes, %	11.05	31.36	12.16	32.68	.27
Chronic obstructive pulmonary disease, %	13.27	33.94	6.85	25.27	<.01
Other, %	23.35	42.32	45.29	49.78	<.01

matched samples. The probability of hospitalization for the non-telehealth group was 0.17 and for the telehealth group it was 0.10. The difference between these 2 groups indicates that the hospitalization rate in the telehealth group was 7 percentage points lower than the rate in the non-telehealth group (or 41% relative change), and this difference is statistically significant (95% confidence interval 4.2, 9.4).

In addition to the hospitalization rate, we estimated a model to assess the factors that were related to home visits for non-telehealth group participants, and then predicted the number of home visits for telehealth participants based on the estimated parameters for the non-telehealth participants. We compared the difference between the actual and the predicted number of home visits. The difference between the actual and predicted visits was only about 1 additional visit (ie, 10 actual vs 9 predicted visits).

## DISCUSSION

After propensity-score matching, our results indicate that Medicare patients in the telehealth group had a probability of hospitalization about 7 percentage points lower than that in the non-telehealth group, which is consistent with the findings of meta-analysis studies indicating that the use of telehealth reduces the hospitalization rate for patients with several chronic health conditions. Although the number of home health visits in the telehealth group was slightly higher than what would be expected, the cost savings from reducing hospitalizations in the telehealth group were still high,

■ **Table 2.** Descriptive Statistics for the Telehealth and Non-Telehealth Groups After Matching

Variable	Telehealth (n = 1349)		Non-Telehealth (n = 4524)		P (t test or $\chi^2$ test)
	Mean	SD	Mean	SD	
Age, y	78.70	7.56	78.91	7.64	.48
Female, %	65.23	47.64	64.68	47.50	.81
White, %	69.24	46.17	69.34	46.11	.93
Live alone, %	28.17	50.00	28.47	45.14	.86
Case-mix weight	1.84	0.90	1.84	0.90	.82
Past hospitalization, %	54.26	49.84	53.89	49.87	.85
Alzheimer's disease, %	0.89	9.39	0.82	9.00	.83
Heart disease, %	35.88	47.98	34.91	47.69	.60
Hypertension, %	15.57	36.27	17.27	37.81	.23
Diabetes, %	11.05	31.36	9.79	29.72	.28
Chronic obstructive pulmonary disease, %	13.27	33.94	14.31	35.03	.43
Other, %	23.35	42.32	22.91	42.04	.78

eralized to other home health agencies with different organizational structures. Further research is needed on multiple home health agencies that use telehealth monitoring systems in different organizational contexts. Second, the study focused on hospitalization within the first 30-day episode of home healthcare. As a result, the findings from this study should not be generalized to home health episodes beyond the first 30 days. Third, due to the lack of data, no conclusions could be drawn about whether or not the reported hospitalizations were preventable. Finally, the propensity score matching performed was based only on observed variables. Other un-

measured factors such as patient education might affect the results based on propensity score matching. This possibility warrants further investigation.

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■ **Table 3.** Difference in the Probability of Hospitalization Between the Telehealth and Non-Telehealth Groups in the Matched Samples

Postestimation Parameter Simulation	Probability (95% Confidence Interval)
Pr (telehealth = 0)	0.17 (0.15 - 0.19)
Pr (telehealth = 1)	0.10 (0.09 - 0.12)
Pr (telehealth = 0) – Pr (telehealth = 1)	0.07 (0.04 - 0.09)



tiveness of telehealth monitoring systems for home healthcare patients relies on a small number of home health agencies because the data simply are not available. The Centers for Medicare and Medicaid Services regularly collects information from home health agencies such as the address of the agencies and information on each Medicare beneficiary who receives home health services. Expanding this database to include an indicator for the use and type of telehealth monitoring devices in place would be beneficial for quality improvement efforts.

Furthermore, the types of telehealth monitoring systems and how they are used vary in the literature, which makes it difficult to compare findings across studies.<sup>18-22</sup> Study of the taxonomy of telehealth monitoring systems and comparison of different types of systems (and how they are used in practice) are recommended. All telehealth monitoring systems are not the same; and even if they were similar, they are used very differently by each healthcare provider. This may explain the mixed findings in the literature regarding the effectiveness of different systems.<sup>35</sup> Providing these types of detailed data will allow for the design of studies to determine which types of telehealth monitoring systems are relatively more or less effective, which will ultimately result in quality improvements in clinical practice and management for home healthcare patients.

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**Authorship Information:** Concept and design (HFC, JAP); acquisition of data (HFC, MCK); analysis and interpretation of data (HFC, JAP); drafting of the manuscript (HFC, JAP); critical revision of the manuscript for important intellectual content (MCK); statistical analysis (HFC); and administrative, technical, or logistic support (MCK).

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