TEMPUS *Healthcare*

Tailored Electronic Monitoring Programs for the US

TEMPUS *Healthcare's* Mission

The mission for TEMPUS *Healthcare* is to improve healthcare delivery and reduce costs for patients through our Remote Patient Monitoring Program. We focus on delivering efficient, expert, and cost effective care for patients with or at risk for Congestive Heart Failure, Chronic Obstructive Pulmonary Disorder & Diabetes.

TEMPUS *Healthcare* Description of Provided Services

TEMPUS *Healthcare* uses sophisticated monitoring devices in the client's home. With the care management team's guidance the patient takes their vital signs and the device automatically downloads the readings to TEMPUS *Healthcare's* advanced computerized platform (TOpS). Their care management team of clinicians will observe the vital signs on a daily basis and determine if they are in line with the expected protocols by utilizing the TOpS platform. If TEMPUS Healthcare does not receive vital signs within a specific time frame based their care plan, we call the client and give them a friendly reminder to take their vital signs.

If necessary, the care management professionals will coordinate the care through the assistance of a home care provider in communication with the primary care provider. This procedure should reduce or even avoid hospitalization and emergency room visits of the patient.

TEMPUS *Healthcare's* daily monitoring ensures that the patient receives quality care at a cost efficient rate.

TEMPUS Telehealth addresses all phases of the disease state

Prevention

Acute Phases

Remission

Recurrences

Maintenance

TEMPUS *Healthcare* will assist in the care transition from Hospital to Home. This initiative focuses on ensuring that patients experience a safe, reliable, high quality transitions between all settings that will drive positive patient satisfaction and clinical outcomes.

TEMPUS Healthcare

235 Noah Drive – Franklin – TN – 37067

www.tempushealthcare.com

Provider and Staff Benefits

- Customizable to meet specific disease/chronic management needs
- Complete, objective and subjective data is available upon request
- Allows for pre-emptive care, supporting adjustments to treatment plan or medications
- Reinforces education and compliance to treatment plan
- Breaks the cycle of emergency care and hospital re-admissions
- Supports documentation of time spent for care plan oversight

Discharge Planning Benefits

- For hard-to-place "discharges" that are fragile, non-compliant or without a support system
- Reduces repeat ER visits or hospitalizations

Recommended Criteria for Daily In-Home Health Monitoring Include Patients With…

- Recent hospitalization or ER Visit
- Any condition requiring frequent monitoring or trending of health status information to facilitate clinical management
- Individuals that can avoid admission to alternative living facilities if monitored at home
- History of poor compliance with diet, medication, or self-monitoring

Individual Patient Family Benefits

- Acts as an educational tool to reinforce medication use and diet restrictions
- Encourages patient self-management by reinforcing positive behavior and lifestyle changes
- Tracks and reinforces compliance with treatment plan
- Provides sense of security for users and families through daily monitoring
- Care provided based on their clinical need
- Facilitates patient and caregiver participation in the plan of care, producing better maintainable outcomes

Honeywell HomMed

Product Overview

Genesis DM™

Overview

With its robust feature set, the Genesis DM provides complete remote biometric and symptom evaluation. The Genesis DM seamlessly supplies this information to the LifeStream Management Suite, which provides a single, consolidated view of patient information organized in a way that allows care providers to more effectively monitor patients resulting in more informed clinical decision making.

Voice-Enabled Disease-Specific Symptom Management (DSSM) Modules

- On-demand access through the LifeStream software
- Customizable by diagnosis and disease state.
- Facilitates management of multiple conditions, such as hypertension, COPD, CHF, diabetes, and high-risk pregnancy-related conditions.

Ease of Use

- Automatic download of DSSM content, updates and prompts.
- Optional wireless GPRS connectivity enhances communications.
- Security and encryption provides data protection.

Web-Enabled

- Clear auditory and visual user cues.
- Enhanced interface offers easy set up and adjustment.
- Fast transfer between patients.
- Reminders to help patients track appointments and other events.

Personal Health Device Promotes Stability, Safety, and Confidentiality

- Benefit from rigorous testing for improved usability.
- Provide a dedicated, secure, and private health device to foster HIPAA compliance.
- Leverage a stable, controlled interface for protection against viruses.

To address the needs of a diverse patient population, Honeywell HomMed now offers two patient monitors that work seamlessly with LifeStream™ — the Genesis™ DM and the Genesis Touch™.

Honeywell
HomMed

Specifications

Genesis DM

The Honeywell HomMed Genesis DM Pro/DM Pro BP monitor is a Class II, type BF device that collects and records defined vital signs and uploads the data to the LifeStream Management Suite via a communication network.

Peripheral Medical Devices

The following peripheral medical devices are available for the Genesis DM System:

- Honeywell HomMed Blood Pressure (built in)
- Honeywell HomMed Pulse Oximeter (wired)
- Honeywell HomMed scale (wired and wireless (Bluetooth)).

Honeywell HomMed offers wired interface cables for the following peripheral medical devices, which are able to interface with the Genesis DM System:

- Glucose Meters:
  - Bayer
    - Ascensia Breeze®
    - Ascensia Breeze2®
    - Ascensia Contour®
    - Ascensia Elite XL®
  - Home Diagnostics, Inc.
    - Prestige IQ®
    - TrueTrack Smart System®
  - LifeScan
    - One Touch Basic®
    - One Touch Profile®
    - One Touch Ultra®
    - One Touch Ultra InDuo®
    - One Touch Ultra2®
  - Roche
    - ACCU-CHEK Advantage®
    - ACCU-CHEK Aviva®
    - ACCU-CHEK Compact™ Plus
- Ferraris Piko-1 Peak Flow Meter
- Prothrombin meters
  - ITC ProTme Microcoagulation System ®
  - Hemosense InRatio
- Exergen Temporal Thermometer

