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An Integrated, Clinician-focused Telehealth Monitoring System to Reduce Hospitalization Rates for Home Health Care Patients with Diabetes

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Abstract

Diabetes is one of the leading causes of death and disability in the United States, and hospitalization rates related to this health condition are high and costly to the United States health care system. The purpose of this study was to examine the effect of an integrated, clinician-focused telehealth monitoring system on the probability of hospitalization for home health care patients with diabetes. The study included 2009 data from 699 Medicare beneficiaries receiving home health services in Texas and Louisiana. Propensity score matching, logistic regression, and post-estimation parameter simulation were used to assess how telehealth affects the probability of hospitalization during the first 30 days of home health care. The 30-day hospitalization probability for telehealth and non-telehealth patients was 7% and 19%, respectively. Patients in the telehealth group had a 12 (95% confidence interval = 4.2-20.3) percentage point-lower probability of hospitalization within the first 30 days of home health care than non-telehealth matched patients. The results suggest that telehealth monitoring systems that integrate skilled clinicians with critical care experience can lead to substantially lower hospitalization rates during the first 30 days of home health care, large cost savings, and more effective home health management of patients with diabetes.

Keywords

community health, disease management, health outcomes, managed care, primary care

Diabetes is one of the leading causes of death and disability in the United States, and about 20% of hospitalized patients with diabetes are readmitted to a hospital within 30 days after discharge because of complications.[1] The probability of developing serious complications that may result in preventable hospitalization can be reduced through comprehensive disease management regimens, which include diet, exercise, medication management, and blood sugar and hemoglobin A1c monitoring.[2]

There were about 3.2 million Medicare beneficiaries who used home health care in 2008, with diabetes being one of the high-volume diagnoses.[3,4] Home health clinicians provide home-based care to patients during visits. Home health care services are also partially coordinated through primary care providers, and these services are consistent with the provision of longitudinal, whole-person care.[5] Many primary care providers and patient-centered medical homes see home health care services as an integral part in the continuum of care, and they refer patients to telehealth-delivered programs when they are available and appropriate.[6] Thus, well-designed telehealth programs potentially can support physician efforts of providing high-quality, community-based care throughout the continuum of care. Primary care doctors who rely on telehealth programs that have been shown to be effective can really have an effect on increasing health care quality while keeping health care system costs in check by reducing hospitalization rates.

Given that the health status of many patients changes between home health visits, timely intervention would be very difficult without continuous monitoring and may increase the risk of hospitalization. The purpose of this study is to examine the effect of an integrated, clinician-focused telehealth monitoring system on the probability of hospitalization for diabetes patients during the first 30 days of home health care.

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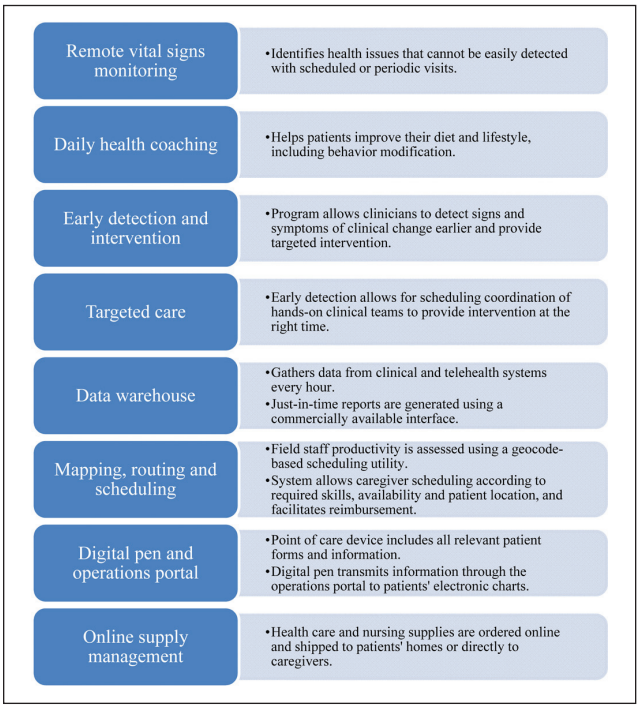

Figure 1. Telehealth monitoring system: main elements.

Research Design and Methods

The data for this study come from a network of home health agencies operating in communities in Texas and Louisiana. In 2006, this network implemented a telehealth system that includes—among other elements—a remote monitoring device (to track patients' vital signs), a transmission system (to transfer clinical data to a monitoring center), and a communication system (see Figure 1). The device reminds patients to check vital signs daily, verbally and visually. If patients do not follow the assigned schedule to check their vital signs, they are contacted by an administrative support person who evaluates the reason for nontesting and coordinates retesting. If the clinical data for a given patient are abnormal, a clinical specialist with critical care experience contacts the patient and/or his/her caregiver to assess the patient's condition and to provide timely intervention when necessary.

