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Original Article

Can Telemonitoring Reduce Hospitalization and Cost of Care? A Health Plan's Experience in Managing Patients with Heart Failure

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Abstract

Telemonitoring provides a potentially useful tool for disease and case management of those patients who are likely to benefit from frequent and regular monitoring by health care providers. Since 2008, Geisinger Health Plan (GHP) has implemented a telemonitoring program that specifically targets those members with heart failure. This study assesses the impact of this telemonitoring program by examining claims data of those GHP Medicare Advantage plan members who were enrolled in the program, measuring its impact in terms of all-cause hospital admission rates, readmission rates, and total cost of care. The results indicate significant reductions in probability of all-cause admission (odds ratio [OR] 0.77; $P < 0.01$), 30-day and 90-day readmission (OR 0.56, 0.62; $P < 0.05$), and cost of care (11.3%; $P < 0.05$). The estimated return on investment was 3.3. These findings imply that telemonitoring can be an effective add-on tool for managing elderly patients with heart failure. (*Population Health Management* 2014;xx:xxx–xxx)

Introduction

Patients with heart failure face a progressively deteriorating course of disease, with exacerbations and the accompanying debilitating symptoms that require urgent medical attention and often lead to frequent hospitalizations and emergency department visits. Patient self-monitoring of signs and symptoms offers a means to detect early signals of deteriorating conditions and the opportunity to intervene before urgent/emergent care and hospitalization is necessary. Remote monitoring of heart failure patients may offer an efficient means to manage patients without the need for face-to-face contact, increasing access to care as needed, especially when warning signs of an impending exacerbation of the patient's condition emerge.

Geisinger Health Plan (GHP), a regional full-service managed care organization serving members residing mainly in rural Central Pennsylvania, developed and implemented a focused heart failure telemonitoring program in March of 2008. Although GHP has had a case management program in effect since 1998 for heart failure, the addition of telemonitoring was seen as a new tool to help extend the case manager's reach for monitoring individuals with often advancing heart failure. More specifically, GHP provided Advanced Monitored Caregiving Bluetooth scales with an Interactive Voice Response (IVR) system to members with heart failure. The IVR system included a list of questions specifically designed to detect changes in physical condition indicating exacerbation, such as shortness of breath, swelling, appetite, and prescription management. To fully utilize the system, the member needed to have a landline or cellular phone service to transmit weight measurements via the Bluetooth-enabled scale and to take the IVR calls.

Enrollment in the telemonitoring program was restricted to those GHP members who were identified through a variety of methodologies including physician referral and claims data. Once identified, a GHP case manager confirmed the heart failure diagnosis via the electronic medical record, if available, or discussion with the managing physician (primary care or cardiologist). Clinical criteria for enrollment in the heart failure telemonitoring program included, but were not limited to, members having a diagnosis of heart failure validated by an echocardiogram ejection fraction of less than 40%, or by medical record documentation of diastolic dysfunction. Additionally, to be eligible to participate in the program members had to be able to step on a scale and steady themselves to obtain an accurate weight, as well as have good cognitive function to respond to questions regarding the current state of their health. They were disenrolled from the program (1) if the case manager

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determined that the member was in a stable condition and no longer required the program; (2) if the member voluntarily opted out of the program; (3) if no longer a GHP member; or (4) if the member expired. The design and implementation of this telemonitoring program was guided by the existing literature in this area.[1–4] Note that enrollment or disenrollment in the telemonitoring program was not tied to hospitalization or any particular acute event; that is, members were not automatically enrolled in the program upon discharge, for instance.

In this context, case managers hired and trained by GHP are recognized as an integral part of the patient-centered primary care team whose goal is to work with members to identify early indicators of exacerbation or worsening condition. They work closely with the members' clinical care providers and are provided the ability to expedite appointments and to coordinate additional labs or tests that may be necessary. With the near real-time data collected via the telemonitoring program, case managers identify those instances in which members' biometric readings or IVR responses are out of their specified ranges and send an alert to their primary care providers. The case manager then collaborates with the primary care team as indicated for resolution. Resolution of the alert may include setting up follow-up appointments with the appropriate care provider, activation of a member-specific medication management plan, reinforcement of self-management activities such as diet, or other updates to the care plan as necessary.

