2020

The Association Between the Medicare Bundled Payments Initiative and Cardiac Rehabilitation Enrollment

Jing Li
University of Kentucky, jingli.tj@uky.edu

STUDENT AGREEMENT:

I represent that my capstone and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained needed written permission statement(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine) which will be submitted to UKnowledge as Additional File.

I hereby grant to The University of Kentucky and its agents the irrevocable, non-exclusive, and royalty-free license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless an embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

REVIEW, APPROVAL AND ACCEPTANCE

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's capstone including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Jing Li, Student

Ty Borders, Committee Chair

Richard Ingram, Director of Graduate Studies

THE ASSOCIATION BETWEEN THE MEDICARE BUNDLED PAYMENTS INITIATIVE AND CARDIAC REHABILITATION ENROLLMENT

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Public Health in the
College of Public Health
at the University of Kentucky

By

Jing Li

Lexington, Kentucky

Co- Directors: Dr. Ty Borders, Professor of Health Management and Policy

and Dr. Glen Mays, Professor of Health Systems, Management and Policy

Lexington, Kentucky

2020

https://orcid.org/0000-0003-3433-5661

ABSTRACT OF DISSERTATION

THE ASSOCIATION BETWEEN THE MEDICARE BUNDLED PAYMENTS INITIATIVE AND CARDIAC REHABILITATION ENROLLMENT

Cardiac rehabilitation (CR) represents a proven-effective intervention in secondary prevention that can stabilize, slow or reverse cardiovascular disease (CVD) progression, facilitate the ability of the patient to preserve or resume an active and functional contribution to the community, and reduce the risk of future cardiovascular events. Despite multiple guideline recommendations for CR and coverage by Medicare and most health plans, participation in CR remains low. Bundled payments are one of the suggested reforms designed to move health care providers toward to value-based care and is very applicable to the CR utilization in patients diagnosed with acute myocardial infarction (AMI) or have undergone through procedures of coronary artery bypass grafting (CABG) or percutaneous coronary interventions (PCI), since it has the potential to catalyze and accelerate the establishment of innovative delivery models that could achieve greater communication and coordination among providers across the continuum of care and improve CR referral, enrollment and adherence.

This study examined the association of Center for Medicare and Medicaid Services (CMS) Bundled Payments for Care Improvement (BCPI) initiative and CR uptake, patient outcomes and health care utilization among Medicare beneficiaries, as well as the potential collateral effect on health disparities in CR uptake and health outcomes in patients who are female, living in rural areas, are non-white, or are dual-eligible in Medicare and Medicaid, by conducting difference-in-difference analysis to a secondary data set.

In our analysis, we found that participation in the CMS BPCI initiative for cardiac episodes (AMI, CABG, PCI) was not associated with an increase in 3-month CR enrollment. The differential changes tended to be in both directions, though when we looked at hospitals by initiation of participation, the early-entrant cohort (i.e., Jan-BPCI) showed an observed improvement in 3-month CR enrollment rate. The disparities in CR enrollment regarding race, sex, socioeconomic status and rurality were demonstrated in our study. Though BPCI initiative has potential to reduce disparities in CR enrollment, our results did not show reduced disparities in CR enrollment among vulnerable groups regarding sex and SES, compared pre- and post- BPCI implementation.

Our study suggests: 1) it is imperative to describe the plans for integration of process and outcome data in design of model and advance understanding of how these models might be implemented to improve health for future policy changes and new initiatives; and 2) it is imperative to advance understanding of how these models might be designed and implemented to reduce health disparities. The new bundled payments policy needs to be sufficiently flexible to allow and encourage health systems to determine and implement the best approaches to reduce disparities in their settings and populations.

KEYWORDS: Cardiac Rehab, Bundled Payment, Health Policy, Payment Model, Health Disparities

Jing Li

(Name of Student)

04/15/2020

Date

THE ASSOCIATION BETWEEN THE MEDICARE BUNDLED PAYMENTS INITIATIVE AND CARDIAC REHABILITATION ENROLLMENT

By
Jing Li

Ty Borders
Co-Director of Dissertation

Glen Mays
Co-Director of Dissertation

Richard Ingram
Director of Graduate Studies

04/20/2020
Date

ACKNOWLEDGMENTS

Many thanks to my committee members, Drs. Ty Borders, Glen Mays, Susan Smyth and Arny Stromberg. I am so grateful for your encouragement and the time you dedicated to help me on this journey.

I am also grateful to the many professors and teachers who shared their knowledge and wisdom with me throughout my academic life.

Finally, thank you, Dr. Mark V. Williams, for your valuable feedback and support throughout this process. I would not be where I am today without you providing me the initial opportunity to work with you and your team in addition to your encouragement and support. I will be forever grateful for your commitment to me.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 3 STUDY MANUSCRIPT ONE Tables

CHAPTER 4 STUDY MANUSCRIPT TWO Tables

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

1.1 Background of the Project

Health care spending in the United States has significantly increased accounting for approximately 20% of national health spending and 15% of federal budget.[1,2] This poses a substantial threat to long-term economic viability and competitiveness of the country.[3] A major cause of the high health care costs is the still dominant fee-for-service (FFS) reimbursement system that promotes delivery of fragmented care by physicians, hospitals and post-acute care settings.[4] Through the FFS model, claims are filed and paid separately for services provided even when they are related to single episode of care.[5] This approach to payment is wasteful, discourages resource stewardship and care coordination across multiple providers affecting quality of care and patient experience.[6]

Bundled payments are one of the suggested reforms designed to address the inadequacies of the FFS and to move providers away from the FFS structure toward payment models that seek to provide high quality healthcare at affordable costs.[5,7-11] Under bundled payments, providers are responsible for the total cost of pre-determined episode of care including labor costs, medical devices such as implants, complications, post-acute care and readmissions.[12] Payments are distributed among all providers in a health care system involved with that patient, including hospitals and other facilities.

Following the passage of comprehensive health reform in 2010, bundled payments have become one of the central strategies utilized by the Centers for Medicare and Medicaid Services (CMS) to increase health care quality while controlling costs.[12] The Bundled Payments for Care Improvement (BCPI) Initiative launched by the Center for Medicare and Medicaid Innovation (CMMI) in 2013 included four bundled payment tracks made available to hospitals, physician groups, and post-acute care facilities willing to participate. The four tracks included different phases of care (hospitalization and associated readmission vs hospitalization and post discharge care vs post-acute care only), 48 clinical conditions (e.g. AMI-acute myocardial infarction, CABG-coronary artery bypass grafting, hip replacement), and 3 episode lengths (30, 60 and 90 days).[4]

Cardiovascular disease (CVD) remains the leading cause of mortality and morbidity worldwide[13-15] and in the U.S.—impacting more than 13 million Americans with an estimated cost of over $200 billion per year.[16] CVD also is the leading cause of premature and permanent disability and has a considerable impact on individuals and communities. CVD is mainly attributable to modifiable risk factors, such as hypertension, dyslipidemia, obesity, smoking, and a sedentary lifestyle. Recent estimates attribute over 1 in every 3 deaths to CVD and over 90% of CVD morbidity and mortality to preventable risk factors.[17] Cardiac rehabilitation (CR) represents a proven-effective intervention in secondary prevention that can stabilize, slow or reverse CVD progression, facilitate the ability of the patient to preserve or resume an active and functional contribution to the community, and reduce the risk of future cardiovascular events.[18] Extensive evidence[19-22] has shown that CR reduces risk of CVD events over the ensuing year; lowers hospital readmissions, mortality, and costs; enhances medication adherence; and improves exercise performance, quality of life and psychological well-being. Despite multiple guideline recommendations for CR and coverage by Medicare and most health plans, participation in CR remains low.[16,23,24] Moreover, only about 50% of patients referred to CR actually enrolled and participated.[25,26]

Health disparities are a major Issue in CR participation and adherence. Older persons, women, nonwhites, those living in lower socioeconomic (SES) neighborhoods, and individuals with comorbidities are less likely to enroll in CR programs.[27-30] Poor participation and adherence to CR typically leads to worse outcomes in these underrepresented groups.[31-33]

1.2 Study Goal and Specific Aims

The FFS reimbursement policies do not account for the potential downstream cost savings, e.g., the one associated with reduced readmissions. Current reimbursement policies are also generally inadequate to cover expenses associated with the infrastructural requirements of a center-based CR program and require direct hospital or health system support. Whether new payment mechanisms in the era of value-based care will alter this dynamic remains to be seen. Bundle payment is very applicable to the CR utilization in patients diagnosed with AMI or have undergone through procedures of CABG or percutaneous coronary interventions (PCI),[34] since it has the potential to catalyze and accelerate the establishment of innovative delivery models, such as team-based care that could achieve greater communication and coordination among providers across the continuum of care and improve CR referral, enrollment and adherence.[35] Through the BPCI initiative, over 200 health systems selected AMI, CABG, and PCI as selected episodes in Model 2. With the incentives under the shared-saving contracts, these providers have implemented a variety of quality improvement and care management programs which have broadly changed their care delivery system and processes. With these, we expect that there will be a better CR uptake. Furthermore, at the core of bundled payments is the opportunity to provide patients with an end-to-end view of a required treatment option, along with a clear explanation of episode treatments, costs, experiences, and outcomes.[36] Therefore, there is an expectation that BPCI models can reduce healthcare disparities among minorities by enhancing healthcare access and standardizing care pathways. The study specific aims are listed below.

Aim 1: Evaluate the association between BPCI initiative and CR enrollment

Hypothesis: The patients discharged from hospitals that are in BPCI model had better CR enrollment rate.

Aim 2: Assess the patient outcomes including 7-day emergency department (ED) visit, 30-day readmission, and examine the disparity among race, sex, urban/rural, and socioeconomic groups.

Hypothesis: The patients discharged from hospitals that are in BPCI model had lower post-discharge ED visits and readmissions. The health disparity was not worsened.

Aim 3: Assess the health service utilization changes by BPCI initiative.

Hypothesis: The patients discharged from hospitals that are in BPCI model had lower inpatient rehabilitation facility and skilled nursing facility (SNF) use and higher outpatient services such as home health.

1.3 Overview of Project Processes

Through a PCORI (Patient Centered Outcome Research Institute)-funded study, our research team obtained data from ResDAC (Research Data Assistance Center) for 390 hospitals who completed a survey about their care transition practices, which includes about 3.5 million Medicare fee-for-services beneficiaries' 2009-2014 Part A & B claims data. These 390 hospitals demonstrated broad diversity with respect to geographic region, urban or rural location, system membership, academic affiliation, and bed capacity, while representing a sample comparative to hospitals across the United States.

This study will examine the association of BPCI initiative and CR uptake, patient outcomes (e.g., 7-day emergency department visits, 30-day readmissions), and health care utilization among Medicare beneficiaries, as well as the potential collateral effect on health disparities in CR uptake and health outcomes in patients who are female, living in rural areas, are non-white, or are dual-eligible in Medicare and Medicaid, by conducting difference-in-difference analysis to a secondary data set.

CHAPTER 2. LITERATURE REVIEW

2.1 Treatment Gap and Health Disparities in Cardiac Rehabilitation

The multifaceted interventions CR programs offer include exercise training, nutrition counseling, cardiovascular risk factor reduction strategies, and psychosocial and vocational support. Nevertheless, CR programs are grossly underused and rates of referral and participation have been low.[37-39] Limited access, lack of insurance coverage and out-of-pocket cost for co-pays have been attributed to these low rates.[40] Furthermore, according to several studies, there are limited data on current CR participation and the national use patterns and predictors of CR use have not been evaluated thoroughly.[37-40]

Peters et al.[37] conducted a population-based, cross-sectional analysis to assess the trends in CR participation post AMI and to identify predictors of participation using data from the Behavioral Risk Factor Surveillance System conducted by Centers for Disease Control and Prevention. The study found that the participation levels in CR had remained relatively flat over the past decade despite increases in referral rates: among approximately 33,000 survey respondents between 2005 and 2015, CR participation ranged from 35% in 2005 to 39% in 2009 and from 38% in 2011 to 32% in 2015. Multivariable logistic regression showed that women, blacks, and uneducated patients were less likely to participate in CR.

Doll and colleagues[38] assessed rates of referral to CR, as well as completeness of participation (number of sessions attended), among older adults and compared characteristics between patients who did and did not participate after referral. The authors linked clinical data from the National Cardiovascular Data Registry Acute Coronary Treatment Intervention Outcomes Network Registry-Get With the Guidelines to Medicare claims for patients 65 years or older presenting with AMI from January 2007 through December 2010. Findings from this study showed that in over 50,000 patients, only 62.4% were referred when they were discharged from the hospital, and approximately one third of the patients who were referred attended an initial session. The authors conclude that quality improvement efforts should focus not only on increasing referral rates but also on addressing barriers to attending CR sessions, such as travel distance, copayments, and lack of coordination between inpatient and outpatient clinicians. Alternative methods of providing CR, such as home-based programs, may be needed to improve participation rates.[38]

In another study, Sukul et al.[39] linked two data sources; 1) Blue Cross Blue Shield of Michigan Cardiovascular Consortium (BMC2) clinical PCI registry and 2) claims-based registry developed by the Michigan Value Collaborative (MVC) to evaluate the association between the participation of CR among patients referred and the previously literature described covariates, including patient demographics, clinical characteristics, comorbidities, insurance status, and travel distances. Between January 2012 and October 2016, of over 40,000 PCI episodes, only 31.5% of patients attended at least 1 CR session within 90 days after discharge. Findings from this study showed that patients with more acute presentations of PCI were more likely to attend CR, the presence of comorbidities was generally associated with decreased odds of attending CR, patients who were dual eligible were significantly less likely to attend CR after a referral was made, and patients living in ZIP codes with a higher proportion of families below 125% of the federal poverty level or a higher Area Deprivation Index were associated with a trend toward lower odds of attending CR. [39]

Suaya and colleagues[40] analyzed outpatient CR use after hospitalizations for AMI or CABG procedure in over 250,000 FFS beneficiaries aged ≥65 years who survived for at least 30 days after hospital discharge using Medicare claims data. They used multivariable analyses to identify predictors of CR use and to quantify geographic variations in its use. They also obtained unadjusted, adjusted-smoothed, and standardized rates of CR use by state. According to this study, overall, 13.9% of patients hospitalized for AMI and 31.0% of patients who underwent CABG used CR. Consistent with other studies, older individuals, women, nonwhites, and patients with comorbidities were significantly less likely to receive CR. Undergone CABG procedure during the index hospitalization, higher median household income, higher level of education, and shorter distance to the nearest CR program were important predictors of higher CR use. Adjusted CR use varied 9-fold among states, ranging from 6.6% in Idaho to 53.5% in Nebraska. The highest CR use rates were clustered in the north central states of the United States.[40]

Frechette et al.[41] assessed the rates of referral and participation, along with a preliminary analysis of potential barriers to participation to the CR program at Dartmouth-Hitchcock Medical Center (DHMC). Through a quality improvement–based retrospective review of over 700 consecutive patients who underwent PCI, CABG, or valve surgery from January 1, 2015 to June 30, 2015, the authors aimed to determine whether the patient was referred for CR. Participation rates and the effect of time delay and patient-specific factors on participation were also examined. The review found that 98% post-procedural patients were evaluated by the inpatient rehabilitation nurse and 76.5% of patients were referred to DHMC or regional rehabilitation programs. Of those referred, the participation rates were 84% in those referred to on-site program and 60% in those referred to regional program respectively. The wait time between hospital discharge and CR initiation was negatively correlated with participation rates for both on-site and regional programs.

In a study conducted by Zhang and colleagues,[42] the authors examined predictors of initiation, adherence, and completion of CR in a unique, minority predominant, urban population. Approximately 600 patients with AMI, coronary artery disease, HF, stable angina, and valvular heart disease who were first time-time referred to the outpatient CR program at Montefiore Medical Center between 1997 and 2010 were included in the analysis. Adherence was defined as attendance of at least 18 sessions of CR, and completion was defined as attendance of 36 sessions. Of the referred patients, 67.8% initiated CR, and 57.3% of those attended at least 18 sessions while only 35.0% of those completed all sessions. This study also identified patients of nonwhite and lack of insurance were less likely to initiate CR. White patients and older patients were more likely to adhere to CR, while requirement of a copayment was associated with poor adherence.

The CMS tracks referral to CR after a qualifying diagnosis (AMI, PCI, CABG surgery, HF, valve surgery) as a performance measure. Compared with other hospital quality measures such as aspirin and β-blocker use after myocardial infarction, CR referral rates are unfavorably low. Furthermore, referral to CR does not assure that a patient will enroll or complete a recommended treatment course. System-based mechanisms to improve referral rates are needed, but are unlikely to meaningfully narrow this treatment gap unless they are supplemented by other efforts. In a survey study to a national sample of CR programs, the results highlighted the gaps in the use of evidence-based strategies that have been shown to improve delivery of CR. While programs were aware of participation gaps, appeared able to monitor rates, and could probably institute process changes, the monitoring of participation rates was suboptimal, quality improvement initiatives were infrequent, and proven strategies for increasing patient participation were inconsistently utilized.[43]

2.2 Bundled Payments and Cardiovascular Care

Evidence suggests that bundled payments are most visible and impactful in the area of cardiovascular care.[5] Previous studies have focused on CV, and it is likely that future studies will continue to do so because of the increasing rates of CVD in the United States, resulting to high medical costs and fatal outcomes.[44] Moreover, care for CVD include multiple providers and involves an interdisciplinary team including primary care, cardiology, cardiac surgery, anesthesiology radiology and others. In addition, CVD patients receive care in multiple health care settings. Given these factors, bundled payments have the potential to improve care coordination and generate savings for cardiovascular care.[5]

Cardiovascular conditions have played a critical role in the evolution and development of bundled payments.[5] In 1984, following the introduction of the Inpatient Prospective Payment System (IPPS), the Texas Heart Institute developed CardioVascular Care Providers, Inc., bundled hospital and physician charges together for cardiovascular surgery.[5,45] The plan was initially administered to non-Medicare patients (below 65 years) in 1984 and thereafter, extended to Medicare patients who required CABG procedure in 1993. Detailed evaluations of the program have been limited, though the results from the institute have claimed that the plan was beneficial to patients, physicians, and providers.[45] It was reported that, through this model, patients received quality medical care with little to none out-of-pocket expense as well as had increased access to care; physicians were able to establish and expand patient referral bases and reduce overhead expenses because of streamlined billing processes; and payers experienced large savings and were able to better predict costs for cardiovascular care.[45]

The Health Care Financing Administration (HCFA), now the CMS, initiated the Medicare Participating Heart Bypass Center Demonstration in 1991.[46] Medicare paid each of the participating hospitals a bundled payment for CABG to cover all inpatient and physician services as well as any costs related to readmissions. It was at the hospitals and physicians' discretion to divide the bundled payment the way they preferred. Four hospitals in initial cohort showed reductions in length of stay (LOS) and costs of care,[46] and then the program expanded to include three additional hospitals in 1993. All participating hospitals were also able to join privately managed care contracts that employed bundled payments for cardiac surgery.[5] Compared to control hospitals that utilized FFS, Medicare spending in participating hospitals decreased by 10% over the 5 years of the demonstration, and approximately 86% of the reduction was attributed to bundled payments.[5,46]