Languages

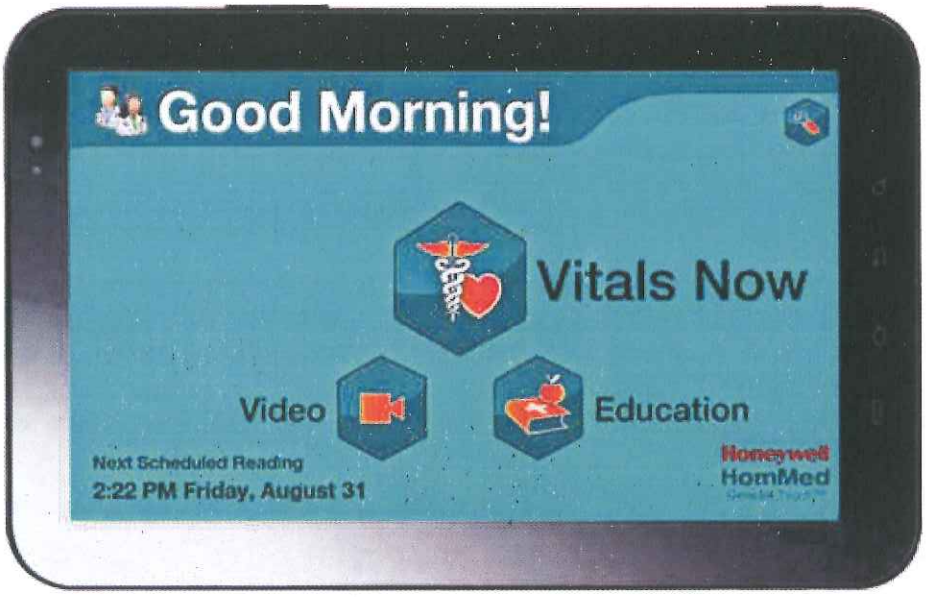
- Clinician: US English, Dutch, Canadian French
- Patient: Menu selectable; standard is US English Audio (Male and Female voice) and Text

UK English	Portuguese	Armenian	Polish
Italian	German	Spanish	Russian
French	Canadian French	Hindi	Welsh
Urdu	Bengali	Punjabi	Dutch

Honeywell
HomMed

Product Overview

Genesis Touch™



Experience the Power of Touch!

Overview

With its robust feature set, the Genesis Touch leverages an Android-based tablet platform that offers patients an intuitive, consumer-based interface providing access to a full range of LifeStream™ applications, services, and devices. This FDA-cleared personal health device revolutionizes how care givers interact with patients by enabling simple, video-based communication in addition to traditional telemonitoring.

Improved Patient Interaction

- Enhance patient oversight with a simple, integrated video application for face-to-face contact, enabling additional symptom evaluations, and lowering the cost of interacting with remote patients.
- Augment care giver and physician interaction by increasing visibility to patient health status with video calls that allow for up to 100 audio participants.
- Leverage a more interactive environment to improve educational effectiveness through easy call recording and playback.
- Facilitate broad video adoption with cost-effective licensing structure and simplified video license management for patients.

Honeywell
HomMed

Enhanced Ease of Use

- Improve patient compliance and adoption with simple, intuitive user interface.
- Minimize set-up and installation times when devices are paired in advance with Blue Tooth peripherals that require no physical wiring within the patient's residence.
- Streamline workflows with fully compatible clinical libraries.
- Enable care providers to facilitate patient flexibility by determining whether biometric acquisition is scheduled or patient-reported.
- Leverage simple communications options for fully integrated WiFi and cellular connectivity with support for 3G/4G and WiFi.
- An innovative platform that enables extensibility and interoperability with the LifeStream Management Suite.

Platform for Innovation

- Enhanced mobility promotes an active patient lifestyle and improves patient compliance and adoption by allowing the device to be used where the patient is – whether in bed or out and about.
- Leverage the Android OS to onboard solutions and services that address the full care continuum - from disease management to health and wellness coaching.
- Customize your patient's experience from biometrics collection to language and patient-specific education.

To address the needs of a diverse patient population, Honeywell HomMed now offers two patient monitors that work seamlessly with LifeStream™ — the Genesis™ DM and the Genesis Touch™.

FDA-Cleared Personal Health Device Promotes Stability, Safety, and Confidentiality

- Benefit from rigorous testing for improved usability.
- Provide a dedicated, secure, and private health device to foster HIPAA compliance.
- Leverage a stable, controlled interface for protection against viruses.
- Enhance device integration with a seamless, pre-configured Bluetooth interface.

Specifications

Genesis Touch

Genesis Touch leverages a Samsung Galaxy Tab™ 7.0 platform with 2.3 OS, 3G and Wi-Fi capability.

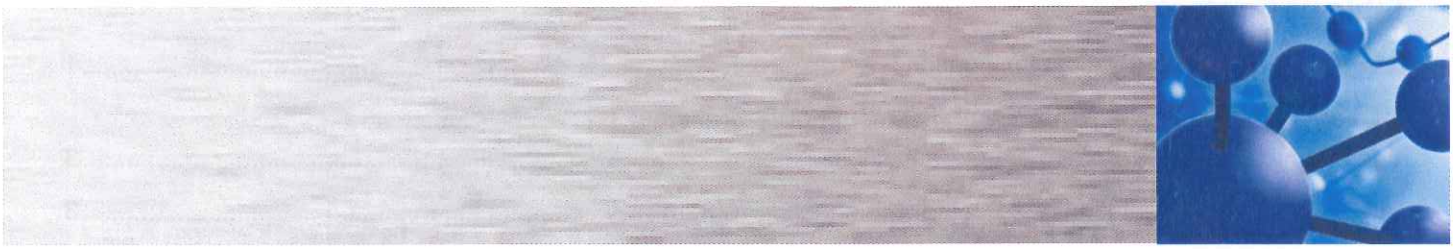
Peripheral Medical Devices

The following Bluetooth peripheral medical devices are available for use with the Genesis Touch System:

- Honeywell HomMed scale.
- A&D Precision Health scale.
- ChoicemMed Fingertip Pulse Oximeter (FDA-cleared).
- A&D Digital Blood Pressure Monitor (FDA-cleared).

White Paper

Honeywell HomMed



Telehealth for Chronic Care Management

With CMS looking closely at CHF hospital readmissions within 30 days, have you considered the reimbursement loss risk for your organization in 2010?

By: Eric Zalas, M.B.A.

Table of Contents

The World Health Organization reports that chronic disease is responsible for 60 percent of all deaths worldwide.[1] The U.S. Department of Health and Human Services Agency for Healthcare Research and Quality (AHRQ) estimates that treating the nation's ten most expensive medical conditions cost nearly $500 billion in 2005.[2] Heart conditions were the most expensive health conditions to treat. According to a 2006 estimate, approximately 5.7 million people suffer from congestive heart failure (CHF) in the United States.[3] About 30 percent of these individuals, 1.59 million patients, are Class III and Class IV heart failure patients.[4] The lifetime risk of developing heart failure at the age of 40 is 20 percent, and approximately 380,000 people above the age of 65 will be diagnosed with CHF annually.[5] Heart failure is also the leading cause of hospitalization in people older than age 65. The demographic "over age 65" from the Baby Boomer generation will likely give rise to increased numbers of heart failure patients during the next few decades.[6]

Congestive Heart Failure: Cost Implications

The healthcare community is increasingly concerned with the growing number of patients hospitalized with heart failure. CHF was listed as the underlying cause in 57,120 deaths in 2004.[7] In 2006, over 1.1 million CHF patients were discharged from a hospital.[8] Studies show that within four to six months after discharge, 47 percent of the patients are likely to be readmitted to the hospital.[9] In a comprehensive review of more than 13 million Medicare patients discharged from 4,926 hospitals between 2003 and 2004, almost 27 percent of heart failure patients were rehospitalized within 30 days of discharge.[10]