A GHP case manager typically maintains an average caseload of approximately 125 to 150 members at any given time. The types of members included in this caseload generally are individuals with complex chronic conditions (eg, heart failure, chronic obstructive pulmonary disease [COPD], diabetes), the frail elderly, or members transitioning from hospital to home. The role of a GHP case manager is multifaceted—handling transitions of care, care coordination of complex and multi-comorbid members, and ensuring that evidence-based clinical guidelines and protocols are implemented and followed for each member, all while being part of the overall multidisciplinary care team. One of the key elements of case management is timely follow-up and appropriate touchpoints with the members. Telemonitoring, therefore, potentially provides a key asset to case managers as it allows appropriate prioritization of member contacts during their workday, increasing efficiency. For instance, without the telemonitoring system the case manager would have to call every member to assess daily weight change while asking specific questions about symptom monitoring. By automating this process via telemonitoring, case managers can quickly identify and focus on those members facing greater need on any given day.

The purpose of this study is to evaluate the impact of this telemonitoring program using claims data related to changes in hospital admission and readmission rates as well as cost of care among the GHP members with heart failure who had participated in the program. It was hypothesized that when these members were enrolled in the telemonitoring program, they became less likely to be admitted and readmitted to a hospital, compared to when they were not enrolled in the program. This also implies that the total cost of care for these members was lower when they were enrolled in the telemonitoring program compared to when they were not enrolled in the program.

Data

For the purposes of this study, GHP claims data were collected for those members who were enrolled in the heart failure telemonitoring program at any point during the study period (January 1, 2007–October 31, 2012). Even though the telemonitoring program officially had started in March of 2008, the study period included 1 year prior to the official start date to capture any baseline trends and preintervention claim patterns. Furthermore, the final sample was restricted to those GHP Medicare Advantage plan members who were at least 65 years old and maintained their GHP Medicare Advantage plan membership throughout the entire 70-month study period. This restriction was applied in order to reduce any confounding related to switching health plans and end-of-life care. In addition, the sample was further restricted to those GHP Medicare Advantage members who were in the ''gatekeeper'' product types to reduce variability in utilization related to members' choosing out-of-network providers.

Therefore, the final data set had a balanced panel structure; that is, every member in the sample appeared exactly 70 times in the data set, each observation corresponding to his or her unique month of claim during the study period. Some members had a ''break'' in the enrollment, during which they had disenrolled from the program for some period and then reenrolled. The exact reasons for such discontinuation and termination of enrollment in the program were not available to the researchers, however. A binary indicator variable was created to flag such months during which a member was enrolled in the telemonitoring program. This data structure allowed examination of the correlation between each member's enrollment/disenrollment in the program over time with his or her own patterns in hospital admission and cost of care over time. In other words, each member in the data set served as his or her own comparison.

Four dependent variables were obtained from the claims data: all-cause hospital admission, 30-day readmission, 90-day readmission, and per-member-per-month (PMPM) allowed amounts. The allowed amounts represented the sum of all payments made by GHP directly to providers and the member's out-of-pocket expenses in the form of copayments and deductibles. For all-cause hospitalization, a binary indicator variable was created that equaled 1 if the member experienced any hospitalization during a given month and zero otherwise. Similarly, for the 30-day and 90-day readmissions, binary indicator variables were created that equaled 1 if the member experienced a readmission within 30 days or 90 days after initial discharge and zero otherwise. These variables were coded as missing if the member did not have an initial hospital admission (and therefore could not have had a readmission) in a given month.

The key explanatory variable in this analysis was the binary indicator variable that equaled 1 if the member was enrolled in the heart failure telemonitoring program during a given month and zero otherwise. Other covariates included the following: an indicator variable for whether the member

was in one of Geisinger's advanced patient-centered medical homes,[5] member's age as well as age-squared (to allow nonlinear age effect) at each period, and year and month of claim (to adjust for seasonality). Information about the sex of the member was available in the data but was not used as a covariate because, as will be explained, only time-varying member characteristics were used in the estimation models.

In addition, a set of indicator variables that captured whether the member had any claims related to chronic diseases in each period also was obtained. Chronic diseases considered for this study included chronic kidney disease, coronary artery disease, COPD, asthma, diabetes, hypertension, end-stage renal disease, depression, and cancer. Furthermore, an indicator variable for congestive heart failure (CHF) also was obtained and included in the estimation models. Because, as noted, the analytic data included claims data from 1 year prior to the official start date of the telemonitoring program to capture preintervention claim patterns, some members might not yet have developed heart failure during this preintervention period. Therefore, the CHF indicator variable distinguishes those member-month observations in the claims data set in which the member had not yet developed CHF.