The analysis presented here is based on a retrospective, nonexperimental design. The study included 2009 data from 699 Medicare beneficiaries with diabetes who received services within the first 30 days of a 60-day episode of home health care. A dichotomous dependent variable was created to identify whether or not diabetes patients experienced hospitalization within the first 30 days of home health. The primary variable of interest is whether or not patients used telehealth monitoring.

Given that patients were assigned into the telehealth/non-telehealth groups based primarily on clinical assessments, propensity score matching was used to account for selection bias.[7-11] The propensity score is the likelihood of a patient being assigned to the telehealth group based on his/her clinical needs including the variable for patient's case-mix weight,[12] the patient's capability of using a remote monitoring device (measured by whether or not the patient lived alone and age) and sex and race/ethnicity for other patient characteristics. The propensity score was constructed for each patient and then used to match patients in the telehealth and non-telehealth groups using caliper matching without replacement.[10,13]

Logistic regression and post-estimation parameter simulation were used to investigate how the use of telehealth was related to the probability of hospitalization. Statistical simulation allows for the consideration of estimation and fundamental uncertainty. One thousand samples were drawn from a multivariate normal distribution, with a mean equal to the vector of estimated parameters (from a logistic regression) and the variance equal to the variance-covariance matrix.[14,15] The effect of telehealth was analyzed by setting the value of the telehealth binary variables to 0 (and 1) and then generating 1000 probability estimates. The median of the difference in the probability estimates was used to obtain the estimated effect of telehealth on hospitalization.

Results

Table 1 presents the descriptive statistics for the telehealth and non-telehealth groups of Medicare beneficiaries with diabetes before and after conducting propensity score matching. The number of Medicare beneficiaries with diabetes in 2009 was 699 (149 patients in the telehealth group and 550 patients in the non-telehealth group). The mean age for patients in the telehealth group compared to those in the non-telehealth group was 76 years and 77 years, respectively. The percentage of whites in the telehealth group compared to those in the non-telehealth group was 56% and 51%, respectively. About 68% of patients in the telehealth group were women, compared to 63% in the non-telehealth group. The percentage of patients who lived alone in the telehealth group compared to those in the non-telehealth group was 33% and 25%, respectively. The case mix weight was 1.92 for patients in the telehealth group, compared to 1.56 for patients in the non-telehealth group.

Before propensity score matching, the mean case-mix weights were significantly different between the telehealth and non-telehealth groups ($P < .001$). After propensity score matching, the mean telehealth/non-telehealth group differences for case-mix weights became statistically insignificant ($P = .98$).

Table 2 presents the results from the post-estimation parameter simulation. In the unmatched data, the probability of hospitalization in the non-telehealth group and telehealth group was 0.201 and 0.071, respectively. The difference in the probability of hospitalization between the two groups was 0.130 (95% confidence interval [CI] = 0.064-0.182). After matching, the probability of hospitalization for

Table 1. Descriptive Statistics for Telehealth and Non-Telehealth Groups before and after Matching

Variables	Telehealth		Non-telehealth		*P* value (*t* test or χ^2 test)
	Mean	Standard deviation	Mean	Standard deviation	
Before matching					
Age (y)	75.93	7.05	76.65	7.31	.270
Female	0.68	0.47	0.63	0.48	.258
White	0.56	0.50	0.51	0.50	.281
Live alone	0.33	0.47	0.25	0.44	.086
Case mix weight	1.92	0.92	1.55	0.77	<.001
No. of observations	149		550		
After matching					
Age (y)	75.93	7.05	76.37	7.19	.598
Female	0.68	0.47	0.68	0.47	.901
White	0.56	0.50	0.56	0.50	.907
Live alone	0.33	0.47	0.33	0.47	1.00
Case mix weight	1.92	0.92	1.92	0.90	.980
No. of observations	149		149		

Table 2. Differences in the Probability of Hospitalization for Diabetes Patients between Telehealth and Non-Telehealth Groups

Post-estimation parameter simulation	Probability [95% CI]
Unmatched data	
Pr (Telehealth = 0)	0.201 [0.168 to 0.236]
Pr (Telehealth =1)	0.071 [0.036 to 0.123]
Pr (Telehealth = 1)	–0.130 [–0.182 to –0.064]
Pr (Telehealth = 0)	
Matched data	
Pr (Telehealth = 0)	0.190 [0.131 to 0.261]
Pr (Telehealth =1)	0.070 [0.036 to 0.122]
Pr (Telehealth = 1)	–0.120 [-0.203 to –0.042]
Pr (Telehealth = 0)	

Abbreviations: CI, confidence interval.

the non-telehealth group becomes 0.190 and the difference in the probability of hospitalization between the telehealth and non-telehealth groups is 0.120 (95% CI = 0.042-0.203), indicating that the use of telehealth is associated with a 12-percentage-point (or 63% relative change) lower probability of hospitalization for home health patients with diabetes.

