The impact of care management information technology model on quality of care after percutaneous coronary intervention: “Bridging the Divides”

William S. Weintraub^{a,*}, Zaher Fanari^b, Daniel Elliott^a, Jennifer Ostertag-Stretch^a, Ann Muther^a, Margaret Lynahan^a, Roger Kerzner^a, Tabassum Salam^a, Herbert Scherrer^a, Sharon Anderson^a, Carla A. Russo^a, Paul Kolm^a, and Terri H. Steinberg^a

^aChristiana Care Health System, Newark, DE, United States

^bPrairie Heart Institute, Springfield, IL, United States

Abstract

Background: Reducing readmissions and improving metrics of care are a national priority. Supplementing traditional care with care management may improve outcomes. The Bridges program was an initial evaluation of a care management platform (CareLinkHub), supported by information technology (IT) developed to improve the quality and transition of care from hospital to home after percutaneous coronary intervention (PCI) and reduce readmissions.

Methods: CareLink is comprised of care managers, patient navigators, pharmacists and physicians. Information to guide care management is guided by a middleware layer to gather information, PLR (ColdLight Solutions, LLC) and presented to CareLink staff on a care management platform, AerialTM (Medecision). An additional analytic engine [NeuronTM (ColdLight Solutions, LLC)] helps, evaluates and guide care.

Results: The “Bridges” program enrolled a total of 2054 PCI patients with 2835 admission from April, 1st 2013 through March 1st, 2015. The data of the program was compared with those of 3691 PCI patients with 4414 admissions in the 3 years prior to the program. No impact was seen with respect to inpatient and observation readmission, or emergency department visits. Similarly no change was noticed in LDL control. There was minimal improvement in BP control and only in the CTM-3 and SAQ-7 physical limitation scores in the patients’ reported outcomes. Patient follow-up with physicians within 1 week of discharge improved during the Bridges years.

Conclusions: The CareLink hub platform was successfully implemented. Little or no impact on outcome metrics was seen in the short follow-up time. The Bridges program suggests that population health management must be a long-term goal, improving preventive care in the community.

*Corresponding author at: Division of Cardiology, Christiana Care Health System, Newark, DE 19317, United States. weintraub@christianacare.org (W.S. Weintraub).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.carrev.2017.06.014>.

Keywords

Information technology; Transition of care; Care management; Percutaneous coronary intervention; Readmissions

1. Introduction

The recognition that rising health care costs in the United States are unsustainable and also the appreciation that health outcomes in the United States lag behind other developed nations has led to efforts to improve outcomes [1]. In particular, the goals are to improve health, improve health care and lower costs [2]. A particular area of concern has been the problem of the transition from hospital to home in patients hospitalized for an acute event [3]. The post-discharge period is a difficult one for patients and families, and the transition has not historically been as efficiently as it might be [4]. A disease area of concern is ischemic heart disease. Patients hospitalized for revascularization or acute myocardial infarctions are at risk of readmission and of recurrent ischemic events [5–7]. There is solid evidence from randomized trials that secondary prevention, including both lifestyle modification and appropriate pharmacologic management, will reduce ischemic events [8]. There is also evidence that readmissions can be reduced, but more data is needed on how to specifically target readmissions rate through quality improvement processes [9,10].

Care management may be able to improve outcomes by making sure that patients get necessary services, and are better able to adhere to therapies [11]. Care management is dependent on adequate information in order to guide therapy. There are multiple data streams concerning patients to be integrated and then presented to the care managers. To successfully accomplish this in a health care system, specialized software is required to integrate in-patient and outpatient data and additional specialized software for the care managers to work with that will help guide their tasks. An additional principle of care management is that it is not possible to provide all services to all patients. Rather patients at highest risk or those where an intervention can reduce risk are those who should receive the most extensive care management support. Patients at lower risk need less intense services.