In 2006, Geisinger Health Plan, a large non-profit integrated delivery system in Pennsylvania, implemented Proven Care program for CABG in three facilities. This included bundled payment for CABG preoperative evaluation and workup, all hospital and physician fees, post-acute care including cardiac rehabilitation, care for post-operative complications and readmissions within 90 days from surgery. Implementation of bundled payment was in conjunction with an evidence-based, pay-for-performance program, which included introduction of 40 "best practice" components adopted from 20 clinical practice guidelines. This study compared 137 patients who underwent elective CABG in the year before implementation of Proven Care to 117 patients who underwent elective CABG after implementation of the program. This study found out that purchasers were highly receptive to bundled payments for CABG, citing a high valuation of financial predictability and aversion to open-ended risk, and high-costs of postoperative complications and treatment failure.[47] A 2007 analysis showed that a 90-day bundled payment and pay-for-performance package improved performance, reduced LOS, and reduced hospital charges by 5%.[47]

The Medicare Acute Care Episode (ACE) Demonstration that started in 2009 included 28 cardiac and 9 orthopedic inpatient surgical services and procedures and tested the use of a global payment for an episode of care as an alternative approach to payment for service delivery. The global payment covered all Part A and Part B services, including physician services, pertaining to the inpatient stay for Medicare FFS beneficiaries. The analysis showed that a modest savings ($585) per episode for Medicare Part A and B expected payments. However, payments for post–acute care services (which are not included in bundled payment) increased, resulting in a net $319 savings per episode.[48]

Previous studies have highlighted the potential of bundled payments to save costs,[49-51] discourage unnecessary care[5,52] and increase transparency. More so, bundled payments have shown to contribute to expanded referral bases and increased market share.[5]

The study by Sutherland and Borden[53] summarized the characteristics of 105 (out of the 107) hospitals participating in Phase 2 of the BPCI Model 2. The study compared the BPCI participants with non-BPCI participants using publicly reported performance data from the Hospital Value-Based Purchasing program. The 105 hospitals were predominantly large, urban hospitals with two thirds being teaching hospitals. Sutherland and Borden reported minor differences between PBCI participants and non-participants with both groups having similar quality scores for pneumonia, hospital acquired infections (HAIs) and heart failure.[53] They also reported that BPCI hospitals performed slightly better on surgical care scores, but performed more poorly on AMI, patient experience and total performance scores. With regards to the number of bundles covered by the participants, 54 of the 105 hospitals selected a single bundle of which 37 were participants in the Clinical Episode of Major Joint Replacement of the Lower Extremity.[53] The authors also reported that BPCI hospitals seem to be larger than most American hospitals and cautioned that this might hold important implications for the generalizability of the BPCI pilot findings to smaller hospitals.[53]

Edwards and colleagues (2015)[54] conducted retrospective analysis of readmissions data from a hospital in Arkansas that elected to participate in the BPCI Model 2 for major joint arthroplasty or reattachment of lower extremity with and without major complications and comorbidities. The hospital and its surgeon entered the Phase 2 period on October 1, 2013. As part of its participation, the hospital evaluated and improved its total joint arthroplasty (TJA) clinical pathway. The intervention included a system-wide contract with a healthcare consulting firm that provided IT infrastructure and trained care mangers (a nurse and a social worker) that served as remote patient navigators and managed the patients and the data related to the 120-day post-discharge episode. CMS data showed that the 30 day readmission for the hospital reduced from 16% to 9.2% during the clinical pathway redesign period. Average length of stay (LOS) for the same period was 1.2 days with 94% discharge to home. Patient satisfaction also increased. Although it is unclear whether the bundled payment or the clinical pathway intervention was directly responsible for the findings, the author argued that personalized communication and care management have significant impact for decreasing readmissions for TJA during a bundled payment model.[54]

Another study[55] reported on preliminary findings from a large, academic, tertiary, urban medical center that participated in a model 2 BPCI program for TJA. The BPCI model discussed in the study covered the costs incurred 72 hours before admission and all inpatient and all post–acute care for 90 days after discharge including physicians' services care by post-acute providers, readmissions, laboratory services, durable medical equipment, prosthetics, orthotics, and supplies. The intervention consisted of evidence-based episodic clinical pathways standardization (e.g., elimination of unnecessary testing) and care coordination infrastructure including the use of a dashboard in electronic medical records to facilitate communication among providers and for daily interdisciplinary rounds to discuss patient progress toward discharge. After one year, data on 721 Medicare primary TJA patients were available for analysis. Findings indicated a 10% reduction in Medicare cost when compared to the baseline period (although this calculation did not factor in the cost of implementing BPCI); decreased LOS (from 4.27 days in 2012 to 3.53 days in April 2015); decreased discharge to inpatient facilities (from 65% in 2012 to 38% in December 2013); and decreased readmission rates (from 17% in 2011 to 11% at the time of manuscript submission). In particular, readmission was more common among patients discharged to facility-based settings (13.7%) than those discharged to self-care or home health services (9%).[55]

Froemke and colleagues[56] analyzed preliminary data from a BPCI pilot site in Oregon that implemented standardized care pathways as a mechanism for improving efficiency and care quality. The study site consisted of two high volume hospitals (2400

TJA procedures per year). The pilot program covered elective primary TJA episode of care beginning 30 days pre-operation and ending 90 days post-discharge. The analyses compared LOS, discharge disposition, total allowed claims, operation room (OR) time, and implant cost were compared between a pre-pilot cohort (n=351) and the pilot cohort (n=317) of patients receiving elective total hip or knee arthroplasty (with DRG 469 or 470 codes). The cohorts were statistically similar in demographic and risk variables. Preliminary findings showed savings of about $256,800 dollars with 62.7% of the procedures performed during the pilot falling below the target price. Compared to the pre-pilot cohort, the pilot cohort showed statistically significant reduction in average LOSs (70.8 vs. 50.2 hours), more home self-care discharge (63.7% vs. 54.1%), and reduction in the total allowed claims per case. However, there were no statistically significant differences in OR time and implant cost.[56]

An analysis of BCPI in 2016[57] showed significant declines in per-episode spending for participants who selected 30-day cardiovascular episodes ($1625 in savings for cardiovascular conditions and $4149 for cardiovascular procedures), however, those declines were limited to patients who used post-acute care, while savings were no longer evident by 90 days.

A study by Navathe and colleagues[58] demonstrated the ability for bundled payments to lead to huge savings among top performing hospitals. The study findings highlighted a decrease in average per-episode payments by 21% from 2008 to 2015, with statistically significant decreases during BPCI participation. The health system's internal cost data showed that post-acute care accounted for 49% of savings, with 51% achieved through reductions in internal hospital costs (implants, blood supply, and room and board), which evidenced that the financial incentives under BPCI model was highlighted as a key motivator to surgeons to standardize implant use and hospital costs through alignment with the hospital.[58] However, the study found no effect on readmissions or emergency department visits.

Although these studies offered positive glimpses, it is not clear if the reported findings were due to participation in the BPCI or the implementation standardized inpatient pathway. Any hospital that implemented such a carefully planned and implemented clinical pathway could have reported similar findings without participating in the BPCI. It is also unclear whether or both of the elements of the intervention (i.e., standardization of clinical pathway and care coordination) contributed equally to the results.

Though there are some evidence that bundled payments are better alternatives to the FFS payment model, little is known about the processes and conditions under which they are successful. Bailit described bundled payments as an “unknown and challenging” but better approach to healthcare payment.[34] As earlier discussed, bundled care holds significant advantages – it reduces fragmentation and waste (i.e., promotes care coordination); promotes care redesign; and promotes transparency of the cost and quality of care.[36] Despite these advantages, bundled payments are not without limitations. Bundled payment models offer lower costs; however, lower costs could be offset by an increase in overall episode volume.[35] Bundled payments could also lead to unintended consequence – underuse of necessary services during a surgical episode,[35] with providers skimping on care (e.g., avoid readmission even when it is necessary) because they don’t want to spend beyond the limit.[59] Bundled payment increases the financial risks of the primary recipient or care coordinator, although an outlier payment policy could help address this problem.[59]

Bundled payment presents a double-edged challenge for hospitals with regards to managing their post-acute care referral networks. On the one hand, hospitals may choose to reduce their network for administrative purposes leading to disadvantages for patients.[59] The narrow networks that result from hospitals and physicians working with preferred post-acute care providers may reduce hospital and other providers' choice.[35] Patients, especially those in rural areas, may need to travel farther for care or may be cared for by providers who don't have the expertise required for treating their conditions.[59,60] On the other hand, maintaining a large number of post-acute providers will also hinder hospitals' ability to effectively manage care cost.[59]

Two new studies highlighted the challenges facing policymakers, health systems and providers in using bundled payments to achieve cost savings and better quality on a wide range of medical and surgical episodes. By comparing spending for patients in BPCI hospitals with spending for patients in non-BPCI hospitals, Navathe and colleagues[61] found hospitals had about $377 in adjusted savings for joint replacements in the original BPCI program for 2013 through 2016, compared with prior to the program. This is much lower than the CMS estimation, 3.9% vs 1.6% in cost reduction. They also found that providers joined BPCI earlier produced the majority of savings, compared with those that joined later. Furthermore, about 30% of the savings were driven by selection of patients whose cost were lower, either being healthier or having better social support. Agarwal et al[62] performed the first systematic review of 20 studies on three of the CMS' bundled payment initiatives — the ACE Demonstration, BPCI and the CCJR model and found that bundled payment has yet to produce spending reductions for medical and surgical conditions other than lower extremity joint replacement. This finding indicated that it may be the case that not all clinical episodes are appropriate for bundled payment models and emphasize the importance to continue examining the impact differences in outcomes by clinical episode. The review also found no evidence that the bundled-payment programs were associated with changes in patient outcomes or unintended consequences such as increased volume of procedures.

2.3 Bundled Payment and Health Disparities

Health disparities continue to persist in the United States[63] leading to variations in quality of care and health outcomes among different races, ethnicities and socio-economic status[64]. Eevidence suggests that alternative payment models such as value-based payments have potential in addressing health equity through payment reforms that reduce race or income-related disparities,[65] and many stakeholders espoused the notion that bundled payment models would reduce healthcare disparities among minorities by encouraging better case management, improving care coordination and standardizing care pathways. However, because prior health reform efforts have unintentionally increased disparities among the underserved,[66] there has been concern that a similar phenomenon could occur within bundled payment models. Some are concerned that BPCI may create unintended effects by prompting participating hospitals to increase the overall volume of episodes paid for by Medicare,[67] which could potentially eliminate program-related savings or prompt them to shift case mix to lower-risk patients.[68] For example, study found that patients undergone TKA and THA in the lower SES group had longer hospital length of stay, were more likely to be discharged to a rehabilitation facility, and be readmitted to the hospital within 90 days than the higher SES group.[69] It is possible that under bundled payment models, providers may improve their performance measures by avoiding high-risk patients (in regards utilization) since these payment models target quality outcomes and overall spending. Such risk selection is likely to contribute to disparity by denying access to care to patients based on health, demographic and socio-economic factors.

Navathe et al.[70] evaluated whether hospital BPCI participation for lower extremity joint replacement (LEJR) was associated with changes in overall volume at the market level and patient case mix.[70] In this observational study, the authors used Medicare claims data and conducted a difference-in-differences analysis to compare 131 markets (hospital referral regions) with at least 1 BPCI participating hospital (n = 322) and 175 markets with no participating hospitals (n = 1340), accounting for 580,043 Medicare beneficiaries treated before and 462,161 after establishing the BPCI initiative. They found volume increases in both BPCI and non-BPCI markets between 2011 and 2015, but no significant differences due to BPCI participation. The adjusted difference-in-differences estimate between the BPCI and non-BPCI markets was 0.32% (95% CI, −0.06% to 0.69%; P = .10). The results suggest that increased volume at BPCI hospitals is likely a result of growing market share, not overall volume spikes. To study the effect of BPCI participation on patient selection the authors compared 20 patient characteristics, including comorbidities, demographics, socioeconomics, and prior utilization, at 265 matched BPCI and non-BPCI hospitals. Findings indicated largely no significant differences across any relevant case-mix measures, which suggests that bundled payments did not significantly affect health disparities. However, patients at BPCI hospitals were less likely to have been admitted to a skilled nursing facility (SNF) in the prior 12 months, leading to a concern that hospitals may be avoiding patients with a history of institutional care. On the other hand, it may be the case that SNF admission is associated with other clinical factors that make joint replacement a less effective option for such patients.[70]

A study by Ibrahim[71] examined racial disparities in total joint replacement among African American patients and noticed that disparities manifested through the likelihood of having joint replacement surgery and quality of postoperative care provided. The study found that though African American patients are disproportionately affected by arthritis, work limitations and severe pain, they were less likely to undergo joint replacement surgery than their white counterparts. This is partially linked to lower preference by African American patients to receive joint replacement, however, other provider and system factors play additional role. In another study, Ibrahim and colleagues[72] showed that even after adjusting for individual and facility level factors, African American patients undergoing elective knee joint replacement were more likely to be discharged to an inpatient rehabilitation facility (IRF) or a SNF rather than to a home with qualified health services. Studies have linked discharge to an IRF/SNF to significantly higher risks of 30-day readmission to the hospital rather than those discharged home with health services.[73]

Fang et al.[74] examined racial disparities in discharge destination after total knee arthroplasty (TKA) during early BPCI implementation and during late implementation at one large academic urban hospital in Philadelphia, Pennsylvania. The study found that though all races showed trends to decreasing SNF use during the late implementation, African American patients were more likely to be discharged to SNF as opposed to home than white patients at both early and late BPCI implementation. For both early and late implementation periods, African American patients had significantly higher 90-day readmissions and longer length of stay than white patients, though the 90-day readmission rates decreased for all groups during the time period after BPCI implementation. The better preoperative preparation of patients and discharge planning stimulated by BPCI implementation likely contributed to the overall improvement in post-acute utilization and health outcome, however, there was no significant change (improvement) in racial variations in discharge destination and outcomes after elective TKA.[74]

Early studies of bundled payments for surgical procedures found no evidence of patient selection, and target prices are adjusted partly based on patient risk. Strong financial incentives to provide high value post-acute care may be beneficial to all patients irrespective of their race and SES status. According to Burke and Ibrahim (2018),[75] hospitals that have utilized bundled payments have saved costs through reduction of levels of post-acute care as a result of improved decision making that aim to reduce disparities. Payment reforms have also helped address disparities through incentives provided to hospitals that seek to improve outcomes in populations known to be at risk such as minority, low-income and those disparately affected by certain medical conditions.[76] As a way forward, researchers need to carefully consider how bundled payments may interact with existing disparities.

2.4 Study Conceptual Framework

Given the known cost-effectiveness of CR, efforts of system redesign and community partnership at improving referral and participation rates would likely be a wise investment of time and resources for hospitals and medical systems who participate bundled payment models for cardiovascular episodes. The study framework is described in Figure 1.

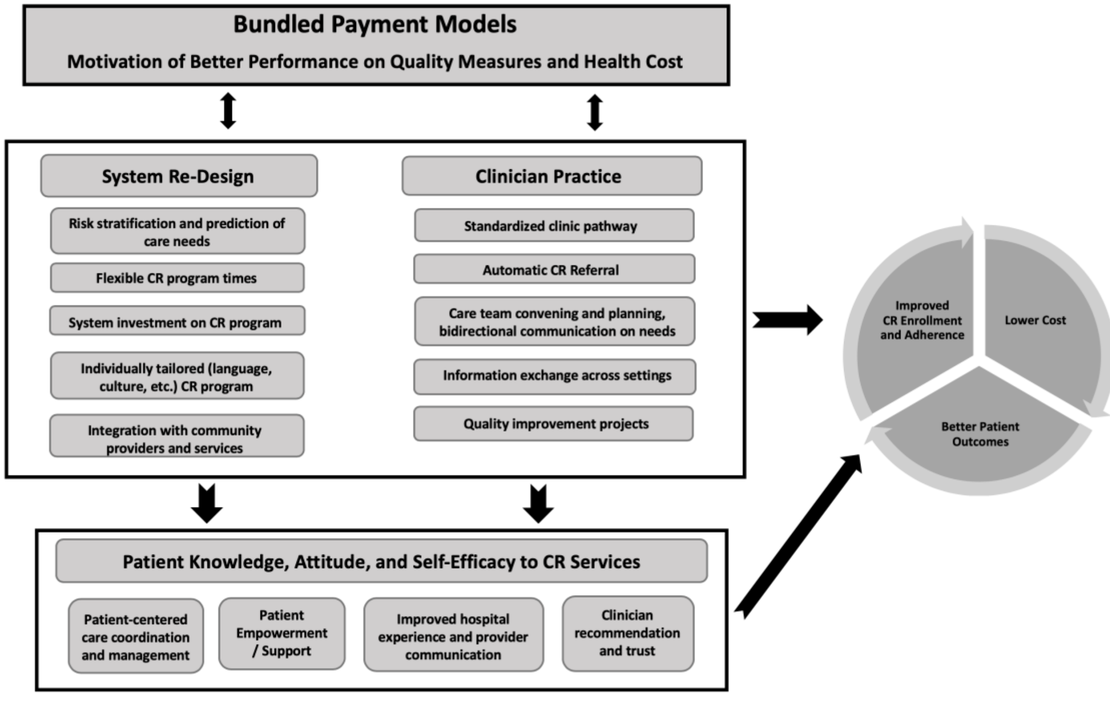

Figure 1. Conceptual Framework

CHAPTER 3. STUDY MANUSCRIPT ONE – THE ASSOCIATION BETWEEN THE CMS BPCI INITIATIVE AND CARDIAC REHABILITATION ENROLLMENT

Background

In the drive to add more value to care, bundled payments serve as a major vehicle for change. Although not a new policy initiative, bundled payments have resurfaced in the current era of health care reforms with its advocates arguing that it can limit health care costs while at the same time improving quality.[1] Paying physicians and health institutions using bundled payments became popular following the passage of comprehensive health reform in 2010. These models seek to align provider interests through provision of fixed payments for all services rendered during a single episode of care rather than paying a separate fee for each specific service.[2] The Center for Medicare and Medicaid Services (CMS) launched the Bundled Payments for Care Improvement (BCPI) Initiative in 2012 and over 200 health systems participated in Model 2, which bundles payment for acute hospitalization and up to 90 days of post-acute care. After the initial Phase I "preparation" period during which CMS and participants preparing for implementation and assumption of financial risk, hospitals started transitioning to the risk-bearing Phase II in October 2013 with selected episodes, including acute myocardial infarction (AMI), coronary artery bypass grafting (CABG), percutaneous coronary interventions (PCI) and others.