Figure 1 shows the total direct and indirect costs of heart failure in the United States is estimated to be $37.2 billion.[11] In commercially insured Medicare and Medicaid populations, the single largest health expenditure is inpatient utilization (nearly 33 percent in 2005) with 13.3 percent of all emergency department visits associated with a hospital admission.[12] In 2006, the Colorado Hospital Association compiled detailed hospitalization cost data for all patient refined diagnosis related group (APR-DRG 194) heart failure. Based on 6,305 CHF hospitalizations at 44 Colorado hospitals in 2006, the average daily cost for hospitalization was $4,873 (Figure 2) and the average length of stay (LOS) was 4.76 days[13] (Figure 3). LOS is the key determinant of cost for heart failure hospitalizations.[14] In addition, the referenced Colorado study found that 87 percent of the patients with APR-DRG 194 were hospitalized with either moderate or major severity, roughly equating to Class II and Class III CHF (Figure 4).

Figure 1: Estimated Direct and Indirect Costs of Heart Failure

American Heart Association, 2009

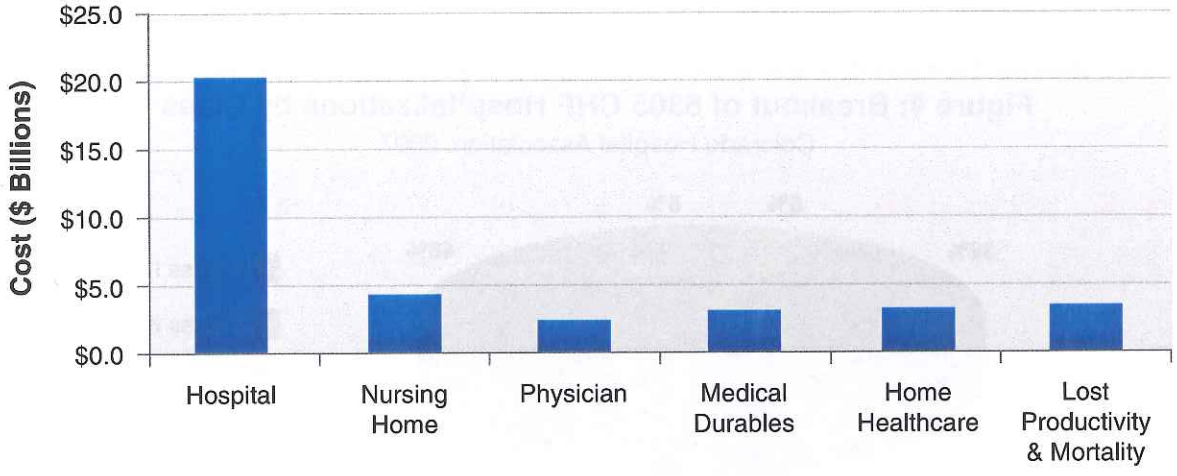


Figure 2: Average CHF Hospitalization Charge/Day

Colorado Hospital Association, 2007

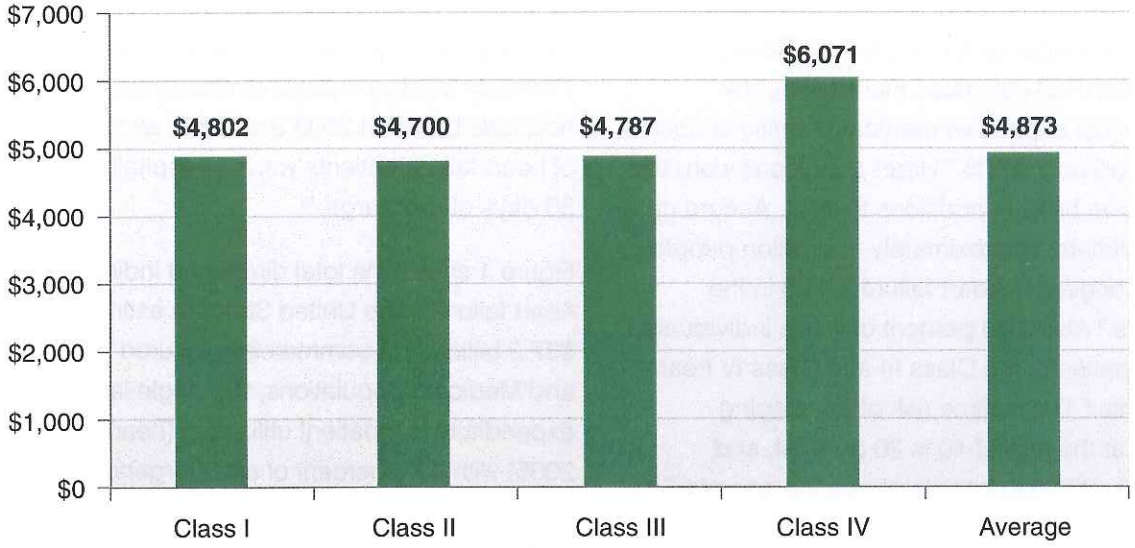


Figure 3: Average LOS for CHF Hospitalizations (n = 6305; 44 hospitals)