Conclusions

The telehealth monitoring system evaluated here is associated with a 12-percentage-point reduction (or 63% relative change) in the 30-day hospitalization probability for home health care patients with diabetes. The use of an integrated, clinician-focused telehealth system seems to benefit not only Medicare beneficiaries with diabetes, but also the health care system by reducing the use of inpatient services. Given that home health care services are partially coordinated through primary care providers, integrated, clinician-focused telehealth systems that are appropriately designed for the unique needs of local/specific populations—as was the case here with Medicare beneficiaries with diabetes—can really have an effect on reducing health care system cost and improving community health. Home health care services that effectively integrate telehealth through the continuum of care could be a key part in the provision of longitudinal, whole-person care. Well-designed telehealth programs can potentially support patient-centered medical homes and accountable care organizations and, thereby, facilitate the delivery of high-quality, community-based care.

There are several limitations to our study. First, one should be cautious when generalizing the findings of this study to home health agencies with telehealth monitoring systems operating under other organizational structures. Second, the propensity score matching performed was based only on observed variables and, as such, unmeasured factors (eg, patient education) may affect the results.

Despite these weaknesses, the results reported here are consistent with the idea that telehealth monitoring systems that integrate skilled clinicians with critical care experience can lead to lower hospitalization rates, substantial cost savings, and more effective disease management for diabetes patients.[16] These systems can substantially help to improve home health and chronic disease management, but, to be successful, they require substantial investments in technology, human resources, and, overall, a willingness to innovate and embrace change. Another important lesson learned is that all the elements of effective home health and chronic disease management need to be reengineered (ie, identified

and broken down into processes). Unbundling allows for the adoption of different components of a system according to need, and for the substitution of each element as they become obsolete and need to be replaced with new approaches or technologies that continuously improve health care delivery.

Declaration of Conflicting Interests

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References

1. Robbins JM, Webb DA. Diagnosing diabetes and preventing rehospitalizations: the urban diabetes study. *Med Care* 2006;44: 292-296.
2. American Diabetes Association. Standards of medical care in diabetes—2010. *Diabetes Care*. 2010;33 Suppl 1:S11-61.
3. Medicare Payment Advisory Commission. Healthcare Spending and the Medicare Program [book online], 2010. http://www.medpac.gov/documents/Jun10DataBookEntireReport.pdf, Accessed December 19, 2010.
4. National Association for Home Care & Hospice. Basic statistics about home care [article online], 2008. http://www.nahc.org/facts/08HC_Stats.pdf. Accessed December 19, 2010.
5. Pham HH. How will the patient-centered medical home relate to the rest of the health-care delivery system? *J Gen Intern Med*. 2009;25:630-634.
6. Health Affairs and Robert Wood Johnson Foundation. Patient-Centered Medical Homes. Health Policy Brief Number 25. September 14, 2010. http://www.healthaffairs.org/healthpolicybriefs/brief_pdfs/healthpolicybrief_25.pdf. Accessed December 19, 2010.
7. Rosenbaum P, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika*. 1983;70:41-55.
8. Rubin DB. Series on statistics: Propensity score methods. *Am J Ophthalmol*. 2010;149:7-9.
9. Rubin DB. The design versus the analysis of observational studies for causal effects: parallels with the design of randomized trails. *Statist Med*. 2007;26:20-36.
10. Perraillion MC. Matching with propensity score to reduce bias in observational studies [article online], 2010. http://www.nesug.org/proceedings/nesug06/an/da13.pdf. Accessed July 15, 2010.
11. Bleich SN, Cutler DM, Adams AS, Lozano R, Murray CJL. Impact of insurance and supply of health professionals on coverage of treatment for hypertension in Mexico: population based study. *BMJ*. 2007;355:875-882.
12. Medicare Payment Advisory Commission. Home Health Care Services Payment System. Washington, DC:MedPAC. 2009. http://www.medpac.gov/documents/MedPAC_Payment_Basics_09_HHA.pdf. Accessed November 3, 2010.
13. Austin PC. Statistical criteria for selecting the optimal number of untreated subjects matched to each treated subject when using many to one matching on propensity score. *Am J Epidemiol*. 2010;172:1092-1097.
14. Stern S. Simulation-based estimation. *J Econ Lit*. 1997;35: 2006-2039.
15. Tomz M, Wittenberg J, King G. Clarify: software for interpreting and presenting statistical results. *J Stat Software*. 2003;8:1-15.
16. Centers for Medicare and Medicaid: Telehealth. https://www.cms.gov/Telemedicine. Accessed December 19, 2010.

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