Studies attribute over 1 in every 3 deaths to Cardiovascular disease (CVD) and over 90% of CVD morbidity and mortality to preventable risk factors, such as hypertension, dyslipidemia, obesity, smoking, and a sedentary lifestyle.[3] Cardiac rehabilitation (CR) is a preventative health strategy created for patients who have experienced an adverse cardiac event. Its primary objectives are to reduce the likelihood of additional adverse coronary events, decrease mortality, and increase quality of life.[4] CR is a coordinated physical, social, and psychological intervention and is designed to influence the underlying risk factors through supervised exercise training and lifestyle reformation for patients following myocardial infarction (MI) and coronary revascularization (percutaneously or surgically). Extensive evidences[5-8] has shown to be clinically effective in reducing both mortality from coronary disease and all-cause mortality, as well as in improving quality of life and psychological well-being. While CR is both a cost and clinically effective method for preventing future cardiac events and recommended by multiple clinical guidelines,[9-11] current enrollment rates for cardiac rehabilitation in the United States generally ranges from only 20% to 30%.[12] This is despite a national target of 70%,[13] showing how CR remains highly underutilized despite the evidence of benefit.

With the incentives under the shared-saving contracts, aiming at care coordination, quality and cost-efficiency, BPCI participating hospitals need to redesign their care delivery processes, implement quality improvement efforts and invest in care management programs. Therefore BPCI is very applicable to the CR enrollment in patients diagnosed with AMI or have undergone through procedures of CABG or PCI,[14] with the potential to catalyze and achieve greater communication and coordination among providers across the continuum of care and improvement in CR enrollment.[15] With these, we expected that there will be a better CR enrollment in BPCI participating hospitals in these selected cardiac episodes. In addition to improved index inpatient cost efficacy, the most savings from the BPCI initiative is expected to be from reduced readmissions and use of post-acute care, such as skilled nursing facilities (SNFs). In this context, we used a difference-in-differences (DID) approach to evaluate the association between hospital BPCI early implementation and patient CR enrollment post-discharge from AMI, CABG or PCI, and examined the potential change in discharge destination for hospitals in early BPCI implementation for these cardiac episodes.

Methods

Through a PCORI-funded study, our research team obtained administrative claims data from ResDAC for 390 hospitals, which includes about 3.5 million Medicare fee-for-services (FFS) beneficiaries' 2009-2014 Part A & B claims data. These 390 hospitals demonstrated broad diversity with respect to geographic region, urban or rural location, system membership, academic affiliation, and bed capacity, while representing a sample comparative to hospitals across the United States. This dataset provided us an opportunity to study the potential impacts on hospitals in early BPCI implementation, i.e., January 2014 to December 2014, as well as examine the timing of participation and the effects.

Study Design, Setting, and Participants

This observational study used secondary data sources for a DID method analysis of CR enrollment in Medicare FFS beneficiaries hospitalized for AMI treatment or procedures of CABG or PCI during a three-year time period (2012-2014). This design provided an ability to observe and compare changes of CR enrollment in Medicare claims data that occur before vs. after establishing the BPCI initiative.

Two study periods were defined: the pre-BPCI period, which spanned the fourth quarter of 2012 through the third quarter of 2013 (October 2012-September 2013) and the

BPCI Phase II early implementation period, which spanned the first quarter of 2014 through the fourth quarter of 2014 (January 2014-December 2014).

AMI (primary diagnosis only), PCI, or CABG were identified using International Classification of Diseases (ICD), 9th Revision, Clinical Modification and Current Procedural Terminology (CPT) codes (MI 410.xx; PCI 0.66, 17.55, 36.0x, 92973, 92974, 92980–92982, 92984, 92995, 92996, G0290, G0291, 92920, 92921, 92924, 92925, 92928, 92929, 92933, 92934, 92937, 92938, 92941, 92943, 92944; CABG 36.10–36.16, 36.19, 36.2, 33510–33514, 33516–33519, 33521–33523, 33530, 33533–33536, 33572, 35600, S2205, S2206, S2207, S2208, S2209). We excluded patients unlikely to be eligible for CR, including those who died during the index hospitalization or in ≤30 days of the index event, were transferred to another hospital, discharged to hospice or comfort care, or left against medical advice.

Data Sources

The data sources were used in this analysis include:

1) CMS BPCI Analytic Files (BPCI Model 2 participation), publicly available;
2) Medicare FFS Claims Data, obtained through ResDAC data request;
3) Medicare Master Beneficiary Summary File, obtained through ResDAC request;
4) American Hospital Association (AHA) Hospital Survey File, purchased from AHA;
5) CMS Hospital Impact File, publicly available;
6) Area deprivation index (ADI), obtained publicly file using 2010 U.S. Census data files.

Exposure Measure and Comparison Groups

Hospital BPCI participation was the exposure measure. In order to assess the association of the BPCI participation on the outcomes of interest, patients with AMI/CABG/PCI episode receiving care from BPCI hospitals were considered as the intervention group and patients receiving care from non-BPCI hospitals in the same time frame were matched into a control group, with 1:3 matching ratio. Given that patients are clustered in one hospital that is the episode initiator and hospital structures, processes and operation influence how the services and care delivered to patients, most studies evaluating alternative payment models conduct matching at the hospital/organization level. However, patient demographics and other characteristics can vary after matching in the intervention and control groups. Though can be adjusted in statistical modeling, this heterogeneity still can cause flawed results. In our study, we proposed the patient level match, with several hospital characteristics taken into consideration, aiming for a more comparable control group. As a comparison and sensitivity analysis, we also created hospital-matching cohorts and reported the analysis results.

Separate baseline and post-intervention (i.e., BPCI Phase II date) patient matching were conducted with a baseline time period of 10/1/2012 through 9/30/2013, post-intervention implementation time period of 1/1/2014 through 12/31/2014. Effort was taken to make sure hospitals contributing patients to control group at the baseline the same hospitals contributing patients to control group at the post-intervention. Matching was done using Mahalanobis distance between patient discharges. The Mahalanobis distance is the “distance” between observations/cases, based on the standardized measurements of the variables used in the distance calculation. The standardization of variables prior to the distance calculation ensures that variables with relatively large values and ranges compared to other variables do not dominate the subsequent matching algorithm. An optimal matching algorithm was used to minimize the overall sum of case-control distances. Variables used in matching algorithm included age (continuous), sex, race, Medicare-Medicaid dual eligibility, disabled, patient resident location (rural/urban cluster/urban area), DRG weight, selected Elixhauser comorbidity index groups, patient residency location, patient residency ADI, hospital size, hospital teaching status, hospital urban/rural status, and hospital patient case mix index. (see Table 1 below for all the variables).

Table 1 Variables Used for Matching of Patients Received Care in BPCI and non-BPCI hospitals

Age (in years)
Sex (male, female)
Race (white, black, other)
Medicare-Medicaid dual eligibility (yes, no)
Disabled (yes, no)
Patient residency urban-rural status (rural, urban)
DRG weight
Selected Elixhauser comorbidities (yes, no): Hypertension complicated, Diabetes complicated, Chronic Pulmonary Disease, Other Neurological Disorders, Renal Failure, Liver Disease, Metastatic Cancer, Rheumatoid Arthritis, Obesity, Coagulopathy, Mental Health/Drug Abuse/Alcohol abuse
Patient residency ADI
Hospital size
Hospital patient case mix index
Hospital ownership
Hospital teaching status (major, minor, non) [a]
Hospital urban-rural status (large urban, other urban, rural)

[a] From the AHA Annual Survey, major teaching hospitals are those that are members of the Council of Teaching Hospitals (COTH), minor teaching hospitals are non-COTH members that had a medical school affiliation reported to the American Medical Association, and nonteaching hospitals are all other institutions.

Outcome Measures

Primary outcome measure was CR enrollment. Enrollment of CR is defined as attendance of at least one session in 3 months post-discharge. CR program attendance is identified using CPT codes (93797 and 93798), Healthcare Common Procedure Coding System (HCPCS) codes (S9472, S9473, G0422 and G0423), and revenue center code 943 in Medicare claims. Secondary outcome measures included 30-day readmissions, 7-day ED visits, and discharged to SNF or inpatient rehabilitation facility (IRF).

Covariates

We used multivariable statistical models to control for a set of patient, hospital and community characteristics that otherwise may confound the relationship between BPCI participation and CR enrollment. Our covariate selection was based on our literature review and previous studies' findings. The patient level covariates include all variables used for matching; the hospital level covariates included structure (e.g., having rehabilitation service) in addition to the ones for matching, and the community level covariates included ADI. For hospital-matching cohorts, the multivariable models also included patient level covariates, the same ones we included for patient-matching cohorts.

The Medicare claims data sources contain encounter-level information about services received by individual patients, while other data sources contain information about the hospitals and communities in which patients receive care. Encounter-level data were aggregated to the person episode level and then linked to hospital-level and community-level data using dates of service, location of service, and geographic identifiers.

Statistical Analysis

The baseline characteristics for BPCI and non-BPCI hospitals and patients were described. The association of BPCI participation and CR enrollment changes was evaluated using a DID method to test for differential changes in the likelihood that patients would enroll in CR program at participant vs nonparticipant hospitals before and after BPCI was initiated. This approach removes biases in post-BPCI initiation period comparisons between the BPCI and non-BPCI group that could be the result from permanent differences between those groups, as well as biases from comparisons over time in the BPCI group that could be the result of trends due to other causes of the outcome. The DID was implemented as an interaction term between time and BPCI dummy variables in a regression model. The statistical model for primary outcome measure is listed here.

$$Y = \beta_0 + \beta_1[post] + \beta_2[BPCI_n] + \beta_3[post * BPCI_n] + \beta_4[covar] + \varepsilon$$

Y is the CR enrollment measure for beneficiary i attributed to $BPCI_n$ or control group. $\mathrm{BPCI_n}$ indicates various BPCI cohorts (i.e., implementation start date) while the control group is set as the reference group. *post* is a dummy variable represents whether it is post entry year, and it is different for different cohorts of BPCIs. *covar* represents different covariates at BPCI or patient or community level.

Results

Two hospitals in our data set started Phase II (implementation phase) BPCI with AMI/CABG/PCI as selected episodes, one started in January 2014 (i.e., Jan-BPCI) and another started in April 2014 (i.e., Apr-BPCI).

Table 2 shows the patient level matching cohorts. To compare similarity in the matched cohort, we used standardized difference, the comparison of the means or medians of continuous covariates and the distribution of categorical covariates between intervention and control groups. Although there is no universally agreed upon criterion, a standardized difference that is less than 0.1 has been taken to indicate a negligible difference in the mean or prevalence of a covariate between treatment groups.[16] In our study, all matching variables' absolute standardized mean differences are within the recommended criterion of less than 0.1.

Table 2. BPCI and Non-BPCI AMI/CABG/PCI Episode Patient-Level Matched Cohorts (1:3 matching)

Matching Variable	Non-BPCI (N=5,055)		BPCI (N=1,685)		Absolute Standardized Mean Difference
	Mean	Std Dev	Mean	Std Dev	
AGE	75.37	9.14	75.51	9.55	-0.11
Gender (% Male)	59.3%	49.0%	59.3%	49.0%	0.00
Race (% White)	91.6%	28.0%	91.6%	28.0%	0.00
Medicare-Medicaid Dual Eligibility (% Yes)	20.0%	39.0%	20.0%	39.0%	0.00
Disabled (% Yes)	7.7%	27.0%	7.7%	27.0%	0.00
DRG Weight	2.78	1.79	2.92	2.02	-0.12
Elixhauser – Hypertension, Complicated Dx	84.5%	36.0%	84.3%	36.0%	0.01
Elixhauser – Diabetes, Complicated Dx	9.0%	29.0%	9.2%	29.0%	0.00
Elixhauser – Chronic Pulmonary Disease Dx	27.2%	44.0%	25.4%	44.0%	0.03
Elixhauser – Other Neurological Disorders Dx	6.7%	25.0%	6.3%	24.0%	0.01
Elixhauser – Renal Failure Dx	23.9%	43.0%	24.3%	43.0%	0.00
Elixhauser – Liver Disease Dx	1.5%	12.0%	1.3%	11.0%	0.00
Elixhauser – Metastatic Cancer Dx	0.5%	7.0%	0.8%	9.0%	0.00
Elixhauser – Coagulopathy Dx	5.0%	22.0%	6.1%	24.0%	-0.01
Elixhauser – Rheumatoid Arthritis Dx Groups	3.4%	18.0%	3.7%	19.0%	0.00
Elixhauser – Obesity Dx Groups	12.4%	33.0%	14.8%	35.0%	0.00
Elixhauser – Mental Health/Drug/ Alcohol Abuse Dx Groups	14.9%	36.0%	13.1%	34.0%	0.02
Hospital Case Mix Index	1.74	0.14	1.80	0.10	-0.05

The demographics and clinical characteristics of patients cared for by the BPCI hospitals were comparable to the control group at both the pre- and post-BPCI implementation period as demonstrated in Table 3. The notable difference in demographics was the patients in BPCI cohort had significant lower proportion of living in rural area, compared with patients in non-BPCI cohort (p<0.001). There were some differences in clinical characteristics for the post-BPCI implementation time frame: more patients treated by BPCI participating hospitals had metastatic cancer (1.2% vs. 0.4%, p=0.022), rental failure (26.8% vs. 22.6%, p=0.028), diabetes with complications (11.6% vs. 8.8%, p=0.035), and obesity (16.3% vs. 12.2, p=0.041).

In unadjusted analysis (Table 4), during the pre-BPCI time frame, compared to the Non-BPCI group, episodes from the BPCI hospitals had similar 3-month CR enrollment (p=0.105) and similar 30-day readmission (p=0.796), while had lower 7-day ED visit and higher discharge placement to SNFs or IRFs (p<0.001 and p=0.004). For post-BPCI period, similar results were observed: when compared with non-BPCI group, episodes from the BPCI group had similar 3-month CR enrollment and 30-day readmission, lower 7-day ED visit but higher SHF/IRF placement.

Table 3. Descriptive Statistics for AMI/CABG/PCI Episodes from BPCI Participating Hospitals and Control Group (Patient-Level Matched Cohorts)

	Pre-BPCI (10/1/2012 to 9/30/2013)		Post-BPCI (1/1/2014 through 12/31/2014)	
	BPCI	Non-BPCI	BPCI	Non-BPCI
Number of Patient Encounters	1,032	3,096	653	1,959
Demographics				
Age - Avg. (S.D.)	75.1 (9.62)	75.0 (9.23)	76.2 (9.39)	76.0 (8.97)
Gender				
Male %	59.9%	59.9%	58.5%	58.5%
Race				
White %	91.2%	91.2%	92.2%	92.2%
Urban/Rural Classification				
Rural Area %	4.1%	15.9%	4.3%	14.7%
Insurance Status				
Medicare-Medicaid Dual Eligibility %	20.8%	20.8%	18.7%	18.7%
Patient Acuity				
DRG Weight - Avg. (S.D.)	2.89 (1.89)	2.79 (1.79)	2.97 (2.2)	2.77 (1.79)
Comorbidities				
Elixhauser Comorbidity Indicators				
Hypertension Complicated Dx Code %	84.6%	84.3%	83.9%	84.7%
Other Neurological Disorders Dx Code %	5.2%	6.2%	8.0%	7.5%
Chronic Pulmonary Disease Dx Code %	25.9%	27.7%	24.7%	26.4%
Diabetes Complicated Dx Code %	7.7%	9.1%	11.6%	8.8%
Renal Failure Dx Code %	22.7%	24.7%	26.8%	22.6%
Liver Disease Dx Code %	1.1%	1.5%	1.7%	1.4%
Metastatic Cancer Dx Code %	0.5%	0.5%	1.2%	0.4%
Coagulopathy Dx Code %	6.0%	5.3%	6.1%	4.3%
Rheumatoid arthritis Dx Code %	3.2%	3.2%	4.6%	3.8%
Obesity Dx Code %	14.4%	12.6%	15.3%	12.2%
Mental Health/Drug /Alcohol Abuse Dx Code %	12.3%	15.2%	14.4%	14.3%

Table 4. Descriptive Outcomes for AMI/CABG/PCI Episodes from BPCI Participating Hospitals and Control Group – Before and After BPCI Implementation (Patient-Level Matched Cohorts)

	Pre-BPCI			Post-BPCI		
Outcomes	BPCI	Non-BPCI Group	p-value	BPCI	Non-BPCI Group	p-value
Cardiac Rehab Enrollment (N)	1032	3096		457	1360	
3-Month Enrollment (%)	22.4%	20.3%	0.105	21.7%	21.8%	0.964
Health Utilization (N)	1032	3096		589	1729	
30-Day Readmission Rate (%)	13.9%	14.2%	0.796	13.9%	15.0%	0.632
7-Day ED Visit Rate (%)	35.1%	45.7%	**<0.01**	42.4%	48.9%	**0.017**
Discharge Placement (N)	1022	3055		642	1925	
To SNF/IRF[a] (%)	19.6%	15.7%	**0.004**	24.8%	17.1%	**<0.001**

[a]SNF – Skilled Nursing Facility; IRF – Inpatient Rehabilitation Facility

In multi-variate modeling, there were no differences in 3-month CR enrollment, 30-day readmission rates and SNF/IRF discharge placement in the patients discharged from BPCI participating hospitals, compared to patients in the non-BPCI cohort (p=0.210, p=0.784, p=0.555 respectively, Table 5a). However, there was an increase in 7-day ED visits in patients from BPCI cohort (p=0.003, Table 5a). The mean comparison also showed the similar results (Table 5b), with patients in the Apr-BPCI implementation cohort having significantly higher 7-day ED visits (p=0.0351) while all other measures showed no difference in both Jan-BPCI and Apr-BPCI implementation cohorts.

Table 5a. Outcomes by BPCI Participation – Logistic Modeling (Patient-Level Matched Cohorts)

Outcome	Factor Interested	Level	Estimate	Standard Error	OR p-value	Type 3 p-value
3-Month CR Enrollment	Post	Yes	0.114	0.0868	0.190	0.190
	Bundle	Jan-BPCI	0.248	0.2091	0.236	0.065
		Apr-BPCI	0.317	0.1531	**0.038**	
	Post*Bundle	P-Jan-BPCI	0.263	0.3256	0.420	0.210
		P-Apr-BPCI	-0.278	0.1901	0.143	
30-Day Readmissions	Post	Yes	0.040	0.0884	0.650	0.650
	Bundle	Jan-BPCI	0.060	0.2262	0.790	0.945
		Apr-BPCI	-0.030	0.1591	0.850	
	Post*Bundle	P-Jan-BPCI	0.055	0.3426	0.872	0.784
		P-Apr-BPCI	-0.128	0.1958	0.512	
7-Day ED Visits	Post	Yes	0.057	0.0652	0.378	0.378
	Bundle	Jan-BPCI	0.092	0.1799	0.609	**0.027**
		Apr-BPCI	-0.323	0.1228	**0.009**	
	Post*Bundle	P-Jan-BPCI	-0.418	0.2713	0.123	**0.003**
		P-Apr-BPCI	0.408	0.1429	**0.004**	
SNF/IRF Discharge Placement	Post	Yes	0.067	0.0891	0.453	0.453
	Bundle	Jan-BPCI	-0.055	0.2666	0.836	**0.003**
		Apr-BPCI	0.536	0.1602	**<.001**	
	Post*Bundle	P-Jan-BPCI	0.403	0.3740	0.281	0.555
		P-Apr-BPCI	0.043	0.1787	0.809	

Table 5b. Outcomes by BPCI Participation – Adjusted Mean Comparison (Patient-Level Matched Cohorts)

Outcome	Non-BPCI Cohort (%)			Jan-BPCI Cohort (%)					Apr-BPCI Cohort (%)				
	Pre	Post	Diff	Pre	Post	Diff	DID[a] Value	DID *p* Value	Pre	Post	Diff	DID Value	DID *p* Value
3-Month CR[b] Enrollment	20.0	21.8	1.8	24.3	30.3	6.0	4.2	0.4782	22.0	19.6	-2.4	-4.2	0.2107
30-Day Readmission	14.2	15.1	0.9	17.7	18.0	0.3	-0.6	0.8918	13.0	14.9	1.9	1.0	0.9668
7-Day ED Visit	45.7	48.2	2.5	63.5	60.7	-2.8	-5.3	0.2601	29.0	38.9	9.9	7.4	**0.0351**
SNF/IRF[c] Discharge Placement	15.7	17.1	1.4	14.0	18.4	4.4	3.0	0.3481	20.7	27.5	6.8	5.4	0.4586

[a]DID – Difference in difference; [b]CR – Cardiac Rehabilitation
[c]SNF – Skilled Nursing Facility; IRF – Inpatient Rehabilitation Facility

Sensitivity Analysis – Hospital-Level Matched Cohorts

We followed 1:4 matching and had two hospitals in the BPCI cohort and eight hospitals in the non-BPCI cohort. The analysis using hospital-level matched cohorts showed same results in all study outcomes and we include the mean comparison results in Table 6.