Colorado Hospital Association, 2007

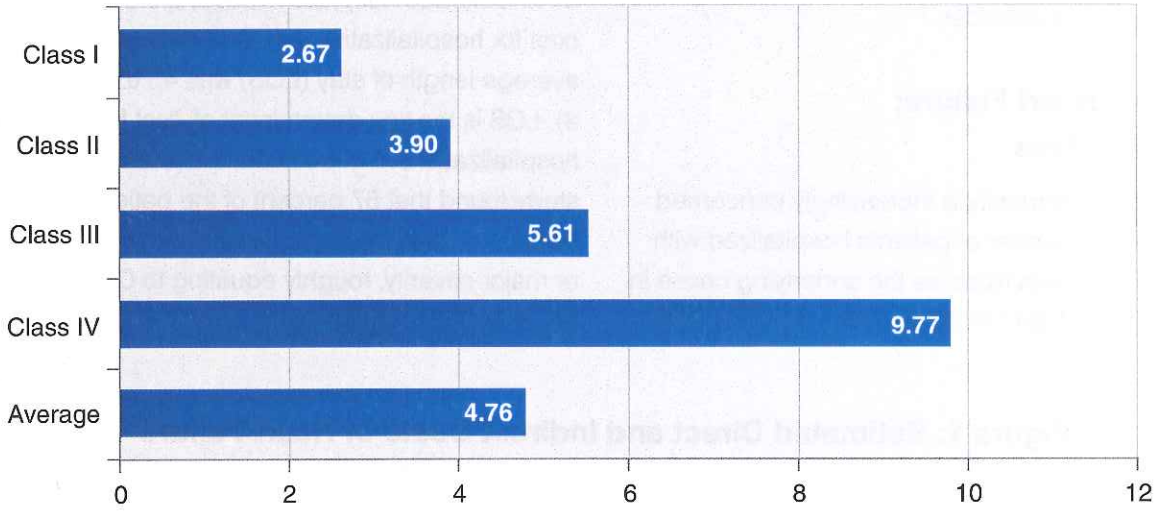
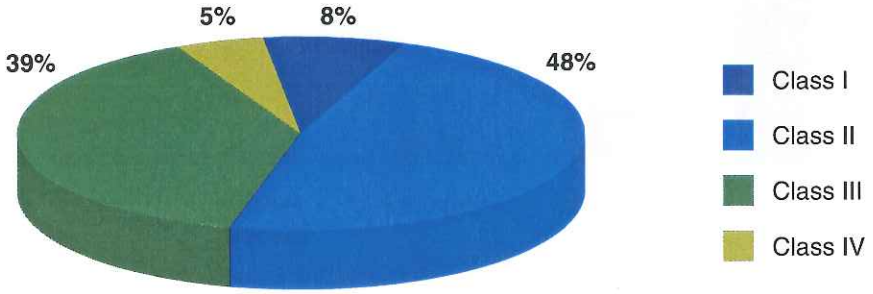


Figure 4: Breakout of 6305 CHF Hospitalizations by Class

Colorado Hospital Association, 2007



Chronic Care Crossroads: What Reimbursement Policy Changes Mean for Hospitals and Healthcare Organizations

The Centers for Medicare & Medicaid Services (CMS) has quietly shifted policy in a way that may arguably reshape the U.S. healthcare system.[15] In 2009, Medicare will require hospitals to report readmissions within 30 days of discharge for patients with three major medical diagnoses: heart failure, pneumonia and acute myocardial infarction.[15]

For CMS, readmissions are an indicator of quality failure. Jencks *et al.* estimated that 90 percent of rehospitalizations within 30 days of discharge are unplanned and that the cost to Medicare for these unplanned rehospitalizations in 2004 was $17.4 billion.[16] Beginning in 2010, reimbursement for these readmissions may be modified or denied. Heart failure ranks first among all causes of Medicare discharges. A typical DRG reimbursement for heart failure would be approximately $4,800 based on national averages.[17] In a review of cost data, the average hospital lost $1,288 per HF patient.[18] If the CMS policy regarding early hospital readmissions is enacted in 2010, a typical 250-bed hospital faces a loss of annual reimbursement of about $1.5 million.[19]

> *...we are focused on reducing unnecessary hospitalization to both remain competitive financially and also improve the health of our members.*
>
> Michael Sherman, M.D., Corporate Medical Director, Physician Strategies, Humana

Implications for the CMS policy shift regarding early rehospitalizations is not just limited to hospitals – the large healthcare providers or managed care organizations are also taking notice. Michael Sherman, M.D., serves as corporate medical director, physician strategies, for Humana based in Louisville, Kentucky. "As we see CMS seek to reduce the rate of increase in healthcare spending, we are also looking at likely reductions in what the government pays to organizations like Humana for managing the Medicare Advantage population," he said. "Accordingly, we are focused on reducing unnecessary hospitalizations in order to both remain competitive financially and also improve the health of our members."

The Solution: Implementation of a Scalable Telehealth Program

Fortunately, a cost-effective solution is available for heart failure patients. The Framingham Heart Study, begun in 1948 and completed in 1966, was the first landmark study that focused on the epidemiology of hypertensive or arteriosclerotic cardiovascular disease. Among the many findings, the data from the study showed that heart failure patients who experienced slight increases in weight and blood pressure levels over time would likely experience negative medical outcomes including hospitalization.[20] Therefore, it is reasonable to conclude that if the patient's objective biometrics – such as weight and blood pressure – could be monitored and reviewed by a clinician on a daily basis, the patient could receive immediate medical intervention, which may help prevent an expensive ER visit or hospital episode.

A recent study conducted by the Center for Connected Health, a division of Partners HealthCare, suggests that a well-designed remote patient monitoring program may help reduce early rehospitalization rates and emergency room visits for heart failure patients. The study included 42 heart failure patients admitted to Massachusetts General Hospital in Boston.[21] The patients, averaging age 70, were randomized to receive usual care for heart failure, and a follow-up on all patients was conducted three months after monitoring was initiated. Patients in the remote monitoring group experienced lower average hospital readmission rates (31 readmissions per 100 people) compared to patients in usual care (38 readmissions per 100 people) and non-participants (45 readmissions per 100 people).[21] Patients in the remote monitoring group also had fewer heart-failure related readmissions and emergency room visits than usual care and non-participating patients. Researchers said the results show a positive

trend but are based on only three months of follow-up and did not reach statistical significance. A previous study by the Massachusetts-based group showed a similar program reduced all-cause hospital admissions by 25 percent in participating homebound patients.[21]

Telehealth Implementation Success Case Studies

Implementing remote patient management through a scaled telehealth program is one solution to the problem of high rehospitalization rates for CHF and other chronic patients. Hospital systems and integrated healthcare delivery networks (IDNs) can help mitigate potential reimbursement shortfalls through the implementation of a well designed telehealth program if CMS policy on early readmissions takes place. Many hospitals and IDNs are already utilizing telehealth monitoring of chronic patients to improve clinical outcomes and to reduce costs.

Honeywell HomMed, the market leader in providing telehealth and remote patient monitoring solutions, has successfully assisted more than 650 customers in implementing a telehealth program. One example is Allegan General Hospital in Allegan, Michigan.

In 2005, Allegan Homecare created a telehealth program using the Honeywell HomMed remote patient monitoring equipment. Telehealth monitors were given to all CHF patients, chronic obstructive pulmonary disease (COPD) patients recovering from open heart surgeries, and patients with a history of hypertension. While enhancing patient care was initially the goal of the program, Allegan quickly realized impressive movements in operational capacity and financial performance. The telehealth program allowed Allegan to increase patient census by 25 percent in three years and become the third most profitable area in the hospital. Dale Chapman, director of patient services at Allegan, noted, "We're providing better patient care, significantly reducing the number of nurse visits required per episode and increasing the productivity of nurses, making us more profitable than we ever have been."