In the “Bridging the Divides” program we set out to develop an IT-enabled longitudinal care management program for patients following an acute myocardial infarction (MI) or percutaneous coronary intervention (PCI). The goals of this program were to decrease readmissions, improved patients reported outcomes, improve management of hypertension and hyperlipidemia. The purpose of the present report is to describe our initial experience with IT enabled care management for ischemic heart disease with an emphasis on readmissions and secondary prevention.

2. Materials and methods

2.1. Patient population

The study population comprised patients presenting to the emergency department with a type 1 MI and had angiographically documented coronary artery disease or patients undergoing revascularization by percutaneous coronary intervention (PCI). This program

was considered part of standard medical care, and this was reflected in the consent process. Patients were offered the opportunity to opt out of the program. This process was carefully reviewed by the IRB and Christiana Care legal services and is consistent with the law in the state of Delaware.

The goal was to seek to enroll all consecutive patients hospitalized for PCI. This was largely, although not absolutely, achieved as some patients were not in the hospital long enough to allow the care management to enroll them. The period of patient recruitment was from April 1, 2013 until March 31, 2015.

2.2. Care management

A team comprised of nurses, pharmacists, social workers and physicians (CareLink Services) provided care management to program participants. The CareLink team underwent web-based health coach training and continuous education about clinical issues and community resources. Detailed care plans and interaction schedules were developed for patients at each severity level. The care plans were integrated into our IT-enabled care management platform, utilizing the ‘bundling’ of tasks and auto-firing of future tasks based on planned interaction schedules.

An embedded Care Manager met with new enrollees in the hospital and coordinated immediate post-discharge care. This included the scheduling of first follow-up appointments with cardiologists and primary care providers, ensuring access to discharge medications, and a ranging transportation. CareLink staff conducted most interactions with enrollees by telephone. During these calls, assessments were made on a series of clinical issues [e.g. chest pain, shortness of breath, fluid overload, medication adherence, symptoms or concerns related to co-morbidities] and non-clinical issues [e.g. difficulties in scheduling or attending follow-up visits, or barriers to obtaining medications]. CareLink staff engaged a network of resources including physicians, pharmacies or community organizations to resolve concerns. Enrollees were empowered to call CareLink directly for either clinical or non-clinical issues. CareLink staff also met with patients periodically at appointments in physician’s offices, and engaged in video-conferences with enrollees receiving Home Health Care services.

CareLink leadership invested substantial effort in developing relationships with clinical providers in the hospital and in post-acute care medical practices. A CareLink pharmacist developed close ties with our area pharmacies so as to be able to provide patients more options such as home delivery or pill-box filling. The CareLink team joined a home health care agency and area skilled nursing facilities by weekly teleconference for updates on enrollees. CareLink cultivated a method of direct contact with managers at high volume cardiology practices to streamline needs such as scheduling of urgent appointments.

In order to increase the adherence to statins, our pharmacist under-took detailed medication reconciliation with high-risk patients. In addition, if any member of the CareLink team recognized that a patient was not on an appropriate high-intensity statin, the pharmacist reviewed the medications and called prescribers to alert them to the possibility of this gap in care. CareLink provided home blood pressure monitors to patients in need of them, and reviewed blood pressure readings at each telephone call. Education about the need for

medication adherence and diet and lifestyle modification was regularly given. CareLink routinely identified enrollees who were active smokers and counseled them repeatedly about options for smoking cessation and referred them to community programs. CareLink encouraged enrollment in cardiac rehabilitation and facilitated scheduling.

CareLink placed heavy emphasis on directing patients to appropriate sites for regular follow-up or urgent care, and pro-actively identified issues that could lead to the need for emergency care. The CareLink Medical Director undertook a detailed analysis of each high-risk patient, attempting to detect all potential factors that could lead to readmission. A model to predict patients at high risk for readmissions was developed by studying the pre-Bridges patient population and was used to further help in identifying high-risk patients early at admission [12]. Further-more, the entire CareLink team participated in a weekly review of all high-risk patients, working collaboratively to brainstorm solutions for patients' needs. A regular review of readmissions or complications in patients' progress was undertaken by the whole team in an attempt to learn lessons that were then applied to the care of future patients.