Methods

The research team exploited the within-person variation in each member's heart failure telemonitoring program enrollment over time to examine whether there were any statistically significant associations between the program enrollment and the dependent variables. More specifically, member fixed effects were used in the multivariate regression models to remove variation across members in the sample by including a dummy variable for every member (ie, each member served as his or her own comparison). This approach removes all confounding related to any time-invariant factors, such as sex and race, as well as any underlying health conditions not directly observed from the data. Put differently, the fixed effects model approach essentially answers the following questions: How does a member's probability of hospital admission and readmission, along with his/her total cost of care, change when he/she is enrolled in the heart failure telemonitoring program, relative to the period when he/she is not enrolled in it?

To estimate the impact of the telemonitoring program on all-cause hospital admissions and readmissions, 3 logistic regression models were estimated and the corresponding odds ratios were obtained, because the dependent variables were binary indicator variables that equaled 1 if the member experienced any admission or readmission and zero otherwise. The use of member fixed effects implied that those members who did not exhibit any variation over time in admissions or readmissions (ie, never admitted/readmitted or always admitted/readmitted) necessarily drop out of the estimation sample. Consequently, the estimation sample sizes for admission and readmission analyses were substantially smaller than the original sample size.

To estimate the impact of the telemonitoring program on cost of care, the research team used a generalized linear model with log link function and gamma distribution. To obtain the cost savings in dollar terms, the team estimated the ''expected'' total cost by setting the heart failure telemonitoring indicator variable in the regression model to zero to determine the expected cost if the member had not been enrolled in the program. This was then compared against the ''observed'' total cost, which was obtained as regression-adjusted cost with the heart failure telemonitoring indicator variable set to 1 as observed in the data set. The difference between the expected and observed cost represented the dollar amount of savings associated with the telemonitoring program. A bootstrap method with 100 replications was used to obtain 95% confidence intervals around the cost estimates.

In all regression models, the research team included an interaction term between the heart failure telemonitoring indicator variable and the indicator variable for whether the member was in one of Geisinger's advanced patient-centered medical homes at the same time that they were enrolled in the telemonitoring program. This interaction term was designed to account for any differential effects of the telemonitoring program that depended on whether the member was already exposed to a transformed primary care delivery model relative to the traditional one.

Results

In total, 1708 members were eligible and had enrolled in the telemonitoring program at any point during the study period. However, after applying the aforementioned inclusion and exclusion criteria, there were 541 members included in the final study sample (Table 1). Table 1 suggests that the GHP members included in the study sample were predominantly elderly, had a high prevalence of comorbid conditions (most commonly hypertension and coronary

Table 1. Descriptive Statistics

Number of Members Included in Sample	541
Study Period (Total Length of Observation)	January 2007 through October 2012 (70 months)
Average Length of Program Enrollment in Months (SD)	24 (17)
Age (SD)	79 (6)
$ Total Cost (SD)	1596 (1097)
% Admitted per Month	4.8%
% 30-Day Admitted per Month | Admission	16.2%
% 90-Day Admitted per Month | Admission	30.4%
% Male	49%
% in Patient-Centered Medical Home	87%
% with CKD	56%
% with CAD	81%
% with COPD	40%
% with CHF	96%
% with Asthma	14%
% with Diabetes	54%
% with Hypertension	92%
% with ESRD	4%
% with Depression	21%
% with Cancer	20%

CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; ESRD, end-stage renal disease; SD, standard deviation.

Table 2. Logistic Regression Model Results

Outcome Variables	N	*# Member-Month Observations*	*Odds Ratio*	*95% CI*
All-Cause Admission	497	34,790	0.77***	(0.65–0.91)
30-Day Readmission | Admission	178	987	0.56**	(0.33–0.92)
90-Day Readmission | Admission	262	1347	0.62**	(0.41–0.93)

**$P < 0.05$; ***$P < 0.01$.
CI, confidence interval.

artery disease) and incurred a significant cost of care (average PMPM cost of ~$1600).

Table 1 also indicates that, on average, the members in the sample were enrolled in the telemonitoring program for about 24 months out of the 70-month observation period. Note that the data include claims data from 1 year prior to the official start of the telemonitoring program; therefore, this preintervention period may include some period prior to the development of heart failure for some of the members. This implies that not all members in the sample had heart failure for the entire 70-month duration. Table 2 suggests that members in the sample had experienced significant reductions in their odds of hospital admissions as well as 30-day and 90-day readmissions in a given month. That is, the odds of experiencing a hospital admission in a given month was 23% lower when the members were enrolled in the telemonitoring program. The odds of experiencing a 30-day readmission was 44% lower, and the odds of experiencing a 90-day readmission was 38% lower. These findings are consistent with the results shown in Table 3, which indicate that the implementation of the heart failure telemonitoring program was associated with approximately 11% cost savings during the study period. All of these estimates were statistically significant at 5% level.