Table 6. Outcomes by BPCI Participation – Adjusted Mean Comparison (Hospital-Level Matched Cohorts)

Outcome	Non-BPCI Cohort (%)			Jan-BPCI Cohort (%)					Apr-BPCI Cohort (%)				
	Pre	Post	Diff	Pre	Post	Diff	DID[a] Value	DID *p* Value	Pre	Post	Diff	DID Value	DID *p* Value
3-Month CR[b] Enrollment	35.6	35.4	-0.2	24.3	30.3	6.0	6.2	0.2700	21.9	19.5	-2.4	-2.2	0.4952
30-Day Readmission	16.2	16.3	0.1	17.7	18.0	0.3	0.2	0.9141	13.3	14.7	1.4	1.3	0.8933
7-Day ED Visit	42.0	44.5	2.5	63.5	60.7	-2.8	-5.3	0.2405	29.1	39.2	10.1	7.6	**0.0411**
SNF/IRF[c] Discharge Placement	15.5	17.8	2.3	14.0	18.4	4.4	3.0	0.3481	20.7	27.5	6.8	4.5	0.5922

[a]DID – Difference in difference; [b]CR – Cardiac Rehabilitation
[c]SNF – Skilled Nursing Facility; IRF – Inpatient Rehabilitation Facility

Discussion

The bundled payment model has been argued to be a panacea for overcoming the problem of silo care and payments due to its potential to align reimbursement across a spectrum of care.[17] Not surprisingly, it was highlighted as one of several “alternative payment models” by Health and Human Services (HHS) when the agency described the federal government's efforts to move towards paying for value.[18] Nonetheless, we cannot assume that it will improve value and patients' quality of life. Our study adds to existing literature on bundled payments by evaluating the selected CMS BPCI risk-bearing participants using CR enrollment, a Class I recommendation in multiple American Heart Association (AHA)/American College of Cardiology (ACC) guidelines, as outcome measure instead of the ones that the CMS uses to evaluate participants' performance. The benefits for patients receiving CR are compelling and include reduction in cardiovascular mortality, decreased hospital admissions, and improved health-related quality of life. Logically, health systems would invest in improving CR referral and enrollment to patients who were diagnosed with AMI and/or undergone CABG or PCI to achieve their BPCI financial and quality performance goals. In our analysis, we found that participation in the CMS BPCI initiative for cardiac episodes (AMI, CABG, PCI) was not associated with an increase in 3-month CR enrollment. The differential changes tended to be in both directions, though when we looked at hospitals by initiation of participation, the early-entrant cohort (i.e., Jan-BPCI) showed an observed improvement in 3-month CR enrollment rate. Given that CR enrollment is not one of the quality measures in BPCI, it may be that different efforts to increase efficiencies for BPCI implementation taken by hospitals had different effects on CR enrollment. We did not have the qualitative data to explore this hypothesis. It may also be that it needs longer time to demonstrate meaningful changes in the outcome.

In our analysis, participation in the BPCI was not associated with an improvement in clinical outcomes, neither discharge to institutional facilities. Specifically, the Apr-BPCI cohort had higher 7-day ED visits. However, the Apr-BPCI cohort had much lower ED visits during the pre-BPCI phase and the increased post-implementation ED visit rate were still lower than non-BPCI cohort and Jan-BPCI cohort. This may be explained by the phenomenon that it is much harder to improve from a good performance. It may also be that structural and process changes for BPCI implementation had colleterial effects on different outcome measures. Interestingly, both BPCI and non-BPCI cohorts showed an observed increase in SNF/IRF discharge placement for patients with AMI or undergone CABG/PCI, though the BPCI cohort demonstrated an insignificant larger increase in SNF/IRF use. This increased institutionalized utilization may be appropriate for this population given the acute and severity of illness. This may be another reflection of BPCI hospitals improving CR enrollment in institutional settings.

BPCI builds upon earlier and ongoing efforts around bundled payments. As early as 1991, the Medicare Participating Heart Bypass Center Demonstration tested bundled payments with CABG at seven hospitals.[19] This was followed by efforts to implement bundled payments in other settings or for other populations. For example, Medicare's Acute Care Episode Demonstration, which ran from 2009 to 2012, targeted orthopedic and cardiac conditions in 5 hospitals or health systems.[20] The Geisinger ProvenCare program started with CABG in 2006 and now includes several other conditions and procedures.[21] And the PROMETHEUS payment model offers many different bundles of care. These earlier efforts have highlighted the difficulty of implementing bundled payments.[22,23] Administrative and logistical challenges to bundled payments include establishing provider networks that share and distribute risk, constructing the legal and regulatory framework to support these arrangements, and modernizing information and billing systems to accommodate episodes of care. Recent data suggest that these are continuing challenges.

Evaluations of other alternative payment programs also suggested that benefits can require several years to emerge. The emphasis on value over volume inherent in the BPCI employs care strategies implemented through changes in policies and structural and cultural changes. A successful BPCI requires system-level transformation, reasonably, considerable time and managerial resources to make changes to improve quality and lower costs. It also requires providers to take a more active role in assessing and striking a balance between high-quality, cost-efficient care and financial risk inherent in the bundled payment models. Our result that the participating hospital with longer implementation showed potential improvement in CR enrollment corresponds this long-term time and resource commitment, especially CR referral and enrollment is an interdisciplinary team effort which needs certain key competencies present, such as organizational culture of teamwork, collaborative relationships among providers, and information technology infrastructure for care coordination.[24-29]

CR is highly under-utilized nationally. Enrollment levels in CR have remained relatively flat over the past decade despite increases in referral rates.[30,31] Although there are many reasons why patients do not enroll, multiple studies demonstrate that providers and hospital systems play a key role in encouraging patient enrollment e.g., a more in-depth discussion (either through telephone calls, home visits, or letters) and encouragement of enrollment by medical personnel.[32-35] Several key strategies have been previously described for increasing patient enrollment. These include strong physician recommendations;[36] an early appointment to CR;[37] a reminder phone call in the 2-3 days prior to the enrollment appointment;[38] use of a hospital-based liaison who provides program information, encouragement, and otherwise facilitates outpatient referral;[39] and an automatic/systematic referral which does not rely on physician initiative or memory.[39] Each of these key techniques improves enrollment significantly and can be adopted by hospitals through BPCI implementation, especially given that most of these strategies can be incorporated as part of BPCI care management programs. In our study, the BPCI hospital with observed increase in CR enrollment likely benefited from some of these strategies and techniques, however, we do not have data to confirm.

Our results have several immediate implications for policymakers. The lack of association between implementation of BPCI and CR enrollment suggests that CMS should strongly consider amending the current BPCI evaluation with appropriate process measure quality indicators for each episode that are with proven-effectiveness and in the casual pathway/logic model for more efficient care and better patient outcome and health. Referral to, enrollment in, and completion of CR programs have been proposed as quality indicators in cardiovascular care.[40] Such measures might be considered by the CMS for performance monitoring and evaluation in the BPCI initiative. It also suggests that, though health systems can conduct quality improvement efforts to increase the CR use, there are barriers need policy and system strategies. For example, lack of insurance coverage has been cited as a major reason for continued low referral rates.[41,42] Insurers, including Medicare, should consider various ways of incentivizing CR use through optimizing insurance coverage, such as out-of-pocket cost waiver, financial incentives for patients who participate, increased reimbursement rate, etc. In 2016, Medicare announced the Cardiac Rehabilitation Incentive Payment Model, where the agency would pay hospitals for each session of CR that patients attended after treatment for AMI or CABG surgery. This program was designed to incentivize hospitals to invest in initiatives aimed at improving CR use.

However, this proposed incentive program was cancelled in December 2017.[43] In addition to health insurance coverage, insufficient access, e.g., distance to the nearest CR facility, remains an important limiting factor as demonstrated by studies.[44,45] To overcome this barrier, some have suggested the development of home-based CR programs.[46] Payers, including Medicare, may wish to explore the feasibility of reimbursing community- or home-based CR programs as supplements or alternatives to facility-based programs, particularly in rural and sparsely populated areas. The CMS may also consider starting new demonstrations/initiatives focusing on home-based CR programs for large scale implementation and evaluation.

Our study has several limitations. First, it was an observational study, therefore the results could be confounded by unobserved variables. However, these concerns were mitigated by the quasi-experimental design that incorporated a robust set of patient, hospital, and community characteristics. Second, because we performed a quasi-experimental study of a voluntary program, our results may be biased by selection. We used patient-level matched cohorts to help mitigate while applying hospital-level matched cohorts as sensitivity analysis for study results. Third, our data were limited to two hospitals over a 3-year period, we did not have the power to detect small differences in CR enrollment, utilization or clinical outcomes. While the patients included in the study represent a heterogeneous patient population, our results may not be generalizable to the rest of the BPCI health systems. Fourth, because our data set ends at December 2014, results were limited by the inability to examine long-term effects of BPCI implementation. Fifth, we did not have complete information about participation in other value-based or alternative payment model programs, which may affect the matching outcome therefore potentially the study results. In spite of these limitations, it is worth considering the implications of our results for the current expansion of episode-based payment models.

Conclusion

Given the rapid growth of new care delivery and payment models, it is imperative to describe the plans for integration of process and outcome data in design of model and advance understanding of how these models might be implemented to improve health for future policy changes and new initiatives.

References

1. Shih T, Chen LM, Nallamothu BK. Will Bundled Payments Change Health Care? Examining the Evidence Thus Far in Cardiovascular Care. Circulation. 2015;131(24):2151-2158.
2. The Institute of Medicine. Roundtable on Evidence-Based Medicine, “The Healthcare Imperative: Lowering Costs and Improving Outcomes: Brief Summary of a Workshop. 2010.
3. Yusuf S, Hawken S, Ôunpuu S, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. The Lancet. 2004;364(9438):937-952.
4. Piepoli MF, Corrà U, Dendale P, et al. Challenges in secondary prevention after acute myocardial infarction: A call for action. European Journal of Cardiovascular Nursing. 2017;16(5):369-380.
5. Anderson L, Oldridge N, Thompson DR, et al. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease: Cochrane Systematic Review and Meta-Analysis: Cochrane Systematic Review and Meta-Analysis. Journal of the American College of Cardiology. 2016;67(1):1-12.
6. Rauch B, Davos CH, Doherty P, et al. The prognostic effect of cardiac rehabilitation in the era of acute revascularisation and statin therapy : A systematic review and meta-analysis of randomized and non-randomized studies - The Cardiac Rehabilitation Outcome Study (CROS). 2016.
7. Whalley B, Rees K, Davies P, et al. Psychological interventions for coronary heart disease. Cochrane Heart Group. 2004(2).
8. Wong W, Feng J, Pwee K, Lim J. A systematic review of economic evaluations of cardiac rehabilitation. BMC Health Services Research. 2012;12(1):243.
9. Hillis DL, Smith KP, Anderson LJ, et al. 2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery: Executive Summary: A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation. 2011;124(23):2610-2642.
10. Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI guideline for percutaneous coronary intervention. Catheterization and Cardiovascular Interventions. 2013;82(4):E266-E355.
11. Yancy C, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA Guideline for the Management of Heart Failure. Journal of the American College of Cardiology. 2013;62(16):e147-e239.
12. Ades PA, Keteyian SJ, Wright JS, et al. Increasing Cardiac Rehabilitation Participation From 20% to 70%: A Road Map From the Million Hearts Cardiac Rehabilitation Collaborative. Mayo Clin Proc. 2017;92(2):234-242.
13. Grace SL, Tan Y, Simpson C, Chessex C. Perceptions of cardiac specialists and rehabilitation programs regarding patient access to cardiac rehabilitation and referral strategies. J Cardiopulm Rehabil Prev. 2012;32(3):135-140.
14. Bailit M, Burns M, Painter M. Bundled Payment Across the US Today: Status of Implementations and Operational Findings. Newtown, CT: Health Care Incentives Improvement Institute;2012.

15. Tsai TC, Miller DC. Bundling Payments for Episodes of Surgical Care. JAMA surgery. 2015.
16. Normand ST, Landrum MB, Guadagnoli E, et al. Validating recommendations for coronary angiography following acute myocardial infarction in the elderly: a matched analysis using propensity scores. Journal of clinical epidemiology. 2001;54(4):387-398.
17. Ahlquist A, Javanmardian M, Saxena S, Spencer B. Bundled care: State of play, lessons learned, and future prospects. Strategy&, formerly Booz & Company. http://www.strategyand.pwc.com/global/home/what-we-think/reports-white-papers/article-display/bundled-care-play-learned-prospects. Published 2013. Accessed October 5, 2015, 2015.
18. Burwell SM. Setting value-based payment goals--HHS efforts to improve U.S. health care. N Engl J Med. 2015;372(10):897-899.
19. Cromwell J, Dayhoff DA, Thoumaian AH. Cost savings and physician responses to global bundled payments for Medicare heart bypass surgery. Health Care Financ Rev. 1997;19(1):41-57.
20. Calsyn M, Emanuel EJ. Controlling costs by expanding the medicare acute care episode demonstration. JAMA Intern Med. 2014;174(9):1438-1439.
21. Casale AS, Paulus RA, Selna MJ, et al. "ProvenCareSM": a provider-driven pay-for-performance program for acute episodic cardiac surgical care. Ann Surg. 2007;246(4):613-621; discussion 621-613.
22. Ridgely MS, de Vries D, Bozic KJ, Hussey PS. Bundled payment fails to gain a foothold In California: the experience of the IHA bundled payment demonstration. Health Aff (Millwood). 2014;33(8):1345-1352.
23. Hussey PS, Ridgely MS, Rosenthal MB. The PROMETHEUS bundled payment experiment: slow start shows problems in implementing new payment models. Health Aff (Millwood). 2011;30(11):2116-2124.
24. Fisher ES, McClellan MB, Bertko J, et al. Fostering accountable health care: moving forward in medicare. Health affairs (Project Hope). 2009;28(2):w219-231.
25. McClellan M, McKethan AN, Lewis JL, Roski J, Fisher ES. A national strategy to put accountable care into practice. Health affairs (Project Hope). 2010;29(5):982-990.
26. Shortell SM, Casalino LP. Implementing qualifications criteria and technical assistance for accountable care organizations. JAMA. 2010;303(17):1747-1748.
27. Shortell SM, Casalino LP, Fisher ES. How the center for Medicare and Medicaid innovation should test accountable care organizations. Health affairs (Project Hope). 2010;29(7):1293-1298.
28. Medicare Payment Advisory Commission. Accountable Care Organizations Payment Systems http://www.medpac.gov/documents/payment-basics/accountable-care-organization-payment-systems-15.pdf?sfvrsn=0. Published October 2015. Accessed.
29. American Hospital Association. 2010 Committee on Research. AHA Research Synthesis Report: Accountable Care Organization.
30. Gupta A, Barrabes JA, Strait K, et al. Sex Differences in Timeliness of Reperfusion in Young Patients With ST-Segment-Elevation Myocardial Infarction by Initial Electrocardiographic Characteristics. J Am Heart Assoc. 2018;7(6).

31. Dunlay SM, Pack QR, Thomas RJ, Killian JM, Roger VL. Participation in cardiac rehabilitation, readmissions, and death after acute myocardial infarction. Am J Med. 2014;127(6):538-546.
32. Jolly K, Bradley F, Sharp S, et al. Randomised controlled trial of follow up care in general practice of patients with myocardial infarction and angina: final results of the Southampton heart integrated care project (SHIP). The SHIP Collaborative Group. Bmj. 1999;318(7185):706-711.
33. Wyer S, Earll L, Joseph S, Harrison J, Giles M, Johnston M. Increasing attendance at a cardiac rehabilitation programme: an intervention study using the Theory of Planned Behaviour. Coronary health care. 2001;5(3):154-159.
34. Grace SL, Gravely-Witte S, Brual J, et al. Contribution of patient and physician factors to cardiac rehabilitation enrollment: a prospective multilevel study. Eur J Cardiovasc Prev Rehabil. 2008;15(5):548-556.
35. Tsui CK, Shanmugasegaram S, Jamnik V, Wu G, Grace SL. Variation in patient perceptions of healthcare provider endorsement of cardiac rehabilitation. J Cardiopulm Rehabil Prev. 2012;32(4):192-197.
36. Ades PA, Waldmann ML, McCann WJ, Weaver SO. Predictors of cardiac rehabilitation participation in older coronary patients. Arch Intern Med. 1992;152(5):1033-1035.
37. Pack QR, Mansour M, Barboza JS, et al. An early appointment to outpatient cardiac rehabilitation at hospital discharge improves attendance at orientation: a randomized, single-blind, controlled trial. Circulation. 2013;127(3):349-355.
38. Harkness K, Smith KM, Taraba L, Mackenzie CL, Gunn E, Arthur HM. Effect of a postoperative telephone intervention on attendance at intake for cardiac rehabilitation after coronary artery bypass graft surgery. Heart Lung. 2005;34(3):179-186.
39. Grace SL, Russell KL, Reid RD, et al. Effect of cardiac rehabilitation referral strategies on utilization rates: a prospective, controlled study. Arch Intern Med. 2011;171(3):235-241.
40. Thomas RJ, Witt BJ, Lopez-Jimenez F, King ML, Squires RW. Quality indicators in cardiovascular care: the case for cardiac rehabilitation. J Cardiopulm Rehabil. 2005;25(5):249-256.
41. Suaya JA, Shepard DS, Normand SL, Ades PA, Prottas J, Stason WB. Use of cardiac rehabilitation by Medicare beneficiaries after myocardial infarction or coronary bypass surgery. Circulation. 2007;116(15):1653-1662.
42. Boyden T, Rubenfire M, Franklin B. Will increasing referral to cardiac rehabilitation improve participation? Prev Cardiol. 2010;13(4):192-201.
43. Medicare Program; Cancellation of Advancing Care Coordination Through Episode Payment and Cardiac Rehabilitation Incentive Payment Models; Changes to Comprehensive Care for Joint Replacement Payment Model: Extreme and Uncontrollable Circumstances Policy for the Comprehensive Care for Joint Replacement Payment Model. Final rule; interim final rule with comment period. Fed Regist. 2017;82(230):57066-57104.
44. Gaalema DE, Higgins ST, Shepard DS, Suaya JA, Savage PD, Ades PA. State-by-state variations in cardiac rehabilitation participation are associated with educational attainment, income, and program availability. J Cardiopulm Rehabil Prev. 2014;34(4):248-254.