2.3. Information technology methods

The design goal for the health information technology infrastructure was to eliminate both [1]: the data divide between existing data sources that have been developed but that currently operate in isolation and [2], the clinical divide that exists between clinical care settings and providers. The design of the HIT platform is based on the following guiding principles:

- The platform would be tested with a single disease state, but would support any disease state, population, care management, or utilization program.
- The CareLink “hub” would utilize software analytics to identify program participants and patients who need particular levels of service. This would be done through the use of data analytics and real-time algorithms that would react to individual data points. The goal was to eliminate a one-size-fits-all care plan; care management was to be patient specific, based on acuteness and severity of illness.
- Care management software was implemented in a manner that had not previously been used by care provider organizations.
- A real-time “learning” data environment was established to continuously inform the program managers of best practices and innovative learnings.

Recognizing that patients don't receive all their care within one closed healthcare system, the data platform was designed to integrate clinical data that is generated across multiple delivery sites and health systems using various technology solutions. A cross-organization data platform was designed to consume information from disparate systems, both within Christiana Care and elsewhere in Delaware, on which predictive analytics are used to identify cohorts of patient who will receive required care management. This data platform is used for three purposes [1]: to analyze clinical data from disparate systems and multiple business entities [2], to use evidence-based algorithms to generate operational tasks for the

CareLink Hub staff, and [3] to observe correlations and other findings that relate to clinical care. The technical platform is described in detail in the online appendix.

2.4. Outcomes

We identified inpatient, non-elective readmissions to Christiana Care within 30 days of discharge from the index procedure. We identified readmissions at our own system and we used QualityNet Data from CMS to identify readmissions at other hospitals. Scheduled admissions for staged PCI were not considered as readmissions. Patients reported outcomes were assessed at 30 days and it included: 1- The CTM-3 (Three-Item Care Transition Measure) a three-question scale to assess preparation for discharge, with higher numbers being better. The Seattle Angina Questionnaire-7 (SAQ-7) scores for the domains of physical limitation, angina frequency and quality of life (or disease perception). Patients were studied for achievement of LDL cholesterol and blood pressure goals (<100 mg/dL for LDL-C and <140/90 for blood pressure) at 1 year. Follow-up timing after discharge was assessed as well.

2.5. Statistical analysis of outcome measures

We compared outcomes for three years prior to and two years of the bridges program (first row of Table 1). Continuous variables are reported as means (summarized as mean $\pm$ SD) and standard deviations, categorical variables as percentages (summarized as frequency (%)). Differences in demographic and clinical variables between Bridges years were analyzed by linear regression for continuous variables using Student's *t*-test or logistic regression for dichotomous variables using χ^2 test. Variables Trends (over the Bridges study period) in 30- day, non-elective readmission rates and blood pressure and LDL-C control at 6 months post-discharge were assessed by hierarchical logistic regression (some patients had more than one hospitalization). Trends were based on Bridges years or a quarterly time frame. Care Management contact with patients was categorized as 1–7, 8–14, 15–30 and N30 days after discharge. These data were analyzed by ordinal logistic regression. Graphical displays of trends over the Bridges study period included fractional polynomial (FP) smoothing of the trends [13]. Both unadjusted and adjusted analyses were performed for 30-day readmission. The covariates for adjusted analyses included: age, sex, race (black and other race with white as reference), previous number of hospitalizations within 6 months, previous AMI, previous PCI, previous CABG, total Elixhauser comorbidity count, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), diabetes, renal failure, hospital length of stay and discharge disposition (home with services, skilled nursing facility (SNF) and other facility with discharge to home as reference).

3. Results

The “Bridges” program enrolled a total of 2054 PCI patients from April 2013 through March 2015. The data of the program was compared with those of 3691 PCI patients in the 3 years prior to the program.