Table 3 also suggests that the estimated return on investment associated with the telemonitoring program was approximately 3.3. That is, for every $1 spent to implement this program, there was approximately $3.30 return on this investment in terms of the cost savings accrued to GHP. The investment cost was calculated as the sum of the cost of purchasing the Bluetooth scale as well as the cost of the automated calls to the members. The cost was determined on a PMPM basis for each member for the number of the months during which the member was enrolled in the program. The cost associated with case management activities for the members participating in this program was not separately identified and included in this calculation because any case management activity related to the telemonitoring program was considered to be a part of the routine case management efforts performed by the case managers.

Discussion

This study suggests that GHP's implementation of a telemonitoring program for its members who experience heart failure was associated with significant reductions in hospital admission and readmission rates, which translated into approximately 11% cost savings and a return on investment of approximately 3.3. It is important to note that GHP's telemonitoring program was implemented as an additional tool and resource to augment the existing case management infrastructure and not as an independent, stand-alone program carved out specifically for members with heart failure. Embedding this tool within the daily workflow of case managers has allowed them to track each member's clinical progress in near real time, increasing the opportunities for proactive intervention based on biometric and symptom information.

As noted, a member's enrollment or disenrollment in the telemonitoring program was not dependent on any acute event. For instance, members might have been automatically enrolled in the program upon hospital discharge. If such were the case, these results would have been subject to a potential bias stemming from the fact that the initial enrollment in the program coincided with a period of an acute (ie, high cost) event, after which the cost and intensity of care in subsequent periods would have been lower regardless of the telemonitoring program (ie, regression to the mean). Because this was not the case, regression to the mean is not a plausible alternative explanation.

The finding of this study differs from some of the prior studies that examined similar interventions in other settings and concluded little to no effect.[3] The existing literature illustrates, as does this study, some of the main challenges of demonstrating the success of heart failure telemonitoring

Table 3. Estimated Cost Impact by Year

Year	*PMPM Cost ($): Expected*	*PMPM Cost ($): Observed*	*Difference*	*% Difference (Bootstrap 95% CI)*	*Return on Investment*
2008	$1711	$1521	$190	11.1% (1.0%–21.2%)	2.5
2009	$1964	$1732	$232	11.8% (1.5%–22.1%)	3.4
2010	$1918	$1699	$219	11.4% (1.3%–21.5%)	3.5
2011	$1869	$1660	$209	11.2% (1.1%–21.3%)	3.4
2012	$1963	$1752	$212	10.8% (0.7%–20.9%)	3.4
Overall	$1916	$1699	$216	11.3% (1.2%–21.4%)	3.3

PMPM, per member per month; CI, confidence interval.

programs. First, most heart failure patients are elderly and have multiple medical conditions. This makes it inherently difficult to isolate and measure the program's impact in terms of patient outcomes. Second, it may be that the benefits associated with telemonitoring are not related to the intensity of home monitoring but to improvements in patient adherence to instructions provided regarding weight control, diet, and medications.[6] To the extent that such behavior changes are one of the main goals of GHP's case management strategy, however, distinguishing the program's impact in terms of greater intensity of monitoring or to members' behavior changes is not possible within this context.

The analytic method used in this study did not rely on use of a comparison group. Rather, it relied on variation in the cost over time and the probabilities of hospital admissions and readmissions in a given month for each member in the sample; in essence, each member serves as his or her own comparison over time. Although a randomized controlled design would have been ideal, the research team recognized that it was not a feasible option given the high cost of conducting such a trial as well as the potential ethical concern over withholding potentially beneficial interventions to a large number of at-risk members.

This study has several important limitations. First, the analysis relies on existing observational secondary data that may not fully capture all the potential confounders. In particular, the fact that GHP required that eligible members be able to step on a scale and steady themselves in order to obtain an accurate weight may have led to an unintended but systematic selection bias of less severe members in the study sample. Second, the fact that the study sample included only those GHP members who appeared in all 70 months of the observation period necessarily implies that no one in the sample was deceased during the study period and thus death could not be examined as a potential outcome variable. Therefore, the finding is applicable only to those heart failure patients who have survived for at least some length of time and are amenable to case management efforts. However, to the extent that this is the target population of the heart failure telemonitoring intervention, the study finding is still quite relevant and useful for those interested in implementing similar interventions.

Author Disclosure Statement

Dr. Maeng, Dr. Starr, Ms. Tomcavage, Ms. Sciandra, Ms. Salek, and Mr. Griffith declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: all authors are employees of Geisinger Health System. The authors received no financial support for the research, authorship, and/or publication of this article.

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