45. Smith KM, Harkness K, Arthur HM. Predicting cardiac rehabilitation enrollment: the role of automatic physician referral. Eur J Cardiovasc Prev Rehabil. 2006;13(1):60-66.
46. Curnier DY, Savage PD, Ades PA. Geographic distribution of cardiac rehabilitation programs in the United States. J Cardiopulm Rehabil. 2005;25(2):80-84.

CHAPTER 4. STUDY MANUSCRIPT TWO – HEALTH DISPARITIES, BUNDLED PAYMENT POLICY, AND CARDIAC REHABILITATION ENROLLMENT AFTER CARDIAC EPISODES

Background

The high prevalence of coronary heart disease (CHD) and its important contribution to disability[1-3] underscore the importance of efforts to improve clinical outcomes and prevent recurrent CHD events. Cardiac rehabilitation (CR) is an important component of secondary prevention for patients who have experienced an acute myocardial infarction (AMI) or have undergone coronary artery bypass graft (CABG) or percutaneous coronary interventions (PCI) surgery. Meta-analyses of randomized controlled trials have consistently shown that participation in CR programs improves mortality and morbidity outcomes and favorably influences cardiac risk factors.[4-7] Outpatient CR can be initiated as soon as 3 weeks after hospital discharge, generally in a supervised hospital- or community-based ambulatory setting. Core components of CR include an exercise plan; nutritional counseling; management of blood lipid levels, diabetes mellitus, high blood pressure, and weight; smoking cessation; and psychosocial interventions, with the aim of maintaining independence in activities of daily living and improving quality of life (QoL).[8] Despite its proven benefits, the use of CR has remained low. Data from the ACTION-Get With The Guidelines registry (2014)[9] demonstrated opportunities for improvement: 1 in 4 patients with non-ST-elevation myocardial infarction (STEMI) and 1 in 7 with STEMI were not referred, and absence of CR referral at hospital discharge occurred in 40% of patients following a PCI.[10] More concerning, 2/3 of patients surveyed in the Behavioral Risk Factor Surveillance System who had an AMI, did not receive CR.[11] Moreover, an enrollment gap also exists in CR, only about 50% of patients referred to CR actually enrolled and participated.[12,13] Furthermore, health disparities are a major issue in CR enrollment. Lower CR use rates were found in women, nonwhites, older persons, dual eligibles, those living in lower socioeconomic (SES) neighborhoods, individuals with more comorbidities, and those live father from a CR facility.[14-17] Significantly, once patients are enrolled in a CR program, existing evidence indicates that participation results in similarly positive outcomes regardless of gender, race and ethnic minority.[18] Reduced use of CR services in these underrepresented groups will lead to further disparity in other cardiac health outcomes.

Disparities can be caused by a variety of factors: unconscious bias and cultural insensitivity, differential health care (attitude, belief, use, etc.), and social, economic and environmental inequities are all potential ones. Often, reducing health disparities is not a priority for health care organizations. Generally payment systems do not directly encourage reducing health disparities, but major national organizations and federal agencies are increasingly recognizing that payment systems may be an important mechanism for reducing health disparities.[19,20] Alternative payment models, such as bundled payments, may have the potential to address health disparities by encouraging care transformations.[21,22] Through launching the Bundled Payments for Care Improvement (BPCI) initiative in 2013, bundled payments have now become a central strategy for the Centers for Medicare and Medicaid Services (CMS) to increase quality while controlling health care costs. Many stakeholders espoused the notion that BPCI would reduce healthcare disparities among minorities by encouraging better case management, improving care coordination and standardizing care pathways. Therefore, there is an expectation that BPCI participating hospitals with AMI/CABG/PCI as selected episodes may reduce health disparities in CR enrollment since the core of bundled payments is to provide patients with an end-to-end view of a required treatment option, along with a clear explanation of episode treatments, costs, experiences, and outcomes.[23] The net effect of the BPCI is difficult to predict. It is conceivable that existing vertical inequalities (within patient groups) related to health outcomes will be narrowed, whereas horizontal inequalities (between patient groups) might be exacerbated, thus leaving in place a well-entrenched disparity. In this context, we used a difference-in-differences (DID) approach to examine the changes in CR enrollment among vulnerable groups in BPCI hospitals.

Methods

Through a PCORI-funded study, our research team obtained administrative claims data from ResDAC for 390 hospitals, which includes about 3.5 million Medicare fee-for-services (FFS) beneficiaries' 2009-2014 Part A & B claims data. These 390 hospitals demonstrated broad diversity with respect to geographic region, urban or rural location, system membership, academic affiliation, and bed capacity, while representing a sample comparative to hospitals across the United States. This dataset provided us an opportunity to study the potential impacts on hospitals in early BPCI implementation, i.e., January/April 2014 to December 2014.

Study Design, Setting, and Participants

This observational study used secondary data sources for a DID method analysis of CR enrollment in Medicare FFS beneficiaries hospitalized for AMI treatment or procedures of CABG or PCI during a three-year time period (2012-2014). This design provided an ability to observe and compare changes of CR enrollment in Medicare claims data that occur before vs. after establishing the BPCI initiative.

Two study periods were defined: the pre-BPCI period, which spanned the fourth quarter of 2012 through the third quarter of 2013 (October 2012-September 2013) and the BPCI Phase II early implementation period, which spanned the first quarter of 2014 through the fourth quarter of 2014 (January 2014-December 2014).

AMI (primary diagnosis only), PCI, or CABG were identified using International Classification of Diseases (ICD), 9th Revision, Clinical Modification and Current Procedural Terminology (CPT) codes (MI 410.xx; PCI 0.66, 17.55, 36.0x, 92973, 92974, 92980–92982, 92984, 92995, 92996, G0290, G0291, 92920, 92921, 92924, 92925, 92928, 92929, 92933, 92934, 92937, 92938, 92941, 92943, 92944; CABG 36.10–36.16, 36.19, 36.2, 33510–33514, 33516–33519, 33521–33523, 33530, 33533–33536, 33572, 35600, S2205, S2206, S2207, S2208, S2209). We excluded patients unlikely to be eligible for CR, including those who died during the index hospitalization or in ≤30 days of the index event, were transferred to another hospital, discharged to hospice or comfort care, or left against medical advice.

Data Sources

The data sources were used in this analysis include:

1) CMS BPCI Analytic Files (BPCI Model 2 participation), publicly available;
2) Medicare FFS Claims Data, obtained through ResDAC data request;
3) Medicare Master Beneficiary Summary File, obtained through ResDAC request;

4) American Hospital Association (AHA) Hospital Survey File, purchased from AHA;
5) CMS Hospital Impact File, publicly available;
6) Area deprivation index (ADI), obtained publicly file using 2010 U.S. Census data files.

Exposure Measure and Comparison Groups

Hospital BPCI participation was the exposure measure. In order to assess the association of the BPCI participation on the outcomes of interest, patients with AMI/CABG/PCI episode receiving care from BPCI hospitals were considered as the intervention group and patients receiving care from non-BPCI hospitals in the same time frame were matched into a control group, with 1:4 matching ratio. Given that patients are clustered in one hospital that is the episode initiator and hospital structures, processes and operation influence how the services and care delivered to patients, we conducted matching at the hospital/organization level.

The Mahalanobis distance is the "distance" between observations/cases, based on the standardized measurements of the variables used in the distance calculation. The standardization of variables prior to the distance calculation ensures that variables with relatively large values and ranges compared to other variables do not dominate the subsequent matching algorithm. An optimal matching algorithm was used to minimize the overall sum of case-control distances. Variables used in matching algorithm included, hospital size, ownership, teaching status, urban/rural status, and hospital patient case mix index. (see Table 1).

Table 1 Variables Used for Matching of BPCI and non-BPCI hospitals

Hospital size
Hospital ownership
Hospital teaching status (major, minor, non) [a]
Hospital urban-rural status (large urban, other urban, rural)
Hospital patient case mix index

[a] From the AHA Annual Survey, major teaching hospitals are those that are members of the Council of Teaching Hospitals (COTH), minor teaching hospitals are non-COTH members that had a medical school affiliation reported to the American Medical Association, and nonteaching hospitals are all other institutions.

Outcome Measures

Primary outcome measure was CR enrollment. Enrollment of CR is defined as attendance of at least one session in 3 months post-discharge. CR program attendance is identified using CPT codes (93797 and 93798), Healthcare Common Procedure Coding System (HCPCS) codes (S9472, S9473, G0422 and G0423), and revenue center code 943 in Medicare claims. Secondary outcome measures included 30-day readmissions, 7-day ED visits, and discharged to SNF or inpatient rehabilitation facility (IRF).

Covariates

We used multivariable statistical models to control for a set of patient, hospital and community characteristics that otherwise may confound the relationship between BPCI participation and CR enrollment. Our covariate selection was based on our literature review and previous studies' findings. The patient level covariates included age (continuous), sex, race, Medicare-Medicaid dual eligibility, disabled, patient resident location (rural/urban cluster/urban area), DRG weight, selected Elixhauser comorbidity index groups. The hospital level covariates included structure (e.g., having rehabilitation service) in addition to the ones used for matching, and the community level covariates included ADI.

The Medicare claims data sources contain encounter-level information about services received by individual patients, while other data sources contain information about the hospitals and communities in which patients receive care. Encounter-level data were aggregated to the person episode level and then linked to hospital-level and community-level data using dates of service, location of service, and geographic identifiers.

Statistical Analysis

The baseline characteristics for BPCI and non-BPCI hospitals and patients were described. The associations of BPCI participation and CR enrollment changes in health disparity groups were evaluated using a DID method to test for differential changes in the likelihood that patients would enroll in CR program at participant vs nonparticipant hospitals before and after BPCI was initiated. This approach removes biases in post-BPCI initiation period comparisons between the BPCI and non-BPCI group that could be the result from permanent differences between those groups, as well as biases from comparisons over time in the BPCI group that could be the result of trends due to other causes of the outcome. The DID was implemented as interaction terms between time and BPCI variables and between disparity group (race, gender, dual eligible, or rural) and BPCI variables in a regression model. The statistical model for primary outcome measure is listed here.

$$\begin{aligned} \mathrm{Y} = {} & \beta_0 + \beta_1[post] + \beta_2[BPCI_n] + \beta_3[post * BPCI_n] + \beta_4[disparity] \\ & + \beta_5[disparity * post] + \beta_6[disparity * BPCI_n] \\ & + \beta_7[disparity * post * BPCI_n] + \beta_8[covar] + \varepsilon \end{aligned}$$

Y is the CR enrollment measure for beneficiary i attributed to $BPCI_n$ or control group. $\mathrm{BPCI_n}$ indicates various BPCI cohorts (i.e., implementation start date) while the control group is set as the reference group. *post* is a dummy variable represents whether it is post entry year, and it is different for different cohorts of BPCIs. *disparity* is a variable represents whether it is a certain interested group. *covar* represents different covariates at BPCI or patient or community level.

Results

Two hospitals in our data set started Phase II (implementation phase) BPCI with AMI/CABG/PCI as selected episodes, one started in January 2014 (Jan-BPCI) and another started in April 2014 (Apr-BPCI).

Table 2 shows the hospital level matching cohorts. To compare similarity in the matched cohort, we used standardized difference, the comparison of the means or medians of continuous covariates and the distribution of categorical covariates between intervention and control groups. Although there is no universally agreed upon criterion, a standardized difference that is less than 0.1 has been taken to indicate a negligible difference in the mean or prevalence of a covariate between treatment groups.[24] In our study, all matching variables' absolute standardized mean differences are within the recommended criterion of less than 0.1.

Table 2. BPCI and Non-BPCI AMI/CABG/PCI Episode Matched Cohorts (1:4 matching)

Hospital Matching Variable	Non-BPCI (N=8)	BPCI (N=2)
Size (large)	50%	50%
Ownership (not-for-profit)	100%	100%
Teaching status (major teaching)	50%	50%
Urban-rural status (other urban)	100%	100%
Patient case mix index	1.7265 (0.2102)	1.7098 (0.1913)
Matching Scores	**Non-BPCI (N=8)**	**BPCI (N=2)**
Mean	0.0836	0.1538
Standard deviation	0.0698	0.1923
Minimum	0.0182	0.0178
Maximum	0.1762	0.2898
Mean difference	0.0702	

The demographics and comorbidities of patients cared for by the BPCI and non-BPCI hospitals can be found in Table 3. There were notable differences between two cohorts. The patients in the BPCI cohort were older, more females, much less living in rural areas and more Medicare-Medicaid dual eligible. When looking at comorbidities, patients in BPCI cohort had lower proportions of having diabetes with complications, other neurological disorders, renal failure, coagulopathy, obesity, or mental health/drug/alcohol abuse.

Table 3. Descriptive Statistics for Patients from BPCI and Non-BPCI Participating Hospitals

Demographics/Characteristics	Non-BPCI	BPCI	P-value*
Number of Patient Encounters	5,724	1,698	
Demographics			
Age - Avg. (S.D.)	74.5 (9.73)	75.5 (9.58)	**<.001**
Gender			
Male %	62.3%	59.3%	**0.025**
Race			
White %	91.6%	91.0%	0.672
Urban/Rural Classification			
Rural Area %	31.4%	4.1%	**<.001**
Insurance Status			
Medicare-Medicaid Dual Eligibility %	14.6%	20.3%	**<.001**
Patient Acuity			
DRG Weight - Avg. (S.D.)	3.27 (2.31)	2.93 (2.09)	**<.001**
Elixhauser Comorbidity Indicators			
Hypertension Complicated Dx Code %	86.0%	84.2%	0.057
Other Neurological Disorders Dx Code %	8.3%	6.3%	**0.005**
Chronic Pulmonary Disease Dx Code %	24.3%	25.4%	0.371
Diabetes Complicated Dx Code %	11.6%	9.4%	**0.009**
Renal Failure Dx Code %	26.9%	24.2%	**0.028**
Liver Disease Dx Code %	1.8%	1.5%	0.388
Metastatic Cancer Dx Code %	1.1%	0.8%	0.297
Coagulopathy Dx Code %	11.6%	6.0%	**<.001**
Rheumatoid arthritis Dx Code %	4.8%	3.8%	0.091
Obesity Dx Code %	23.7%	14.7%	**<.001**
Mental Health/Drug/Alcohol Abuse Dx Code %	16.4%	13.3%	**0.002**

*Calculated by ANOVA for numerical covariates and chi-square test for categorical covariates

In unadjusted health disparity analysis (Table 4), females had lower CR enrollment in 3 months post discharge than males, at both pre-BPCI and post-BPCI implementation periods (9.7% in difference, $p<.001$ and 8.8% in difference, $p<.001$, respectively). Similarly, patients who are black had lower CR enrollment, though the statistical significance at post implementation period was marginal (9.8% in difference, $p<.001$ and 10.9% in difference, $p=0.056$, respectively), as well as patients who are Medicare-Medicaid dual eligible had lower CR enrollment (14% in difference, $p<.001$ and 18% in difference, $p<.001$, respectively). Of note, the size of black group at the post-implementation was small, with total of 54 patients. Interestingly, our result showed that people living in rural areas had higher CR enrollment, compared to ones living in non-rural areas at both pre- post- periods (11.5% in difference, $p<.001$ and 13.8% in difference, $p<.001$, respectively).

In multi-variate modeling, patients who are female and dual eligible, and living in rural areas were less likely to participate in CR program in 3 months post hospital discharge (Table 5, $p=0.023$, $p<.001$, respectively), while patients living in rural areas were more likely to participate in CR program in 3 months post discharge ($p<.001$). Our results did not show temporal effect and these health disparities remained significant in the post-BPCI period. There was also no associations between BPCI implementation and health disparities in our results (Table 5). After adjusting other factors, people who are females and dual eligible were more likely to be discharged to SNF or IRF ($p<.001$ for both). The mean comparison of BPCI and non-BPCI cohorts by different health disparity groups also showed the similar results regarding BPCI effects (Table 6).

Table 4. Descriptive Outcomes – by Patient Groups, Before and After BPCI Implementation

	Before (Oct 2012 – Sept 2013)			After (Jan 2014 – Dec 2014)		
	Male	Female	p-value	Male	Female	p-value
Cardiac Rehab Enrollment (N)	2,472	1,656		1,064	753	
3-Month Enrollment (%)	24.5%	14.8%	**<.001**	25.4%	16.6%	**<.001**
Health Utilization (N)	2,472	1,656		1,381	967	
30-Day Readmission Rate (%)	13.2%	15.5%	**0.04**	12.6%	17.3%	**0.002**
7-Day ED Visit Rate (%)	39.0%	49.0%	**<0.01**	42.4%	52.8%	**<.001**
Discharge Placement (N)	2,453	1,624		1,506	1,061	
To SNF/IRF[a] (%)	12.6%	22.8%	**<.001**	16.2%	23.1%	**<0.001**
	Non-Dual Eligible	Dual Eligible	p-value	Non-Dual Eligible	Dual Eligible	p-value
Cardiac Rehab Enrollment (N)	3,268	860		1,519	298	
3-Month Enrollment (%)	23.5%	9.5%	**<.001**	24.7%	6.7%	**<.001**
Health Utilization (N)	3,268	860		1,919	429	
30-Day Readmission Rate (%)	13.3%	17.3%	**0.002**	14.1%	16.6%	0.187
7-Day ED Visit Rate (%)	41.9%	47.2%	**0.005**	46.2%	48.7%	0.349
Discharge Placement (N)	3,233	844		2,098	469	
To SNF/IRF[a] (%)	15.7%	20.6%	**<.001**	17.8%	24.5%	**<0.001**
	White	Non-White	p-value	White	Non-White	p-value
Cardiac Rehab Enrollment (N)	3,764	224		1,694	54	
3-Month Enrollment (%)	21.0%	11.2%	**<.001**	22.0%	11.1%	0.056
Health Utilization (N)	3,764	224		2,168	87	
30-Day Readmission Rate (%)	13.9%	16.5%	0.272	14.7%	13.8%	0.821
7-Day ED Visit Rate (%)	42.7%	50.0%	**0.033**	46.9%	44.8%	0.703
Discharge Placement (N)	3,718	222		2,366	99	
To SNF/IRF[a] (%)	17.0%	14.4%	0.323	19.4%	18.2%	0.756
	Non-Rural	Rural	p-value	Non-Rural	Rural	p-value
Cardiac Rehab Enrollment (N)	3,595	533		1,599	218	
3-Month Enrollment (%)	19.1%	30.6%	**<.001**	20.1%	33.9%	**<.001**
Health Utilization (N)	3,595	533		2,063	285	
30-Day Readmission Rate (%)	14.6%	11.1%	**0.031**	14.9%	11.9%	0.185
7-Day ED Visit Rate (%)	45.3%	27.8%	**<.001**	49.5%	26.3%	**<.001**
Discharge Placement (N)	3,553	524		2,259	308	
To SNF/IRF[a] (%)	17.7%	9.9%	**<.001**	19.9%	13.0%	**0.004**