Table 1 shows the baseline characteristics for PCI patients enrolled during and before the Bridges program. Most patients were discharged home. Readmission rates are presented in

Table 2. There was no change over time. The time course of readmission after PCI is shown in Fig. 1 left panel (unadjusted) and Fig. 1 right panel (adjusted for baseline variables). There was no significant change over time for inpatient readmission, the composite of inpatient and observation stay and the composite of inpatient; observation and emergency department visits (Table 2).

Patient reported outcomes are in Table 2 and Fig. 2. From year one to year two of Bridges there was a slight improvement in the CTM-3 in the PCI population patients (Table 2). The Seattle Angina Questionnaire-7 (SAQ-7) scores for the domains of physical limitation (SAQ-7 PL), angina frequency (SAQ-7 AF) and quality of life (or disease perception, SAQ-7 QI) were assessed. There was an improvement in the domains of physical limitation (SAQ-7 PL). As for the domains of angina frequency (SAQ-7 AF) and quality of life (SAQ-7 QI); although there was an initial improvement, it was not sustainable over time (Fig. 2). The scores were generally high, suggesting at most mild residual angina.

Blood pressure and LDL cholesterol data are presented in Table 2. The majority of patients were at goal, with little clear opportunity for improvement. There was no significant change over time (Table 2). Time to care management contact with the Bridges patients is shown in Table 2 and Fig. 3. The majority of patients were contacted within the first seven days, which improved significantly over time (Table 2).

4. Discussion

We have developed and implemented an innovative approach to care management for population health with novel use of information technology. The information technology solution included 1) data integration, 2) care management support and 3) data analytics. This overall program bridges care from hospital to home, incorporating both inpatient and out-patient care and crosses between health system and multiple independent care facilities. It makes use of the regional health information exchange to provide data from outside of Christiana Care to inform care management. This program successfully enrolled PCI patients between April 2013 and March 2015. We have been able to successfully provide care and measure outcomes in these patients. The program has yet to impact measures of outcome.

Health care systems have traditionally provided acute care and variable levels of continuing care. Even when out-patient care following an acute episode is provided within the health care system, there is often poor coordination between in-patient and out-patient care [4]. Care providers in their offices will generally be poorly informed concerning details of patients' care provided outside their offices. They will generally not have ready access to information, and even if available, it will not be provided in an organized comprehensive manner. In addition there will be sociological and economic concerns of their patients that most care providers will not be able to impact. The CareLink program offers at least a potential solution to this patient management problem.

There has been a general recognition that society is not well served by hospitals providing acute care and leaving out-patient care to the community with little coordination between

them [14]. In particular, patients are at risk when they transition from hospital to home after an acute care episode [3,4]. Patients at such times will often have considerable changes in their medications and ability to care for themselves, placing stress on patients and families. Thus, patients who cannot cope with the care transition may be at high risk for readmission and recurrent events. Ischemic heart disease offers a striking example of the limitations of the traditional pattern of care. Ischemic heart disease is common and in-patient episodes are expensive [15]. There are also compelling clinical trial data that appropriate medical care will prevent additional cardiovascular events [8]. In addition, there are compelling data that many patients do not adhere to evidence based medical therapies [16]. The goal of care management must be to assist patients in overcoming the obstacles to continuing optimal medical therapy.

The information technology (IT) enabled care management program provides an approach to achieving population health and helping patients cope with the social determinants of their health and achieving the goal of optimal medical therapy. However, there have been limitations to this program. It is expensive and difficult to implement. There are presently no off-the-shelf software programs expressly designed for this purpose. The software that exists is generally not interoperable, and thus normalization of the data is a big undertaking. The skill sets in the care management hub are extensive, including care managers, patients' navigators, pharmacists and physicians. Creating such an entity is difficult and time consuming. Getting the software to the point where it will really serve the care management hub is likely to be a several year undertaking. The difficulties of implementing a program such as this may limit its generalizability. However, once developed this approach may offer a system-wide platform for delivering population health.