Another successful telehealth program implementation example is Carolinas Healthcare System (CHS). CHS owns, leases or manages 25 hospitals in North and South Carolina. The System generated more than $4.1 billion in revenue in 2008. CHS sought to improve patient outcomes, reduce rehospitalizations, decrease hospital stays for patients and reduce costs for providing healthcare services. CHS decided on providing a scalable telehealth solution to improve patient outcomes and reduce costs to provide care. CHS liked the web-based Honeywell HomMed LifeStream™ remote patient care system because it could provide a highly standardized program across their entire network, bringing greater efficiencies, standardization and clinical data sharing.

Currently, CHS has 360 Honeywell remote patient monitors and the program has been a success. Marla Nutting, Telehealth Administrator at Valdese Hospital, a part of the CHS system located in Rutherford College, NC, noted, "Since we started using the telemonitors at our home service, we've seen more than a 500 percent return on investment. In addition, our rehospitalization rates have fallen from 30 percent to below 25 percent."

These referenced case studies offer support that a well designed and properly implemented telehealth program may help to improve patient outcomes, reduce rehospitalizations of patients with chronic conditions and reduce costs. These benefits may become even more important given the current shift in CMS policy regarding early rehospitalizations for CHF and other diseases, which may result in a significant loss of reimbursement revenue to hospitals and hospital systems. To improve patient care and outcomes and help mitigate reimbursement risk associated with the new CMS policy shift, implementing a well designed, scalable telehealth program is a feasible and cost-effective solution that healthcare organizations must consider.

Estimating the Economic Benefit of a Telehealth Program

In light of the referenced CMS policy shift, healthcare executives may be faced with a significant DRG risk associated with early CHF rehospitalizations. Results from telehealth clinical studies suggest positive, directional trends regarding reductions in hospitalizations and ER visits. Honeywell HomMed has created a pro-forma financial modeling tool to help customers estimate the DRG reimbursement dollars at risk by the recent shift in policy at CMS and the potential economic benefit of implementing a well designed, scalable telehealth solution.

The proprietary Honeywell pro-forma tool is a high-level, financial model that can be used to estimate the investment required to implement a scaled telehealth program and the long-term financial cost savings associated with such a program. The pro-forma tool first estimates the providers' cost to care for CHF patients based on the number of annual hospitalizations. The model then estimates the cost savings derived from a well designed telehealth program based on data from published and proprietary clinical studies. Implementing a telehealth program will require an investment in monitoring equipment, clinical software, and clinical patient oversight. These costs are included in the model and subtracted from the benefits provided to yield a net economic benefit estimate for the customer. The net benefit estimate of the telehealth program implementation is summarized as a return on investment (ROI) calculation. In addition, the Honeywell proprietary pro-forma model presents the healthcare provider with an estimate of the DRG reimbursement monies for CHF patient hospitalizations that may be "at risk" based on the percentage of early rehospitalizations.

Case 1: Small Integrated Health Care Network (IDN)

This case looks at a typical small integrated healthcare network (IDN) provider with 2,500 CHF hospitalizations per year. This IDN will have approximately $16.25 million in DRG reimbursement at risk based on CHF early rehospitalizations over a five-year period.

The pro-forma model estimates that if a small IDN with 2,500 annual CHF patient hospitalizations implemented a telehealth program scaled up to monitor 1,000 patients each year, the IDN may realize a net economic benefit of $14.2 million over the five-year period, representing an ROI of approximately 183 percent (Figure 5). Note that by implementing a modest telehealth program, the model estimates that the IDN used in this example would likely reduce its DRG risk for early CHF rehospitalizations by 25 percent, or approximately $4 million.

Case 2: Mid-size Hospital

This case looks at a typical mid-size hospital with 500 CHF hospitalizations per year. This hospital will have approximately $3.2 million in DRG reimbursement at risk based on CHF early rehospitalizations over a five-year period.

The pro-forma model estimates that if a mid-sized hospital with 500 annual CHF patient hospitalizations implemented a telehealth program scaled up to monitor 250 patients each year, the hospital may

realize a net economic benefit of over $5.4 million over a five-year period, representing an ROI of approximately 161 percent (Figure 6). Note that by implementing a modest telehealth program, the model estimates that the hospital used in this example would likely reduce its DRG risk for early CHF rehospitalizations by 28 percent, or $900 thousand.

Summary

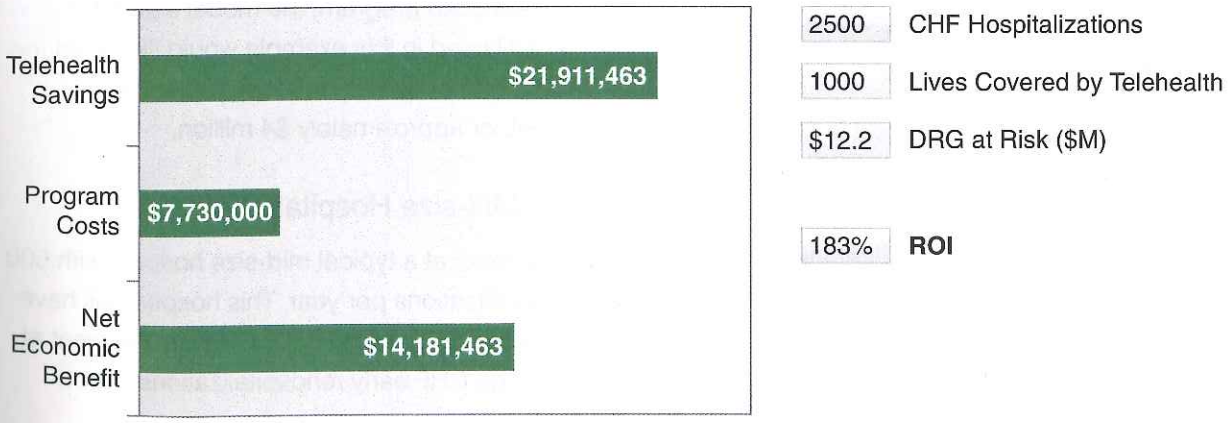
The number of patients suffering from chronic diseases like congestive heart failure is growing at an alarming rate. The recent shift in policy by CMS regarding early rehospitalizations poses the threat of lost reimbursement for hospitals and healthcare organizations. Numerous clinical studies have demonstrated encouraging directional results suggesting that remote patient monitoring helps reduce hospitalizations, ER visits and total costs. Therefore, CMS policy and recent healthcare industry discussions on the concept of "medical home" suggest an increased awareness on the part of the healthcare community in providing patient care in new ways and through new channels.

Kristopher Crawford, M.D., president of Physicians Preferred Monitoring, LLC has observed how these trends are impacting the healthcare market. "Patients routinely utilize multiple medical Web portals to get information to self manage illnesses," said Dr. Crawford. "It is not a stretch to see them utilizing the same methods to get a live health professional to further assist them in managing their illnesses, especially chronic conditions. When you tie this social shift to home telemonitoring devices that give practitioners the objective data that is necessary to compile a more complete clinical picture, you have a situation where virtual care is not just likely but really inevitable."