[a]SNF – Skilled Nursing Facility; IRF – Inpatient Rehabilitation Facility

Table 5. Health Disparity Outcomes by BPCI Participation – Logistic Modeling

Health Disparity – Female vs. Male						
Outcome	Factor Interested	Level	Estimate	Standard Error	OR p-value	Type 3 p-value
3-Month CR Enrollment	Gender	Female	-0.206	0.0906	**0.023**	**0.023**
	Post	Post	0.073	0.0852	0.389	0.389
	Bundle	Jan-BPCI	0.406	0.2433	0.095	0.215
		Apr-BPCI	-0.207	0.3076	0.502	
	Gender*Post	F-P	-0.226	0.1455	0.120	0.120
	Gender*Bundle	F-Jan-BPCI	-0.750	0.4135	0.070	0.054
		F-Apr-BPCI	0.288	0.2033	0.157	
	Post*Bundle	P-Jan-BPCI	0.045	0.4131	0.913	0.991
		P-Apr-BPCI	-0.014	0.2166	0.949	
	Gender*Post*Bundle	F-P-Jan-BPCI	0.965	0.6538	0.140	0.164
		F-P-Apr-BPCI	-0.424	0.3946	0.283	
30-Day Readmissions	Gender	Female	0.133	0.1057	0.210	0.210
	Post	Post	-0.186	0.1035	0.072	0.072
	Bundle	Jan-BPCI	-0.248	0.3143	0.430	0.296
		Apr-BPCI	0.478	0.3434	0.164	
	Gender*Post	F-P	0.170	0.1593	0.285	0.285
	Gender*Bundle	F-Jan-BPCI	0.319	0.4271	0.455	0.100
		F-Apr-BPCI	-0.465	0.2416	0.054	
	Post*Bundle	P-Jan-BPCI	0.060	0.2262	0.790	0.945
		P-Apr-BPCI	-0.030	0.1591	0.850	
	Gender*Post*Bundle	F-P-Jan-BPCI	0.055	0.3426	0.872	0.784
		F-P-Apr-BPCI	-0.128	0.1958	0.512	
7-Day ED Visits	Gender	Female	0.090	0.0814	0.267	0.267
	Post	Post	0.164	0.0755	**0.030**	**0.030**
	Bundle	Jan-BPCI	0.103	0.2274	0.649	0.788
		Apr-BPCI	0.126	0.2584	0.625	
	Gender*Post	F-P	-0.059	0.1214	0.625	0.625
	Gender*Bundle	F-Jan-BPCI	0.279	0.3381	0.410	0.354
		F-Apr-BPCI	0.226	0.1789	0.207	
	Post*Bundle	P-Jan-BPCI	-0.420	0.3551	0.237	0.129
		P-Apr-BPCI	0.281	0.1829	0.125	
	Gender*Post*Bundle	F-P-Jan-BPCI	-0.113	0.5360	0.833	0.897
		F-P-Apr-BPCI	0.112	0.2834	0.693	
SNF/IRF Discharge Placement	Gender	Female	0.537	0.1175	**<.001**	**<.001**
	Post	Post	-0.005	0.1163	0.968	0.968
	Bundle	Jan-BPCI	0.0074	0.4043	0.854	0.570
		Apr-BPCI	-0.380	0.3615	0.293	
	Gender*Post	F-P	-0.005	0.1700	0.975	0.975
	Gender*Bundle	F-Jan-BPCI	0.445	0.5154	0.388	0.186
		F-Apr-BPCI	-0.350	0.2319	0.131	
	Post*Bundle	P-Jan-BPCI	0.925	0.5682	0.103	0.239
		P-Apr-BPCI	0.148	0.2378	0.533	
	Gender*Post*Bundle	F-P-Jan-BPCI	-0.774	0.7541	0.305	0.590
		F-P-Apr-BPCI	-0.053	0.3536	0.882	

Health Disparity – Dual Eligible vs. Non-Dual Eligible

Outcome	Factor Interested	Level	Estimate	Standard Error	OR p-value	Type 3 p-value
3-Month CR Enrollment	Dual	Dual	-0.778	0.1616	**<.001**	**<.001**
	Post	Post	0.032	0.0717	0.655	0.655
	Bundle	Jan-BPCI	0.046	0.2103	0.826	0.815
		Apr-BPCI	-0.188	0.3028	0.535	
	Dual*Post	D-P	-0.543	0.2806	0.053	0.053
	Dual*Bundle	D-Jan-BPCI	0.986	0.5818	0.090	0.125
		D-Apr-BPCI	0.398	0.2919	0.172	
	Post*Bundle	P-Jan-BPCI	0.482	0.3329	0.147	0.297
		P-Apr-BPCI	-0.085	0.1879	0.650	
	Dual*Post* Bundle	D-P-Jan-BPCI	-0.749	1.0439	0.473	0.680
		D-P-Apr-BPCI	-0.417	0.7214	0.563	
30-Day Readmissions	Dual	Dual	0.020	0.1576	0.898	0.898
	Post	Post	-0.142	0.0851	0.096	0,.096
	Bundle	Jan-BPCI	-0.071	0.2361	0.763	0.756
		Apr-BPCI	0.242	0.3401	0.477	
	Dual*Post	D-P	0.193	0.2229	0.387	0.387
	Dual*Bundle	D-Jan-BPCI	-0.198	0.6875	0.774	0.632
		D-Apr-BPCI	0.246	0.2811	0.382	
	Post*Bundle	P-Jan-BPCI	0.151	0.3717	0.685	0.835
		P-Apr-BPCI	0.102	0.2138	0.632	
	Dual*Post* Bundle	D-P-Jan-BPCI	0.378	0.9863	0.702	0.272
		D-P-Apr-BPCI	-0.756	0.4972	0.129	
7-Day ED Visits	Dual	Dual	0.012	0.1205	0.919	0.919
	Post	Post	0.154	0.0636	**0.015**	**0.015**
	Bundle	Jan-BPCI	0.198	0.1859	0.286	0.518
		Apr-BPCI	0.081	0.2539	0.749	
	Dual*Post	D-P	-0.106	0.1738	0.541	0.541
	Dual*Bundle	D-Jan-BPCI	0.203	0.5095	0.690	0.082
		D-Apr-BPCI	0.482	0.2159	**0.025**	
	Post*Bundle	P-Jan-BPCI	-0.360	0.2882	0.212	**0.021**
		P-Apr-BPCI	0.370	0.1568	**0.018**	
	Dual*Post* Bundle	D-P-Jan-BPCI	-0. 679	0.7563	0.369	0.659
		D-P-Apr-BPCI	-0.095	0.3521	0.787	
SNF/IRF Discharge Placement	Dual	Dual	0.735	0.1711	**<.001**	**<.001**
	Post	Post	0.005	0.0919	0.956	0.956
	Bundle	Jan-BPCI	0.374	0.2833	0.187	0.246
		Apr-BPCI	-0.406	0.3540	0.252	
	Dual*Post	D-P	-0.086	0.2374	0.716	0.716
	Dual*Bundle	D-Jan-BPCI	-0.326	0.7617	0.669	0.211
		D-Apr-BPCI	-0.505	0.2885	0.080	
	Post*Bundle	P-Jan-BPCI	0.386	0.4045	0.340	0.631
		P-Apr-BPCI	0.002	0.1985	0.991	
	Dual*Post* Bundle	D-P-Jan-BPCI	0.681	1.0554	0.519	0.427
		D-P-Apr-BPCI	0.529	0.4392	0.228	

Health Disparity – Black vs. White

Outcome	Factor Interested	Level	Estimate	Standard Error	OR p-value	Type 3 p-value
3-Month CR Enrollment	Race	Black	-0.223	0.2476	0.368	0.368
	Post	Post	0.017	0.0699	0.810	0.810
	Bundle	Jan-BPCI	0.121	0.2048	0.556	0.817
		Apr-BPCI	-0.092	0.2994	0.759	
	Race*Post	B-P	-0.929	0.5006	0.063	0.063
	Race*Bundle	B-Jan-BPCI	0.277	0.8931	0.756	0.699
		B-Apr-BPCI	-0.409	0.5496	0.456	
	Post*Bundle	P-Jan-BPCI	0.361	0.3211	0.261	0.326
		P-Apr-BPCI	-0.163	0.1820	0.372	
	Race*Post* Bundle	B-P-Jan-BPCI	1.544	1.6139	0.339	0.567
		B-P-Apr-BPCI	0.742	1.2814	0.562	
30-Day Readmissions	Race	Black	0.001	0.2355	**0.019**	**0.019**
	Post	Post	-0.121	0.0810	0.135	0.135
	Bundle	Jan-BPCI	-0.111	0.2318	0.631	0.637
		Apr-BPCI	0.288	0.3320	0.386	
	Race*Post	B-P	0.128	0.3445	0.710	0.710
	Race*Bundle	B-Jan-BPCI	0.369	0.8779	0.674	0.915
		B-Apr-BPCI	0.045	0.4882	0,927	
	Post*Bundle	P-Jan-BPCI	0.243	0.3524	0.490	0.778
		P-Apr-BPCI	-0.018	0.1966	0.929	
	Race*Post* Bundle	B-P-Jan-BPCI	-0.711	1.5009	0.636	0.771
		B-P-Apr-BPCI	-0.546	0.9366	0.560	
7-Day ED Visits	Race	Black	0.511	0.1852	**0.006**	**0.006**
	Post	Post	0.158	0.0607	**0.009**	**0.009**
	Bundle	Jan-BPCI	0.155	0.1780	0.384	0.404
		Apr-BPCI	0.230	0.2479	0.353	
	Race*Post	B-P	-0.357	0.2728	0.191	0.191
	Race*Bundle	B-Jan-BPCI	12.237	245.0330	0.960	0.920
		B-Apr-BPCI	0.144	0.3541	0.685	
	Post*Bundle	P-Jan-BPCI	-0.384	0.2697	0.154	**0.023**
		P-Apr-BPCI	0.317	0.1437	**0.027**	
	Race*Post* Bundle	B-P-Jan-BPCI	-13.146	245.0354	0.957	0.915
		B-P-Apr-BPCI	0.249	0.5930	0.675	
SNF/IRF Discharge Placement	Race	Black	-0.502	0.0758	0.138	0.138
	Post	Post	-0.029	0.0864	0.734	0.734
	Bundle	Jan-BPCI	0.263	0.2777	0.343	0.200
		Apr-BPCI	-0.561	0.3473	0.106	
	Race*Post	B-P	0.572	0.4518	0.206	0.206
	Race*Bundle	B-Jan-BPCI	0.995	1.0111	0.325	0.476
		B-Apr-BPCI	0.496	0.5507	0.367	
	Post*Bundle	P-Jan-BPCI	0.689	0.3812	0.071	0.181
		P-Apr-BPCI	0.105	0.1811	0.561	
	Race*Post* Bundle	B-P-Jan-BPCI	-14.045	305.8237	0.963	0.927
		B-P-Apr-BPCI	0.318	0.8228	0.699	

Health Disparity – Rural vs. Non-Rural

Outcome	Factor Interested	Level	Estimate	Standard Error	OR p-value	Type 3 p-value
3-Month CR Enrollment	Location	Rural	0.495	0.0932	**<.001**	**<.001**
	Post	Post	-0.029	0.0855	0.0732	0.0732
	Bundle	Jan-BPCI	0.330	0.2143	0.124	0.295
		Apr-BPCI	-0.132	0.2996	0.660	
	Location*Post	R-P	0.073	0.1450	0.614	0.614
	Location*Bundle	R-Jan-BPCI	-1.173	0.5582	**0.036**	0.089
		R-Apr-BPCI	-0.449	0.6401	0.483	
	Post*Bundle	P-Jan-BPCI	0.357	0.3383	0.291	0.980
		P-Apr-BPCI	-0.120	0.1884	0.524	
	Location*Post* Bundle	R-P-Jan-BPCI	0.166	0.9405	0.860	0.980
		R-P-Apr-BPCI	0.111	1.1239	0.922	
30-Day Readmissions	Location	Rural	-0.269	0.1188	**0.024**	**0.024**
	Post	Post	-0.070	0.0917	0.446	0.446
	Bundle	Jan-BPCI	-0.041	0.2367	0.862	0.679
		Apr-BPCI	0.291	0.3322	0.381	
	Location*Post	R-P	-0.169	0.1788	0.344	0.344
	Location*Bundle	R-Jan-BPCI	-0.388	0.3652	0.772	0.906
		R-Apr-BPCI	1.506	0.1993	0.763	
	Post*Bundle	P-Jan-BPCI	0.106	0.3652	0.772	0.906
		P-Apr-BPCI	-0.060	0.1993	0.763	
	Location*Post* Bundle	R-P-Jan-BPCI	0.647	1.0762	0.547	0.574
		R-P-Apr-BPCI	-1.072	1.2608	0.395	
7-Day ED Visits	Location	Rural	-0.903	0.0907	**<.001**	**<.001**
	Post	Post	0.080	0.0698	0.254	0.254
	Bundle	Jan-BPCI	0.442	0.1991	**0.026**	0.053
		Apr-BPCI	0.183	0.2471	0.460	
	Location*Post	R-P	0.218	0.1309	0.096	0.096
	Location*Bundle	R-Jan-BPCI	-1.460	0.5401	**0.007**	**0.024**
		R-Apr-BPCI	0.253	0.7873	0.747	
	Post*Bundle	P-Jan-BPCI	-0.399	0.3006	0.185	**0.011**
		P-Apr-BPCI	0.365	0.1447	**0.012**	
	Location*Post* Bundle	R-P-Jan-BPCI	-1.117	1.1907	0.348	0.355
		R-P-Apr-BPCI	1.167	1.0798	0.280	
SNF/IRF Discharge Placement	Location	Rural	-0.031	0.1318	0.812	0.812
	Post	Post	0.032	0.1007	0.753	0.753
	Bundle	Jan-BPCI	0.450	0.2781	0.105	0.112
		Apr-BPCI	-0.517	0.3471	0.136	
	Location*Post	R-P	-0.134	0.1864	0.473	0.473
	Location*Bundle	R-Jan-BPCI	-1.235	1.0890	0.257	0.410
		R-Apr-BPCI	-0.796	1.1021	0.470	
	Post*Bundle	P-Jan-BPCI	0.285	0.3934	0.468	0.720
		P-Apr-BPCI	0.085	0.1857	0.647	
	Location*Post* Bundle	R-P-Jan-BPCI	1.962	1.3658	0.151	0.356
		R-P-Apr-BPCI	0.077	1.5559	0.961	

Table 6. Health Disparity Outcomes by BPCI Participation

Health Disparity – Female vs. Male

Outcome / Group	Non-BPCI Cohort (%)			Jan-BPCI Cohort (%)					Apr-BPCI Cohort (%)				
	Pre	Post	Diff	Pre	Post	Diff	DID[a] Value	DID p Value	Pre	Post	Diff	DID Value	DID p Value
3-Month CR[b] Enrollment													
Female	29.4	27.6	-1.8	13.6	25.0	11.4	13.2	0.0518	20.2	11.3	-8.9	-7.1	0.1446
Male	39.4	40.2	0.8	33.0	35.6	2.6	1.8	0.9493	23.0	24.9	1.9	1.1	0.8606
30-Day Readmission													
Female	17.5	19.0	1.5	19.8	25.0	5.2	3.7	0.7346	11.9	17.3	5.4	3.9	0.3539
Male	14.2	15.1	0.9	17.7	18.0	0.3	-0.6	0.6929	13.0	14.9	1.9	1.0	0.5832
7-Day ED Visits													
Female	45.8	47.8	2.0	69.1	61.4	-7.7	-9.7	0.1075	34.5	46.7	12.2	10.2	0.1120
Male	39.7	42.4	2.7	59.0	60.0	1.0	-1.7	0.8715	25.5	34.2	8.7	6.0	0.1617
SNF/IRF[c] Discharge Placement													
Female	20.9	22.3	1.4	18.8	23.3	4.5	3.1	0.9046	26.1	34.2	8.1	6.7	0.4940
Male	12.2	15.1	2.9	10.2	13.6	3.4	0.5	0.3017	17.3	23.1	5.8	2.9	0.8403

Health Disparity – Dual Eligible vs. Non-Dual Eligible

Outcome / Group	Non-BPCI Cohort (%)			Jan-BPCI Cohort (%)					Apr-BPCI Cohort (%)				
	Pre	Post	Diff	Pre	Post	Diff	DID[a] Value	DID p Value	Pre	Post	Diff	DID Value	DID p Value
3-Month CR[b] Enrollment													
Dual	14.8	11.5	-3.3	24.0	14.3	-9.7	-6.4	0.7130	13.5	4.5	-9.0	-5.7	0.2356
Non-Dual	39.1	39.3	0.2	24.4	33.3	8.9	8.7	0.1576	24.4	22.7	-1.7	-1.9	0.8034
30-Day Readmission													
Dual	16.4	19.3	2.9	16.0	28.6	12.6	9.7	0.8742	16.6	11.9	-4.7	-7.6	0.1905
Non-Dual	16.1	15.8	-0.3	17.9	16.0	-1.9	-1.6	0.9575	12.3	15.3	3.0	3.3	0.4797
7-Day ED Visits													
Dual	47.4	44.4	-3.0	68.0	50.0	-18.0	-15.0	0.2907	38.9	43.3	4.4	7.4	0.4774
Non-Dual	41.1	44.5	3.4	62.8	62.7	-0.1	-3.5	0.3878	26.2	38.3	12.1	8.7	**0.0259**
SNF/IRF[c] Discharge Placement													
Dual	18.3	20.4	2.1	12.0	30.8	18.8	16.7	0.2252	24.9	35.9	11.0	8.9	0.1394
Non-Dual	15.0	17.4	2.4	14.4	16.2	1.8	-0.6	0.7491	19.5	25.7	6.2	3.8	0.9091

Health Disparity – Black vs. White

Outcome / Group	Non-BPCI Cohort (%)			Jan-BPCI Cohort (%)					Apr-BPCI Cohort (%)				
	Pre	Post	Diff	Pre	Post	Diff	DID[a] Value	DID *p* Value	Pre	Post	Diff	DID Value	DID *p* Value
3-Month CR[b] Enrollment													
Black	15.0	7.0	-8.0	22.2	25.0	2.8	10.8	0.4430	10.2	7.1	-3.1	-4.9	0.6372
White	36.8	36.8	0	24.4	31.3	6.9	6.9	0.2668	22.7	19.6	-3.1	-3.1	0.3648
30-Day Readmission													
Black	18.1	22.1	4.0	22.2	25.0	2.8	-1.2	0.3516	14.3	0	-14.3	-18.3	0.9745
White	16.0	16.1	0.1	16.7	18.1	1.4	1.3	0.6637	13.7	15.8	2.1	2.0	0.6668
7-Day ED Visits													
Black	62.5	59.3	-3.2	100	50.0	-50.0	46.8	0.9709	42.9	50.0	7.1	10.3	0.9593
White	40.7	43.9	3.2	61.9	60.2	-1.7	-4.9	0.3196	28.3	40.4	12.1	8.9	**0.0216**
SNF/IRF[c] Discharge Placement													
Black	9.0	13.4	4.4	22.2	0	-22.2	-26.6	0.9863	16.3	35.7	19.4	15.0	0.1793
White	15.9	18.3	2.4	13.3	19.8	6.5	4.1	0.1124	21.5	26.6	5.1	2.7	0.9455