Although some earlier data suggested that care management might offer an effective strategy for reducing readmissions and associated costs especially if it was directed towards those who are at higher risk for readmission, this was not shown in our study [9,10,17]. It has been suggested that case management intervention needs to start during the hospitalization so that the care quality and patient education can be maximized during the hospital stay [18]. In our approach, we involved all patients early on and coordinated the inpatient and outpatient care. We even developed a locally driven prediction model with ability to predict those and high risk early during admission and directed additional resources towards those at higher risk [12]. Despite the complex program and resources we could not reduce readmission and achieved very minimal improvement in other goal of care.

There are a number of limitations to this study. This was a single institution, observational study, using a time-series approach to assessing the effect of the care management intervention. A randomized trial of the care management intervention was not felt to be practical. There may also not have been enough time for the intervention to affect metrics of readmission or other measure of outcome. Efforts to reduce readmission and improve overall care have been on-going for some years, so at least some of the ability to improve outcomes may have been limited by generally good outcomes at baseline.

5. Conclusion

In conclusion, we have developed and successfully implemented an approach to information technology enabled care management with the intent of improving population health for patients with ischemic heart disease. While we have not been able to reduce readmissions or costs to date, the Bridges grant has facilitated the development of our institutional infrastructure for population health. Thus, Bridges is something of an institutional pilot. During the course of the Bridges program it became clear that reducing readmissions was going to be quite difficult, but that there were more important opportunities for optimizing care. The key lesson of the Bridges program is that population health cannot focus on preventing readmissions over a short time period after an acute event, but must rather focus on the major goal of keeping people healthy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Fig. 1.
30 days non-elective readmissions with functional polynomial smoothing.

Fig. 2. PCI patients' reported outcomes. (Abbreviations: PCI: percutaneous coronary intervention, CTM: care transition measure, SAQ: Seattle Angina Questionnaire, PL: physical limitation, AF: angina frequency, QL: quality of life.)

Fig. 3.
PCI patients' care management contact following discharge.

Table 1

PCI demographic and clinical characteristics by Bridges year.

Variable	Pre-Bridges year 3 4/1/2010–3/31/2011	Pre-Bridges year 2 4/1/2011–3/31/2012	Pre-Bridges year 1 4/1/2012–3/31/2013	Bridges year 1 4/1/2013–3/31/2014	Bridges year 2 4/1/2014–3/31/2015	P value
Dates of enrollment						N/A
Patients #	1280	1254	1157	1017	1037	N/A
Hospitalization #	1434	1504	1476	1386	1449	N/A
Age (years)	63.7 ± 12.2	64.5 ± 12.2	64.6 ± 12.3	64.2 ± 11.9	64.9 ± 11.8	0.091
Male (%)	70.6	67.4	67.2	68.1	67.6	0.195
Race (%)						
White	84.4	81.0	81.5	84.1	79.9	0.120
Black	11.5	13.8	13.1	11.2	14.6	
Other	4.1	5.2	5.4	4.7	5.5	
Previous AMI	10.2	10.6	12.7	11.3	10.4	0.704
Previous PCI	35.4	35.2	37.3	37.7	36.0	0.380
Previous CABG	9.3	9.0	10.4	9.5	8.3	0.594
Previous hospitalization within 6 months (%)						
0	70.7	70.6	71.4	68.7	68.1	0.108
1	19.3	19.9	18.7	17.9	21.0	
>1	10.0	9.5	9.9	13.4	10.9	
Insurance (%)						
Medicare	49.4	51.7	53.4	51.0	54.4	<0.001
Medicaid	5.3	5.7	6.9	7.9	8.1	
Private	41.1	38.0	36.6	36.9	34.6	
Self pay	3.4	3.9	1.1	1.5	0.3	
Other	0.8	0.7	2.0	2.7	2.5	
Elective (%)	37.4	36.3	35.6	36.2	33.1	0.034
Transfer (%)	6.1	9.2	7.3	5.9	4.8	0.002
Elixhauser comorbidities						
Total count	3.2 ± 2.8	3.5 ± 2.9	3.7 ± 2.9	3.9 ± 3.0	3.8 ± 3.1	<0.001
CHF (%)	15.2	18.6	17.2	20.3	20.1	0.002
COPD (%)	20.7	19.6	23.9	22.9	22.7	0.063