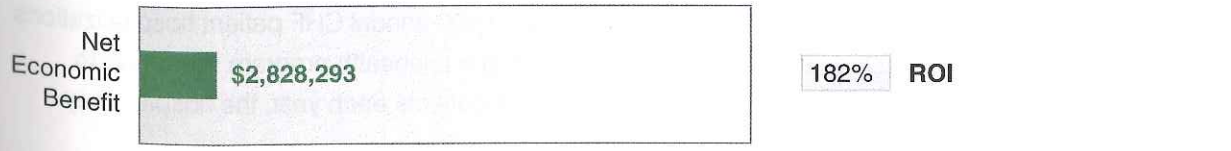
Enhanced control of difficult to manage CHF and diabetic patients is an obvious first step toward cost containment through increased levels of wellness.

Kristopher Crawford, M.D., President,
Physicians Preferred Monitoring, LLC

Figure 5: Hospital System/IDN Case – 5-year Economic Benefit from Telehealth



Hospital System/IDN Case – 1-year Economic Benefit from Telehealth



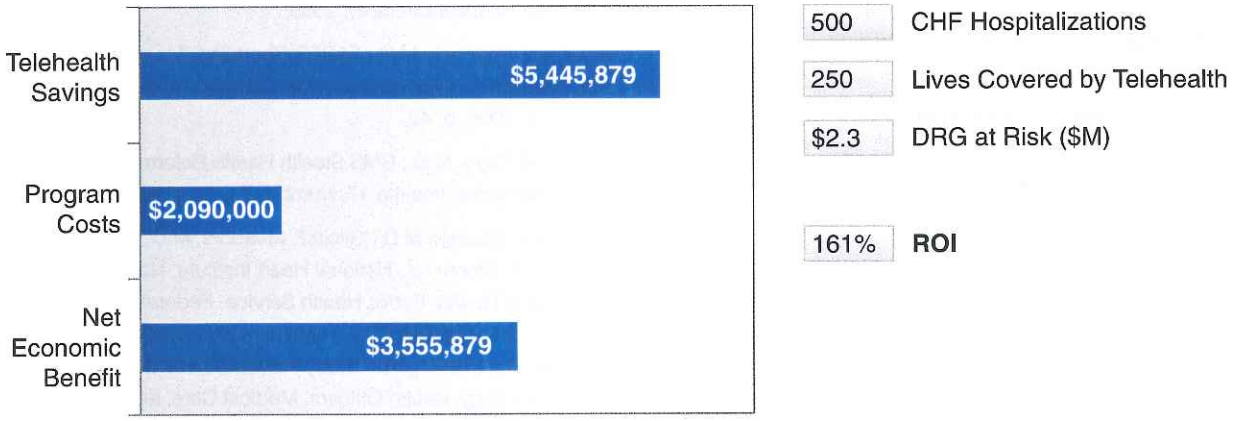
Powerful market forces such as the aging Baby Boomer segment, shortage of physicians, and potential loss of reimbursement for early rehospitalizations for CHF patients will shape healthcare systems' decisions on how to provide care for the chronically ill. "Primary care physicians are vanishing even as demand for their services grows with an aging American population," said Dr. Crawford. "These shortages and other issues will drive home care delivered through in-home health appliances in combination with enhanced self-monitoring and self-care. Costs in the healthcare system are largely and increasingly driven by a few chronic disease states. Enhanced control of difficult to manage CHF and diabetic patients is an obvious first step toward cost containment through the increased levels of wellness."

If you would like to better understand your DRG risk for early CHF hospital readmissions and learn more about how implementing a scaled, telehealth solution may help your organization reduce costs and improve patient outcomes, you may request a free, custom Honeywell pro-forma financial tool assessment for your hospital, IDN, or hospital system by contacting:

Eric Zalas, M.B.A.
Emerging Segment Marketing Manager
Honeywell HomMed
3400 Intertech Drive, Suite 200
Brookfield, WI 53045
262-252-5798 (O)
eric.zalas@honeywell.com

To learn more about Honeywell HomMed's remote patient care product and service offerings, please visit our Web site at www.hommed.com.

Figure 6: Mid-size Hospital Case – 5-year Economic Benefit from Telehealth



Mid-size Hospital Case – 1-year Economic Benefit from Telehealth

About Honeywell HomMed

Honeywell International (www.honeywell.com) is a Fortune 100 diversified technology and manufacturing leader, serving customers worldwide with aerospace products and services; control technologies for buildings, homes and industry; automotive products; turbochargers; and specialty materials. Based in Morris Township, N.J., Honeywell's shares are traded on the New York, London, and Chicago Stock Exchanges. For more news and information on Honeywell, please visit www.honeywellnow.com.

Honeywell HomMed is part of the Honeywell Automation and Control Solutions business group, a global leader in providing product and service solutions that improve efficiency and profitability, support regulatory compliance, and maintain safe, comfortable environments in homes, buildings and industry. For more information about Honeywell HomMed, please visit www.hommed.com.

References

1 Chronic Care at the Crossroads: exploring solutions for chronic care management: Intel Health, 2007.

2 Allison Van Dusen, "America's Most Expensive Medical Conditions"; February 6, 2008; Forbes.com.

3 American Heart Association, Heart Disease and Stroke Statistics – 2009 Update, Dallas, Texas: April 2009.

4 Research Update: Remote Physiologic Monitoring; New England Healthcare Institute; 2009.

5 Congestive Heart Failure, Ideal Life White Paper, June 2008.

6 American Heart Association, Heart Disease and Stroke Statistics – 2008 Update, Dallas, Texas: American Heart Association: 2008.

7 Ariel Linden, Dr. P.H., M.S. and Julia Adler-Milstein. Medicare Disease Management in Policy Context, Health Care Financing Review/Spring 2008/Volume 29, Number 3.

8 American Heart Association, Heart Disease and Stroke Statistics – 2009 Update, Dallas, Texas: American Heart Association: April 2009.

9 Sarwat I. Chaudry, M.D.; Yonghei Wang, M.S.; John Concato, M.D., M.P.H.; Thomas M. Gill, M.D.; Harlan M. Krumholz, M.D., S.M., Patterns of Weight Changes Preceding Hospitalization for Heart Failure, Circulation. 2007; 116: 1549-1554.

10 Stephen F. Jencks, M.D., M.P.H.; Mark V. Williams, M.D., and Eric A. Coleman, M.D., M.P.H., Rehospitalizations Among Patients in the Medicare Fee-for-Service Program, The New England Journal of Medicine. 360; 14: April 2, 2009; 1418-1428.