Health Disparity – Rural vs. Non-Rural

Outcome / Group	Non-BPCI Cohort (%)			Jan-BPCI Cohort (%)					Apr-BPCI Cohort (%)				
	Pre	Post	Diff	Pre	Post	Diff	DID[a] Value	DID *p* Value	Pre	Post	Diff	DID Value	DID *p* Value
3-Month CR[b] Enrollment													
Rural	48.1	49.6	1.5	17.2	30.0	12.8	11.3	0.5323	30.8	25.0	-5.8	-7.3	0.9737
Non-Rural	29.6	29.5	-0.1	25.7	30.4	4.7	4.8	0.3754	21.8	19.3	-2.5	-2.4	0.6154
30-Day Readmission													
Rural	13.8	12.4	-1.4	10.3	10.0	-0.3	1.1	0.6380	30.8	12.5	-18.3	-16.9	0.2912
Non-Rural	17.2	17.9	0.7	19.1	19.0	-0.1	-0.8	0.8643	13.0	14.7	1.7	1.0	0.9624
7-Day ED Visits													
Rural	28.3	33.6	5.3	17.2	10.0	-7.2	-12.5	0.4709	15.4	50.0	34.6	29.3	0.1313
Non-Rural	48.6	49.1	0.5	72.4	67.1	-5.3	-5.8	0.2472	29.3	39.0	9.7	9.2	**0.0372**
SNF/IRF[c] Discharge Placement													
Rural	15.2	17.1	1.9	3.6	10.0	6.4	4.5	0.1631	7.7	12.5	4.8	2.9	0.9282
Non-Rural	15.7	18.2	2.5	16.0	19.5	3.5	1.0	0.6757	20.9	27.9	7.0	4.5	0.6840

[a]DID – Difference in difference; [b]CR – Cardiac Rehabilitation
[c]SNF – Skilled Nursing Facility; IRF – Inpatient Rehabilitation Facility

Discussion

Disparities in the quality of health and healthcare delivery across racial, ethnic, gender, and socioeconomic groups have been documented, specifically when evaluating cardiovascular diseases. To our knowledge, our study was the first one to examine the health disparities in CR enrollment among the BPCI hospitals. BPCI initiative has potential to reduce disparities in CR enrollment for patients who were diagnosed with AMI and/or undergone CABG or PCI. This is in part because the BPCI implementation creates strong financial incentives to provide high-value care, which is likely to benefit all patients regardless of race, gender, SES, etc. The gains in quality actually may be greatest for minority groups, who are historically exposed to higher rates of poor-quality care and higher risk of readmissions and/or ED visits. There was no significant disparities in CR enrollment among different racial groups in our results and this can be caused by small sample size of black patients in our study. Interestingly, our results showed people living in rural areas were more likely to participate in CR program, which is opposite to what literature has showed. This finding needs further study to understand. Our results did not show reduced disparities in CR enrollment among vulnerable groups regarding sex and SES, compared pre- and post- BPCI implementation. The reasons for these unaddressed disparities can be complex and involve patient-, clinician-, and system-level factors, including patients' health beliefs, values and preferences, clinicians' language and cultural competency, CR program structure and capacity, etc. Further study is needed to assess how implementation of BPCI affects the existing disparities in CR enrollment.

Many health care organizations lack the time and resources to address disparities seriously, nor have strong partnerships with payers and/or communities.[19,21] Though bundled payments generate extrinsic motivation, health systems and providers have been focused on more immediate concerns, such as implementing an electronic health record system, building affiliation/network, training frontline clinicians and staff, etc., health disparities are less immediately related to their bottom line. Furthermore, promising multicomponent interventions (e.g., culturally tailored interventions, involving community partners in solutions, and interactive, skills based training for patients) that address the drivers of disparities are costly as well as need to be embedded in a road map or systematic process, incentives gained from cost savings through BPCI participation likely are not sufficiently large to invest for the development and implementation of these approaches.

Our findings reinforce the need to monitor trends in access and outcomes for vulnerable beneficiaries who are eligible for CR program under bundled payments, particularly because of well-known disparities under fee-for-service reimbursement.[25,26] Further research is needed to evaluate whether vulnerable beneficiaries and their communities can access and experience the similar benefits as to their counters. The linkage of BPCI initiative to disparities reduction was not strong. The federal policymakers should include improved risk adjustment mechanisms accounting for other important patient characteristics such as SES, marital status, social support, etc., to encourage providers to accept all appropriate patients. Evidences have showed that using external motivators (such as financial incentives) alone is unlikely to be the effective way to reduce disparities, as only a limited number of processes of care and outcomes can be incentivized.[27-30] For next generation of bundled payments model design, it may be important to reinforce intrinsic motivation to make reducing health disparity a high priority and tailor solutions for their settings and populations while implementing financial incentives to health care organizations and providers. Payers, including Medicare, can integrate measures of disparity into a hospital's financial calculus, and directly reward hospitals for reducing disparities. There are several ways to do this. One approach is to implement disparity performance measures, for example, requiring hospitals to report the CR performance measures stratified by race and ethnicity, to help identify and address disparities. Another approach is to pay hospitals to improve outcomes in populations known to be at high risk, such as minority, low-income, and dual-eligible patients. Payers also can pay directly for services that are underpaid and could drive improvements in these populations, such as transportation and mental health treatment.

Our study has several limitations. First, it was an observational study, therefore the results could be confounded by unobserved variables. However, these concerns were mitigated by the quasi-experimental design that incorporated a robust set of patient, hospital, and community characteristics. Second, because we performed a quasi-experimental study of a voluntary program, our results may be biased by selection. Although we matched hospitals, differences still remained after matching, most notably with geographic region location. Third, our data were limited to two hospitals over a 3-year period, we did not have the power to detect small differences in CR enrollment, utilization or clinical outcomes. While the patients included in the study represent a heterogeneous patient population, our results may not be generalizable to the rest of the BPCI health systems. Fourth, because our data set ends at December 2014, results were limited by the inability to examine long-term effects of BPCI implementation. Fifth, we did not have complete information about participation in other value-based or alternative payment model programs, which may affect the matching outcome therefore potentially the study results. In spite of these limitations, it is worth considering the implications of our results for the current expansion of episode-based payment models.

Conclusion

Given the rapid growth of new care delivery and payment models, it is imperative to advance understanding of how these models might be designed and implemented to reduce health disparities. The new bundled payments policy needs to be sufficiently flexible to allow and encourage health systems to determine and implement the best approaches to reduce disparities in their settings and populations.

References

1. Mozaffarian JD, Benjamin SE, Go KA, et al. Heart Disease and Stroke Statistics—2015 Update: A Report From the American Heart Association. *Circulation.* 2015;131(4):e29-e322.
2. Grace SL, Bennett S, Ardern CI, Clark AM. Cardiac Rehabilitation Series: Canada. *Progress in Cardiovascular Diseases.* 2014;56(5):530-535.
3. Bjarnason-Wehrens B, McGee H, Zwisler A-D, et al. Cardiac rehabilitation in Europe: results from the European Cardiac Rehabilitation Inventory Survey. *European journal of cardiovascular prevention and rehabilitation : official journal of the European Society of Cardiology, Working Groups on Epidemiology & Prevention and Cardiac Rehabilitation and Exercise Physiology.* 2010;17(4):410.
4. Anderson L, Oldridge N, Thompson DR, et al. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease: Cochrane Systematic Review and Meta-Analysis: Cochrane Systematic Review and Meta-Analysis. *Journal of the American College of Cardiology.* 2016;67(1):1-12.
5. Rauch B, Davos CH, Doherty P, et al. The prognostic effect of cardiac rehabilitation in the era of acute revascularisation and statin therapy : A systematic review and meta-analysis of randomized and non-randomized studies - The Cardiac Rehabilitation Outcome Study (CROS). 2016.
6. Whalley B, Rees K, Davies P, et al. Psychological interventions for coronary heart disease. *Cochrane Heart Group.* 2004(2).
7. Wong W, Feng J, Pwee K, Lim J. A systematic review of economic evaluations of cardiac rehabilitation. *BMC Health Services Research.* 2012;12(1):243.
8. Thompson PD, Buchner D, Pina IL, et al. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity). *Circulation.* 2003;107(24):3109-3116.
9. Benjamin JE, Blaha JM, Chiuve ES, et al. Heart Disease and Stroke Statistics—2017 Update: A Report From the American Heart Association. *Circulation.* 2017;135(10):e146-e603.
10. Aragam KG, Dai D, Neely ML, et al. Gaps in Referral to Cardiac Rehabilitation of Patients Undergoing Percutaneous Coronary Intervention in the United States. *Journal of the American College of Cardiology.* 2015;65(19):2079-2088.
11. Fang J, Ayala C, Luncheon C, Ritchey M, Loustalot F. Use of outpatient cardiac rehabilitation among heart attack survivors — 20 states and the District of Columbia, 2013 and four states, 2015. *Morbidity and Mortality Weekly Report.* 2017;66(33):869-873.
12. Mazzini MJ, Stevens GR, Whalen D, Ozonoff A, Balady GJ. Effect of an American Heart Association Get With the Guidelines Program-Based Clinical Pathway on Referral and Enrollment Into Cardiac Rehabilitation After Acute Myocardial Infarction. *The American Journal of Cardiology.* 2008;101(8):1084-1087.

13. Weingarten NM, Salz AK, Thomas JR, Squires WR. Rates of Enrollment for Men and Women Referred to Outpatient Cardiac Rehabilitation. *Journal of Cardiopulmonary Rehabilitation and Prevention.* 2011;31(4):217-222.
14. Suaya AJ, Shepard SD, Normand TS-L, Ades AP, Prottas BJ, Stason BW. Use of Cardiac Rehabilitation by Medicare Beneficiaries After Myocardial Infarction or Coronary Bypass Surgery. *Circulation.* 2007;116(15):1653-1662.
15. Witt BJ, Jacobsen SJ, Weston SA, et al. Cardiac rehabilitation after myocardial infarction in the community. *Journal of the American College of Cardiology.* 2004;44(5):988-996.
16. Beckie MT, Beckstead WJ. Predicting Cardiac Rehabilitation Attendance in a Gender-Tailored Randomized Clinical Trial. *Journal of Cardiopulmonary Rehabilitation and Prevention.* 2010;30(3):147-156.
17. Lavie CJ, Thomas RJ, Squires RW, Allison TG, Milani RV. Exercise Training and Cardiac Rehabilitation in Primary and Secondary Prevention of Coronary Heart Disease. *Mayo Clinic Proceedings.* 2009;84(4):373-383.
18. Engebretson J, Mahoney J, Carlson ED. Cultural competence in the era of evidence-based practice. *J Prof Nurs.* 2008;24(3):172-178.
19. Chin MH. Creating the Business Case for Achieving Health Equity. *J Gen Intern Med.* 2016;31(7):792-796.
20. Joynt KE, De Lew N, Sheingold SH, Conway PH, Goodrich K, Epstein AM. Should Medicare Value-Based Purchasing Take Social Risk into Account? *N Engl J Med.* 2017;376(6):510-513.
21. Chin MH, Clarke AR, Nocon RS, et al. A roadmap and best practices for organizations to reduce racial and ethnic disparities in health care. *J Gen Intern Med.* 2012;27(8):992-1000.
22. Committee on Accounting for Socioeconomic Status in Medicare Payment P, Board on Population H, Public Health P, et al. In: *Systems Practices for the Care of Socially At-Risk Populations.* Washington (DC): National Academies Press (US)
23. Copyright 2016 by the National Academy of Sciences. All rights reserved.; 2016.
24. Ahlquist A, Javanmardian M, Saxena S, Spencer B. Bundled care: State of play, lessons learned, and future prospects. Strategy&, formerly Booz & Company. http://www.strategyand.pwc.com/global/home/what-we-think/reports-white-papers/article-display/bundled-care-play-learned-prospects. Published 2013. Accessed October 5, 2015, 2015.
25. Normand ST, Landrum MB, Guadagnoli E, et al. Validating recommendations for coronary angiography following acute myocardial infarction in the elderly: a matched analysis using propensity scores. *Journal of clinical epidemiology.* 2001;54(4):387-398.
26. Singh JA, Lu X, Rosenthal GE, Ibrahim S, Cram P. Racial disparities in knee and hip total joint arthroplasty: an 18-year analysis of national Medicare data. *Ann Rheum Dis.* 2014;73(12):2107-2115.
27. Ibrahim SA, Kim H, McConnell KJ. The CMS Comprehensive Care Model and Racial Disparity in Joint Replacement. *Jama.* 2016;316(12):1258-1259.
28. Kao AC. Driven to Care: Aligning External Motivators with Intrinsic Motivation. *Health Serv Res.* 2015;50 Suppl 2:2216-2222.

29. Gneezy U, Rustichini A. Incentives, punishment and behavior. *Advances in behavioral economics.* 2004:572-589.
30. Camerer CF, Loewenstein G, Rabin M. *Advances in behavioral economics.* Princeton university press; 2004.
31. Loewenstein G, Volpp KG, Asch DA. Incentives in health: different prescriptions for physicians and patients. *Jama.* 2012;307(13):1375-1376.

CHAPTER 5. IMPLICATIONS FOR HEALTH MANAGEMENT AND POLICY

In summary, CMS's BPCI initiative represents a creative and well-considered strategy to promote value-based health care. The model accomplishes this goal by incentivizing care coordination among health care delivery organizations to effectively support longer episodes of care. The BPCI initiative will move the health care payment system away from FFS to value-based models that could in the long run improve patient outcomes while lowering the cost of care. However, there is always potential for unintended consequences, including the potential widening of health disparities. While this potential unintended consequence has not yet been observed in our study, researchers need to continuously monitor bundled payment implementation going forward. The recently launched BPCI Advanced program will provide a wealth of new data as Medicare and commercial insurers use bundles for more procedures, conditions, and settings—including outpatient clinics. As policymakers and payers consider the next generation of bundled payment models, aligning design with evidence-based process measures/service delivery, intended outcomes and other payment models may be the key to maximizing value. Moreover, evaluation of the policy should include specific assessments on how implementation of the model affects the existing disparities in appropriate service use and outcomes and how the model could be fine-tuned to address important disparities.

APPENDICES

THERE IS NO APPENDIXES

REFERENCES

1. Scamperle K. The fee-for-service shift to bundled payments: financial considerations for hospitals. *Journal of health care finance.* 2013;39(4):55-67.
2. Schroeder SA, Frist W. Phasing out fee-for-service payment. *The New England journal of medicine.* 2013;368(21):2029-2032.
3. Blackstone EA, Fuhr JP, Jr. The Economics of Medicare Accountable Care Organizations. *American health & drug benefits.* 2016;9(1):11-19.
4. Wadhera RK, Yeh RW, Joynt Maddox KE. The Rise and Fall of Mandatory Cardiac Bundled Payments. *JAMA.* 2018;319(4):335-336.
5. Shih T, Chen LM, Nallamothu BK. Will Bundled Payments Change Health Care? Examining the Evidence Thus Far in Cardiovascular Care. *Circulation.* 2015;131(24):2151-2158.
6. Rana AJ, Bozic KJ. Bundled payments in orthopaedics. *Clinical orthopaedics and related research.* 2015;473(2):422-425.
7. Hardin L, Kilian A, Murphy E. Bundled Payments for Care Improvement: Preparing for the Medical Diagnosis-Related Groups. *The Journal of nursing administration.* 2017;47(6):313-319.
8. Centers for Medicare & Medicaid Services. Medicare C for, Baltimore MS 7500 SB, USA M. Affordable Care Act in action at CMS. Available at https://www.cms.gov/about-cms/aca/affordable-care-act-in-action-at-cms.html#. . 2017.
9. Kivlahan C, Orlowski JM, Pearce J, Walradt J, Baker M, Kirch DG. Taking Risk: Early Results From Teaching Hospitals' Participation in the Center for Medicare and Medicaid Innovation Bundled Payments for Care Improvement Initiative. *Academic medicine : journal of the Association of American Medical Colleges.* 2016;91(7):936-942.
10. Press MJ, Rajkumar R, Conway PH. Medicare's New Bundled Payments: Design, Strategy, and Evolution. *Jama.* 2016;315(2):131-132.
11. Centers for Medicare and Medicaid Services. Centers for Medicare and Medicaid Services, Center for Medicare and Medicaid Innovation. BPCI initiative episodes: details on the participating health care facilities. 2013. Available at http://innovation.cms.gov/initiatives/Bundled-Payments/Participating-Health-Care-Facilities/index.html. Accessed June 11, 2016. 2016.
12. Glickman A, Dinh C, Navathe AS. The Current State of Evidence on Bundled Payments. Effects on cost, quality, access, and equity.Issue Brief.https://ldi.upenn.edu/brief/current-state-evidence-bundled-payments. 2018;22(3).
13. Mozaffarian JD, Benjamin SE, Go KA, et al. Heart Disease and Stroke Statistics—2015 Update: A Report From the American Heart Association. *Circulation.* 2015;131(4):e29-e322.
14. Grace SL, Bennett S, Ardern CI, Clark AM. Cardiac Rehabilitation Series: Canada. *Progress in Cardiovascular Diseases.* 2014;56(5):530-535.
15. Bjarnason-Wehrens B, McGee H, Zwisler A-D, et al. Cardiac rehabilitation in Europe: results from the European Cardiac Rehabilitation Inventory Survey. *European journal of cardiovascular prevention and rehabilitation : official*

journal of the European Society of Cardiology, Working Groups on Epidemiology & Prevention and Cardiac Rehabilitation and Exercise Physiology. 2010;17(4):410.