Variable	Pre-Bridges year 3	Pre-Bridges year 2	Pre-Bridges year 1	Bridges year 1	Bridges year 2	P value
Diabetes (%)	36.7	38.8	40.3	42.7	42.9	<0.001
Renal failure (%)	13.7	15.6	13.9	14.3	15.5	0.515
Hypertension (%)	78.5	83.1	88.0	87.5	86.7	<0.001
Depression (%)	13.2	13.3	13.7	17.0	15.3	0.020
Admission BMI	30.9 ± 7.5	31.0±6.7	31.3 ± 7.5	30.8 ± 6.8	30.7 ± 6.6	0.382
Length of stay (days)	2.9 ± 3.8	2.9 ± 4.1	2.7 ± 3.3	2.6 ± 4.5	2.9 ± 5.3	0.486
Discharge disposition (%)						
Home	89.6	89.2	86.9	84.0	85.6	<0.001
Home with services	5.2	5.4	8.0	10.6	8.4	
SNF	1.9	2.7	2.0	1.6	2.1	
Other facility	1.3	1.0	1.8	1.9	1.9	
Died in hospital	2.0	1.7	1.4	2.0	2.0	

Continuous variables are mean ± 1 standard deviation. Abbreviations: AMI: acute myocardial infarction, PCI: percutaneous coronary intervention, CABG: coronary artery bypass grafting, CHF: congestive heart failure, COPD: chronic obstructive pulmonary disease, BMI: body mass index, SNF: skilled nursing facility.

Table 2

PCI patients outcomes after enrollment in Bridges the Divide program.

Outcome	Pre-Bridges year 3	Pre-Bridges year 2	Pre-Bridges year 1	Bridges 1	Bridges year 2	P value
<i>A - Non-elective readmission rates (%)</i>						
Readmission						
I	8.0	9.2	7.0	9.3	7.5	0.409
IO	12.3	12.8	10.5	12.5	12.0	0.396
IOE	16.1	17.0	15.0	16.6	16.1	0.503
<i>B - Blood pressure and LDL-C level control at 6 months post-discharge.</i>						
Blood pressure control	74.1 (243)	76.2 (626)	73.6 (702)	73.4 (684)	70.0 (729)	0.049
LDL-C level control	72.7 (176)	74.9 (283)	73.7 (251)	78.8 (217)	76.0 (246)	0.382
<i>C - Patient reported outcomes of PCI Bridges patients.</i>						
CTM-3	N/A	N/A	N/A	80.3 ± 17.1	83.1 ± 17.0	0.012
SAQ-7 PL	N/A	N/A	N/A	95.9 ± 12.4	98.5 ± 8.0	0.009
SAQ-7 AF	N/A	N/A	N/A	92.7 ± 14.8	93.3 ± 15.2	0.659
SAQ-7 QL	N/A	N/A	N/A	87.2 ± 22.2	86.1 ± 19.7	0.587
<i>D - Care management contact with PCI Bridges patients (%).</i>						
Day 1–7	N/A	N/A	N/A	80.0	90.4	<0.001
Day 8–14	N/A	N/A	N/A	8.2	5.8	
Day 15–30	N/A	N/A	N/A	5.1	2.6	
Day >30	N/A	N/A	N/A	6.7	1.2	

Abbreviations: PCI: percutaneous coronary intervention, I: inpatients, IO: inpatient or observation, IOE: inpatient, observation or emergency department, LDL-C: low density lipoprotein cholesterol, CTM: care transition measure, SAQ: Seattle Angina Questionnaire, PL: physical limitation, AF: angina frequency, QL: quality of life.