11 American Heart Association, Heart Disease and Stroke Statistics – 2009 Update, Dallas, Texas: American Heart Association: April 2009.

12 Congestive Heart Failure, Ideal Life White Paper, June 2008.

13 Colorado 2006 Hospital Charges and Average Length of Stay, Colorado Hospital Association, 2007.

14 Paul J. Hauptman, M.D., Jason Swindle, M.P.H., Thomas E. Burroughs, Resource Utilization in Patients Hospitalized with Heart Failure: American Heart Journal. 155; 6: June 2008; 978-985.

15 Molly Joel Coye, M.D., CMS Stealth Health Reform, Hospitals & Health Networks, Volume 17, Number 24, June 30, 2008.

16 Stephen F. Jencks, M.D., M.P.H.; Mark V. Williams, M.D., and Eric A. Coleman, M.D., M.P.H., Rehospitalizations Among Patients in the Medicare Fee-for-Service Program, The New England Journal of Medicine. 360; 14: April 2, 2009; 1418-1428.

17 American Hospital Directory, 2008.

18 AW. Frank Peacock, M.D., FACEP, Short Stay Management of Heart Failure. Society of Chest Pain Centers; Lippincott, Williams & Wilkins. 2006, p. 42.

19 Molly Joel Coye, M.D., CMS Stealth Health Reform, Hospitals & Health Networks, Volume 17, Number 24, June 30, 2008.

20 Thomas R. Dawber, M.D., Gilcin F. Meadors, M.D., M.P.H., and Felix E. Moore, Jr., National Heart Institute, National Institutes of Health, Public Health Service, Federal Security Agency, Washington D.C., Epidemiological Approach to Heart Disease: The Framingham Study Presented at a Joint Session of Epidemiology, Health Officers, Medical Care, and Statistics Sections of the American Public Health Association, at Seventy-eight Annual Meeting in St. Louis, MO, November 3, 1950.

21 Ambar Kulshreshtha, M.D., M.P.H., Joseph Kvedar, M.D., Alison Watson, M.D., M.P.H., Regina Nieves, R.N., Remote monitoring improves heart failure patient's health, may reduce hospital admissions: American Heart Association, May 1, 2008.

Telehealth and Hospitalizations for Medicare Home Healthcare Patients

Hsueh-Fen Chen, PhD; M. Christine Kalish, MBA, CMPE; and José A. Pagán, PhD

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.

(Am J Manag Care. 2011;17(6):e224-e230)

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.[1] 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.[1] 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.[2] 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.[3]

Telehealth ("The use of telecommunications and information technology to provide access to health assessment, diagnosis, intervention, consultation, supervision and information across distance"[4]) 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.[5-17] 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

In this article
Take-Away Points / e225
Published as a Web exclusive
www.ajmc.com

of telehealth reduces hospitalization rates, but these studies also show wide variation in the types of telehealth systems and interventions adopted.[18-22] 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.

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.

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 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,[23,24] 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.[25] 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[2]; 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.[26] 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.[27-30] 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.[31] 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.[32,33] 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.[34] 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

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

Variable	Telehealth (n = 1349)		Non-Telehealth (n = 4524)		*P* (*t* test or χ^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

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.[5-16] 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 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) Mean	Telehealth (n = 1349) SD	Non-Telehealth (n = 4524) Mean	Non-Telehealth (n = 4524) SD	*P* (*t* test or χ^2 test)
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

given that it costs approximately $7200 to treat a readmitted Medicare patient.[2] As the high hospitalization rate for home healthcare patients remains a concern, use of a telehealth monitoring system might reduce hospitalizations and improve the quality of home healthcare across different communities.

Previous studies examining the effect of telehealth on rehospitalization rates were based on small study samples, which may reduce the power of analysis to detect the effectiveness of a telehealth monitoring system. Future studies could use the propensity score method to overcome the restrictions inherent in study designs based on small samples.

Like other studies, the limitations of our study must be noted. First, one should be cautious when generalizing the findings of this study. Due to the lack of a systematic approach to telehealth data collection in home healthcare, appropriate and complete data could only be obtained from 1 integrated private network of home health agencies. As such, the findings from this study cannot be directly generalized 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 unmeasured factors such as patient education might affect the results based on propensity score matching. This possibility warrants further investigation.

Despite these weaknesses, the results from this study provide valuable information for policy makers and healthcare providers. First, the Medicare program currently pays home health agencies based on an episode adjusted by a case-mix weight, given the patients' clinical and functional conditions as well as the number of therapist visits. This payment system does not take quality of care into account or provide additional payment to home care agencies that utilize telehealth or provide more frequent nursing visits to reduce hospitalizations. With the lack of cost data, we were not able to examine the cost for 1 more nursing visit or to evaluate the cost-effectiveness of the telehealth monitoring system. However, we believe that use of telehealth monitoring systems for home healthcare patients helps to improve the efficiency of healthcare systems by reducing the frequency of costly hospitalizations; thus, adoption of pay-for-performance for home care agencies is suggested, given the high hospitalization rates among patients receiving home healthcare.

Second, data on adoption of telehealth monitoring systems and on the different types of telehealth monitoring systems used by home health agencies should be collected in order to evaluate the effectiveness of these systems. Current research regarding the effec-

■ **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.[18-22] 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.[35] 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.

Acknowledgments

The authors thank Wayne Bazzle, MC, Cheryl Bazzle, BBA, Georgia Brown, BS, and Kim Wong, BBA, at Home Healthcare Partners, LLC, for providing the data used in this study and for their helpful comments and suggestions.

Author Affiliations: From Department of Health Management and Policy (HFC, JAP), University of North Texas Health Science Center, Fort Worth, TX; The Brittain-Kalish Group, LLC (MCK), Fort Worth, TX; Leonard Davis Institute of Health Economics (JAP), University of Pennsylvania, Philadelphia, PA.

Funding Source: The authors report no external funding for this study.

Author Disclosure: The authors (HFC, MCK, JAP) report performing consulting work (data validation and assessment) for Home Healthcare Partners, LLC, though The Brittain-Kalish Group, LLC. The analyses/results reported in this study were conducted independently by the authors. The views expressed in this publication are the views of the authors and do not necessarily reflect the views of Home Healthcare Partners, LLC, or The Brittain-Kalish Group, LLC.

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).

Address correspondence to: Hsueh-Fen Chen, PhD, Department of Health Management and Policy, University of North Texas Health Science Center, 3500 Camp Bowie Blvd EAD 709B, Fort Worth, TX 76107. E-mail: hsueh-fen.chen@unthsc.edu.