16. Benjamin JE, Blaha JM, Chiuve ES, et al. Heart Disease and Stroke Statistics—2017 Update: A Report From the American Heart Association. *Circulation.* 2017;135(10):e146-e603.
17. Yusuf S, Hawken S, Ôunpuu S, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *The Lancet.* 2004;364(9438):937-952.
18. Piepoli MF, Corrà U, Dendale P, et al. Challenges in secondary prevention after acute myocardial infarction: A call for action. *European Journal of Cardiovascular Nursing.* 2017;16(5):369-380.
19. Anderson L, Oldridge N, Thompson DR, et al. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease: Cochrane Systematic Review and Meta-Analysis: Cochrane Systematic Review and Meta-Analysis. *Journal of the American College of Cardiology.* 2016;67(1):1-12.
20. Rauch B, Davos CH, Doherty P, et al. The prognostic effect of cardiac rehabilitation in the era of acute revascularisation and statin therapy : A systematic review and meta-analysis of randomized and non-randomized studies - The Cardiac Rehabilitation Outcome Study (CROS). 2016.
21. Whalley B, Rees K, Davies P, et al. Psychological interventions for coronary heart disease. *Cochrane Heart Group.* 2004(2).
22. Wong W, Feng J, Pwee K, Lim J. A systematic review of economic evaluations of cardiac rehabilitation. *BMC Health Services Research.* 2012;12(1):243.
23. Aragam KG, Dai D, Neely ML, et al. Gaps in Referral to Cardiac Rehabilitation of Patients Undergoing Percutaneous Coronary Intervention in the United States. *Journal of the American College of Cardiology.* 2015;65(19):2079-2088.
24. Fang J, Ayala C, Luncheon C, Ritchey M, Loustalot F. Use of outpatient cardiac rehabilitation among heart attack survivors — 20 states and the District of Columbia, 2013 and four states, 2015. *Morbidity and Mortality Weekly Report.* 2017;66(33):869-873.
25. Mazzini MJ, Stevens GR, Whalen D, Ozonoff A, Balady GJ. Effect of an American Heart Association Get With the Guidelines Program-Based Clinical Pathway on Referral and Enrollment Into Cardiac Rehabilitation After Acute Myocardial Infarction. *The American Journal of Cardiology.* 2008;101(8):1084-1087.
26. Weingarten NM, Salz AK, Thomas JR, Squires WR. Rates of Enrollment for Men and Women Referred to Outpatient Cardiac Rehabilitation. *Journal of Cardiopulmonary Rehabilitation and Prevention.* 2011;31(4):217-222.
27. Suaya AJ, Shepard SD, Normand TS-L, Ades AP, Prottas BJ, Stason BW. Use of Cardiac Rehabilitation by Medicare Beneficiaries After Myocardial Infarction or Coronary Bypass Surgery. *Circulation.* 2007;116(15):1653-1662.
28. Witt BJ, Jacobsen SJ, Weston SA, et al. Cardiac rehabilitation after myocardial infarction in the community. *Journal of the American College of Cardiology.* 2004;44(5):988-996.

29. Beckie MT, Beckstead WJ. Predicting Cardiac Rehabilitation Attendance in a Gender-Tailored Randomized Clinical Trial. *Journal of Cardiopulmonary Rehabilitation and Prevention.* 2010;30(3):147-156.
30. Lavie CJ, Thomas RJ, Squires RW, Allison TG, Milani RV. Exercise Training and Cardiac Rehabilitation in Primary and Secondary Prevention of Coronary Heart Disease. *Mayo Clinic Proceedings.* 2009;84(4):373-383.
31. Hess NC, Kaltenbach AL, Doll AJ, Cohen JD, Peterson DE, Wang YT. Race and Sex Differences in Post–Myocardial Infarction Angina Frequency and Risk of 1-Year Unplanned Rehospitalization. *Circulation.* 2017;135(6):532-543.
32. Prince DZ, Sobolev M, Gao J, Taub CC. Racial Disparities in Cardiac Rehabilitation Initiation and the Effect on Survival. *PM&R.* 2014;6(6):486-492.
33. Bachmann JM, Huang S, Gupta DK, et al. Association of Neighborhood Socioeconomic Context With Participation in Cardiac Rehabilitation. *Journal of the American Heart Association.* 2017;6(10).
34. Bailit M, Burns M, Painter M. *Bundled Payment Across the US Today: Status of Implementations and Operational Findings.* Newtown, CT: Health Care Incentives Improvement Institute;2012.
35. Tsai TC, Miller DC. Bundling Payments for Episodes of Surgical Care. *JAMA surgery.* 2015.
36. Ahlquist A, Javanmardian M, Saxena S, Spencer B. Bundled care: State of play, lessons learned, and future prospects. Strategy&, formerly Booz & Company. http://www.strategyand.pwc.com/global/home/what-we-think/reports-white-papers/article-display/bundled-care-play-learned-prospects. Published 2013. Accessed October 5, 2015, 2015.
37. Peters AE, Keeley EC. Trends and Predictors of Participation in Cardiac Rehabilitation Following Acute Myocardial Infarction: Data From the Behavioral Risk Factor Surveillance System. *J Am Heart Assoc.* 2017;7(1).
38. Doll JA, Hellkamp A, Ho PM, et al. Participation in Cardiac Rehabilitation Programs Among Older Patients After Acute Myocardial Infarction. *JAMA Intern Med.* 2015;175(10):1700-1702.
39. Sukul D, Seth M, Barnes GD, et al. Cardiac Rehabilitation Use After Percutaneous Coronary Intervention. *Journal of the American College of Cardiology.* 2019;73(24):3148.
40. Suaya JA, Shepard DS, Normand SL, Ades PA, Prottas J, Stason WB. Use of cardiac rehabilitation by Medicare beneficiaries after myocardial infarction or coronary bypass surgery. *Circulation.* 2007;116(15):1653-1662.
41. Frechette KM, Conley SM, Tang A, Welch TD. Cardiac Rehabilitation in a Rural Setting: OPTIMIZATION OF REFERRAL AND PARTICIPATION RATES. *J Cardiopulm Rehabil Prev.* 2019;39(1):E4-e7.
42. Zhang L, Sobolev M, Pina IL, Prince DZ, Taub CC. Predictors of Cardiac Rehabilitation Initiation and Adherence in a Multiracial Urban Population. *J Cardiopulm Rehabil Prev.* 2017;37(1):30-38.
43. Pack QR, Squires RW, Lopez-Jimenez F, et al. Participation Rates, Process Monitoring, and Quality Improvement Among Cardiac Rehabilitation Programs

in the United States: A NATIONAL SURVEY. *J Cardiopulm Rehabil Prev.* 2015;35(3):173-180.
44. Go AS, Mozaffarian D, Roger VL, et al. Heart disease and stroke statistics--2014 update: a report from the American Heart Association. *Circulation.* 2014;129(3):e28-e292.
45. Edmonds C, Hallman GL. CardioVascular Care Providers. A pioneer in bundled services, shared risk, and single payment. *Texas Heart Institute journal.* 1995;22(1):72-76.
46. Cromwell J, Dayhoff DA, Thoumaian AH. Cost savings and physician responses to global bundled payments for Medicare heart bypass surgery. *Health care financing review.* 1997;19(1):41-57.
47. Casale AS, Paulus RA, Selna MJ, et al. "ProvenCareSM": a provider-driven pay-for-performance program for acute episodic cardiac surgical care. *Annals of surgery.* 2007;246(4):613-621; discussion 621-613.
48. centers for Medicare & Medicaid Services. Centers for Medicare & Medicaid Services. Evaluation of the Medicare Acute Care Episode (ACE) demonstration: final evaluation report. https://downloads.cms.gov/files/cmmi/ACE-EvaluationReport-Final-5-2-14.pdf. 2017.
49. Miller DC, Gust C, Dimick JB, Birkmeyer N, Skinner J, Birkmeyer JD. Large variations in Medicare payments for surgery highlight savings potential from bundled payment programs. *Health Aff (Millwood).* 2011;30(11):2107-2115.
50. Chandra A, Dalton MA, Holmes J. Large increases in spending on postacute care in Medicare point to the potential for cost savings in these settings. *Health Aff (Millwood).* 2013;32(5):864-872.
51. Mechanic R. Post-acute care--the next frontier for controlling Medicare spending. *The New England journal of medicine.* 2014;370(8):692-694.
52. Miller HD. From volume to value: better ways to pay for health care. *Health affairs (Project Hope).* 2009;28(5):1418-1428.
53. Sutherland JM, Borden WB. Bundled payments for care improvement initiative–insights from the test pilots of payment reform. *Journal of Hospital Administration.* 2015;4(2):p37.
54. Edwards PK, Levine M, Cullinan K, Newbern G, Barnes CL. Avoiding Readmissions—Support Systems Required After Discharge to Continue Rapid Recovery? *The Journal of arthroplasty.* 2015;30(4):527-530.
55. Iorio R, Clair AJ, Inneh IA, Slover JD, Bosco JA, Zuckerman JD. Early Results of Medicare's Bundled Payment Initiative for a 90-Day Total Joint Arthroplasty Episode of Care. *The Journal of arthroplasty.* 2015.
56. Froemke C, Wang L, DeHart M, Williamson R, Ko LM, Duwelius PJ. Standardizing Care and Improving Quality under a Bundled Payment Initiative for Total Joint Arthroplasty. *The Journal of Arthroplasty.* 2015.
57. Centers for Medicare & Medicaid Services. CMS Bundled Payments for Care Improvement Initiative Models 2-4: Year 2 Evaluation & Monitoring Annual Report.https://innovation.cms.gov/Files/reports/bpci-models2-4-yr2evalrpt.pdf. 2016.
58. Navathe AS, Troxel AB, Liao JM, et al. Cost of Joint Replacement Using Bundled Payment Models. *JAMA internal medicine.* 2017;177(2):214-222.

59. Sood N, Huckfeldt PJ, Escarce JJ, Grabowski DC, Newhouse JP. Medicare's bundled payment pilot for acute and postacute care: analysis and recommendations on where to begin. *Health Aff (Millwood).* 2011;30(9):1708-1717.
60. Town R, Gregg W, Moscovice I, Prasad S, Klinger J. *Will Bundling Work in Rural America? Analysis of the Feasibility and Consequences of Bundled Payments for Rural Health Providers and Patients.*: Upper Midwest Rural Health Research Center;2011.
61. Navathe AS, Emanuel EJ, Venkataramani AS, et al. Spending And Quality After Three Years Of Medicare's Voluntary Bundled Payment For Joint Replacement Surgery. *Health Aff (Millwood).* 2020;39(1):58-66.
62. Agarwal R, Liao JM, Gupta A, Navathe AS. The Impact Of Bundled Payment On Health Care Spending, Utilization, And Quality: A Systematic Review. *Health Aff (Millwood).* 2020;39(1):50-57.
63. Agency for Healthcare Research and Quality. National healthcare quality and disparities report and 5th anniversary update on the National Quality Strategy [Internet]. Rockville (MD) : AHRQ ; 2016 Apr [cited 2017 Apr 4]. (AHRQ Publication No. 16-0015). 2015.
64. Institute of Medicine. Unequal treatment: confronting racial and ethnic disparities in health care . Washington (DC) : National Academies Press. 2003.
65. Chin MH. Creating the Business Case for Achieving Health Equity. *Journal of general internal medicine.* 2016;31(7):792-796.
66. Ayanian JZ, Landon BE, Newhouse JP, Zaslavsky AM. Racial and ethnic disparities among enrollees in Medicare Advantage plans. *The New England journal of medicine.* 2014;371(24):2288-2297.
67. Fisher ES. Medicare's bundled payment program for joint replacement: promise and peril? *Jama.* 2016;316(12):1262-1264.
68. Mechanic RE. Mandatory Medicare bundled payment—is it ready for prime time? *New England Journal of Medicine.* 2015;373(14):1291-1293.
69. Courtney PM, Huddleston JI, Iorio R, Markel DC. Socioeconomic Risk Adjustment Models for Reimbursement Are Necessary in Primary Total Joint Arthroplasty. *J Arthroplasty.* 2017;32(1):1-5.
70. Navathe AS, Liao JM, Dykstra SE, et al. Association of hospital participation in a Medicare bundled payment program with volume and case mix of lower extremity joint replacement episodes. *Jama.* 2018;320(9):901-910.
71. Ibrahim SA. Racial variations in the utilization of knee and hip joint replacement: an introduction and review of the most recent literature. *Current orthopaedic practice.* 2010;21(2):126-131.
72. Jorgenson ES, Richardson DM, Thomasson AM, Nelson CL, Ibrahim SA. Race, Rehabilitation, and 30-Day Readmission After Elective Total Knee Arthroplasty. *Geriatric orthopaedic surgery & rehabilitation.* 2015;6(4):303-310.
73. Ramos NL, Karia RJ, Hutzler LH, Brandt AM, Slover JD, Bosco JA. The effect of discharge disposition on 30-day readmission rates after total joint arthroplasty. *The Journal of arthroplasty.* 2014;29(4):674-677.

74. Fang M, Hume E, Ibrahim S. Race, Bundled Payment Policy, and Discharge Destination After TKA: The Experience of an Urban Academic Hospital. *Geriatr Orthop Surg Rehabil.* 2018;9:2151459318803222.
75. Burke RE, Ibrahim SA. Discharge Destination and Disparities in Postoperative Care. *Jama.* 2018;319(16):1653-1654.
76. Chaiyachati KH, Bhatt J, Zhu JM. Time for Value-Based Payment Models to Adopt a Disparities-Sensitive Frame Shift. *Annals of internal medicine.* 2018;168(7):509-510.

VITA

1. Educational institutions attended and degrees already awarded

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
Tianjin Medical University, China	M.D.	07/1997	Medicine
Tianjin General Hospital	Residency	06/2000	Anesthesiology
Tianjin Medical University, China	M.S.	06/2000	Clinical Research
University of Alabama at Birmingham	M.S.	07/2002	Computer & Information Science

2. Professional positions held

1997–2000	Research Associate, Tianjin General Hospital, China
2003–2006	Analyst, Division of Preventive Medicine, University of Alabama at Birmingham
2006–2011	Research Analyst, Alabama Quality Assurance Foundation (QIO)
2011–2013	Project Director, Division of Hospital Medicine, Department of Medicine, Northwestern University Feinberg School of Medicine
2014–2019	Assistant Professor, Department of Internal Medicine
2019–present	Associate Professor, Department of Internal Medicine
2014–2016	Administrative Director, Center for Health Services Research, University of Kentucky
2015–2016	Deputy Director, Office of Value and Innovation in Healthcare Delivery, UK HealthCare
2017–2019	Associate Director, Center for Health Services Research, University of Kentucky
2017–present	Director, Office of Value and Innovation in Healthcare Delivery, UK HealthCare
2019–present	Co-Director, Center for Health Services Research, University of Kentucky

3. Scholastic and professional honors

06/1993 – 07/1997	Annual Outstanding Students, Tianjin Medical University
12/2001	Presidential Honor, University of Alabama at Birmingham
10/2013	URAC 2013 Annual Quality Summit. Bronze Award. PREP: Preventing Readmissions through Effective Partnerships.
07/2014 – 06/2015	Exceptional reviewer for The Journal of Rural Health
2017, 2018, 2019	Wethington Research Award, University of Kentucky
2018	Outstanding reviewer, Annals of Internal Medicine

4. Professional publications

1. **Jing Li**, Wenshuo Li. Nitric oxide: A physiologic message. Journal of Diagnosis and Treatment for Diseases. 1998; 02(1): 56-59.
2. Guolin Wang, **Jing Li**. Effect of Isoflurane, Desflurane and Propofol Anesthesia on Intrapulmonary Shunting during One-Lung Ventilation. Journal of China Anesthesia and Analgesia. 2001;02: 83-85
3. **Li J,** Young R, Williams MV. Optimizing transitions of care to reduce rehospitalizations. Cleve Clin J Med. 2014 May; 81(5): 312-20. PMID: 24789590
4. Williams MV, **Li J**, Hansen LO, Forth V, Budnitz T, Greenwald JL, Howell E, Halasyamani L, Vidyarthi A, Coleman EA. Project BOOST Implementation: Lessons Learned. South Med J. 2014 Jul;107(7):455-65. PMID: 25010589
5. **Li J,** Hinami K, Hansen L, Maynard, G, Budnitz T, Williams MV. Physician Mentored Implementation (PMI): A Promising Quality Improvement Model in Healthcare. Acad Med. 2015 Mar;90(3):303-10. PMID: 25354069
6. **Li J,** Williams MV. Care Transitions: It's the How, Not Just the What. J Gen Intern Med. 2015 May;30(5):539-40. PMID: 25678377
7. **Li J,** Williams MV. Managing superutilizers-staying patient centered is the solution. J Hosp Med. 2015 Jul;10(7):467-8. PMID: 25872496
8. **Li J,** Boulanger B, Norton J, Yates A, Swartz C, Smith A, Holbrook P, Moore M, Latham B, Williams MV. "SWARMing" to Improve Patient Care by Promoting Transparency and a Culture of Safety. Jt Comm J Qual Patient Saf. 2015 Nov;41(11):494-3. PMID: 26484681
9. **Li J,** Brock J, Jack B, Mittman B, Naylor M, Sorra J, Mays G, Williams MV. Project ACHIEVE – Using Implementation Research to Guide the Evaluation of Transitional Care Effectiveness. BMC Health Serv Res. 2016 Feb 19;16:70.. PMID: 26896024

10. Fanucchi, L., Leedy, N, **Li, J**, Thornton, A. Perceptions and practices of physicians regarding outpatient parenteral antibiotic therapy in persons who inject drugs. J of Hosp Med. 2016 Aug;11(8):581-2. PMID: 27043146
11. Naylor MD, Shaid EC, Carpenter D, Gass B, Levine C, **Li J**, Malley A, McCauley K, Nguyen HQ, Watson H, Williams MV. Components of Comprehensive and Effective Transitional Care. J Am Geriatr Soc. 2017 Jun;65(6):1119-1125. PMID: 28369722
12. Scott AM, **Li J**, Oyewole-Eletu S, Nguyen H, Gass B, Mitchell S, Hudson S, Williams MV. Understanding Facilitators and Barriers to Care Transitions: Insights from Project ACHIEVE Site Visits. Jt Comm J Qual Patient Saf. 2017 Sep;43(9):433-447. PMID: 28844229
13. Shen E, Alem A, Khang P, Watson HL, **Li J**, Nguyen HQ. Completion of an outpatient visit after skilled nursing facility discharge and readmission risk. J Am Med Dir Assoc. 2017 Sep 1;18(9):797-798. PMID: 28676290.
14. Edward J, Carreon L, Williams MV, Glassman S, **Li J**. The Importance and Impact of Patients' Health Literacy on Low Back Pain Management. Spine J. 2018 Feb; 18(2): 370-376. PMID: 28939167
15. **Li J**, Talari P, Kelly A, Latham B, Dotson S, Manning K, Thornsberry L, Swartz C, Williams MV. Inter-professional Teamwork Innovation Model (ITIM©) to Promote Communication and Patient-Centered, Coordinated Care. BMJ Qual Saf. BMJ Qual Saf. 2018 Sep;27(9):700-709. PMID: 29444853
16. **Li J**, Williams MV. Hospitalist Value in an ACO World. J Hosp Med. 2018 Apr;13(4):272-276. PMID: 29624190
17. Mitchell SE, Laurens V, Weigel G, Hirschman K, Scott Gordon A, Nguyen HQ, Martin J, Laird L, Levine C, Davis TC, Gass B, Shaid E, **Li J**, Williams MV, Jack BW. Care Transitions from Patient and Caregiver Perspectives. Ann Fam Med. 2018 May;16(3):225-231. PMID: 29760026
18. Glassman S, Carreon L, Brown M, Jones J, Edward J, Li J, Williams MV. The Impact of Health Literacy on Health Status and Resource Utilization in Lumbar Degenerative Disease. Spine J. 2019 Apr;19(4):711-716. PMID: 30395960
19. Li J, Williams MV, Page C, Cassis L, Kern PA, DiPaola RS. The Value of Innovation to Implementation Program (VI2P): A Strategic Approach to Aligning and Leveraging Academic Research and Clinical Care Missions. Learn Health Syst. 2019 Jul 11;3(4):e10199. PMID: 31641687
20. Real K, Bell S, Williams MV, Li J. Observation of Real-Time Communication and Behaviors During Implementation and Patients Experience with Interprofessional Teamwork Innovation Model (ITIM). Jt Comm J Qual Patient Saf. (in print)

5. Typed name of student on final copy

Jing Li