REFERENCES

1. Medicare Payment Advisory Commission. *Report to the Congress: Medicare Payment Policy.* http://www.medpac.gov/documents/Mar10_EntireReport.pdf. Published March 2010. Accessed July 14, 2010.

2. Medicare Payment Advisory Commission. *Report to the Congress: Promoting Greater Efficiency in Medicare.* http://www.medpac.gov/documents/jun07_entirereport.pdf. Published June 2007. Accessed July 7, 2010.

3. Goldsmith J. Analyzing shifts in economic risks to providers in proposed payment and delivery system reforms. *Health Aff (Millwood).* 2010;29(7):1299-1304.

4. Centers for Medicare and Medicaid Services. Telehealth. https://www.cms.gov/Telemedicine. Accessed June 8, 2011.

5. Woodend AK, Sherrard H, Fraser M, Stuewe L, Cheung T, Struthers, C. Telehome monitoring in patients with cardiac disease who are at high risk of readmission. *Heart Lung.* 2008;37(1):36-45.

6. Jerant AF, Azari R, Nesbitt TS. Reducing the cost of frequent hospital admissions for congestive heart failure: a randomized trial of a home telecare intervention. *Med Care.* 2001;39(11):1234-1245.

7. Shah NB, Der E, Ruggerio C, Heidenreich PA, Massie BM. Prevention of hospitalizations for heart failure with an interactive home monitoring program. *Am Heart J.* 1998;135(3):373-378.

8. Wakefield BJ, Ward MM, Holman JE, et al. Evaluation of home telehealth following hospitalization for heart failure: a randomized trial. *Telemed J E Health.* 2008;14(8):753-761.

9. Barnason S, Zimmerman L, Nieveen J, Hertzog M. Impact of a telehealth intervention to augment home health care on functional and recovery outcomes of elderly patients undergoing coronary artery bypass grafting. *Heart Lung.* 2006;35(4):225-233.

10. Dansky K, Vasey J. Managing heart failure patients after formal homecare. *Telemed J E Health.* 2009;15(10):983-991.

11. Dansky KH, Vasey J, Bowles K. Impact of telehealth on clinical outcomes in patients with heart failure. *Clin Nurs Res.* 2008;17(3):182-199.

12. Goldberg LR, Piette JD, Walsh MN, et al; WHARF Investigators. Randomized trial of a daily electronic home monitoring system in patients with advanced heart failure: the Weight Monitoring in Heart Failure (WHARF) trial. *Am Heart J.* 2003;146(4):705-712.

13. Bowles KH, Holland DE, Horowitz DA. A comparison of in-person home care, home care with telephone contact and home care with telemonitoring for disease management. *J Telemed Telecare.* 2009;15 (7):344-350.

14. Cleland JG, Louis AA, Rigby AS, Janssens U, Balk AH; TEN-HMS Investigators. Noninvasive home telemonitoring for patients with heart failure at high risk for recurrent admission and death: the Trans-European Network-Home-Care Management System (TEN-HMS) study. *J Am Coll Cardiol.* 2005;45(10):1654-1664.

15. Benatar D, Bondmass M, Ghitelman J, Avitall B. Outcomes of chronic heart failure. *Arch Intern Med.* 2003;163(3):347-352.

16. Giordano A, Scalvini S, Zanelli E, et al. Multicenter randomised trial on home-based telemanagement to prevent hospital readmission of patients with chronic heart failure. *Int J Cardiol.* 2009;131(2):192-199.

17. Chaudhry SI, Mattera JA, Curtis JP, et al. Telemonitoring in patients with heart failure [published correction appears in *N Engl J Med.* 2011; 364(5):490]. *N Engl J Med.* 2010;363(24):2301-2309.

18. Polisena J, Tran K, Cimon K, et al. Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis. *J Telemed Telecare.* 2010;16(3):120-127.

19. Polisena J, Tran K, Cimon K, et al. Home telemonitoring for heart failure: a systematic review and meta-analysis. *J Telemed Telecare.* 2010;16(2):68-76.

20. Polisena J, Tran K, Cimon K, Hutton B, McGill S, Palmer K. Home telehealth for diabetes management: a systematic review and meta-analysis. *Diabetes Obes Metab.* 2009;11(10):913-930.

21. DelliFraine JL, Dansky KH. Home-based telehealth: a review and meta-analysis. *J Telemed Telecare.* 2008;14(2):62-66.

22. Louis AA, Turner T, Gretton M, Baksh A, Cleland JG. A systematic review of telemonitoring for the management of heart failure. *Eur J Heart Fail.* 2003;5(5):583-590.

23. McCall N, Petersons A, Moore S, Korb J. Utilization of home health services before and after the Balanced Budget Act of 1997: what were the initial effects? *Health Serv Res.* 2003;38(1, pt 1):85-106.

24. Freedman VA, Rogowski J, Wickstrom SL, Adams J, Marainen J, Escarce JJ. Socioeconomic disparities in the use of home health services in a Medicare managed care population. *Health Serv Res.* 2004;39 (5):1277-1297.

25. National Association for Home Care & Hospice. *Basic Statistics About Home Care.* http://www.nahc.org/facts/08HC_Stats.pdf. Updated 2008. Accessed October 26, 2010.

26. Lin CJ, Davitt JK, Meit M, Schwartz M, Marainen J, Davis L. The financial impact of interim and prospective payment systems on home health providers in rural communities. *J Health Care Poor Underserved.* 2005;16(3):576-587.

27. Rosenbaum P, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika.* 1983;70(1):41-55.

28. Rubin DB. Propensity score methods. *Am J Ophthalmol.* 2010;149(1):7-9.

29. Rubin DB. The design versus the analysis of observational studies for causal effects: parallels with the design of randomized trails. *Stat Med.* 2007;26(1):20-36.

30. Bleich SN, Cutler DM, Adams AS, Lozano R, Murray CJ. Impact of insurance and supply of health professionals on coverage of treatment for hypertension in Mexico: population based study. *BMJ.* 2007;335 (7625):875.

31. Medicare Payment Advisory Commission. *Home Health Care Services Payment System.* http://www.medpac.gov/documents/MedPAC_Payment_Basics_09_HHA.pdf. October 2009. Accessed November 3, 2010.

32. Coca-Perraillon M. *Matching With Propensity Score to Reduce Bias in Observational Studies.* Paper presented at: NorthEast SAS Users Group (NESUG); September 17-20, 2006; Philadelphia, PA. http://www.nesug.org/proceedings/nesug06/an/da13.pdf. Accessed July 15, 2010.

33. 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(9): 1092-1097.

34. Stern S. Simulation-based estimation. *J Econ Lit.* 1997;35(4):2006-2039.

35. Bowles KH, Baugh AC. Applying research evidence to optimize telehomecare. *J Cardiovasc Nurs.* 2007:22(1):5-15. ■