2018

Physician-hospital integration and efficiency of accountable care organizations

BOSTON UNIVERSITY

SCHOOL OF PUBLIC HEALTH

Dissertation

PHYSICIAN-HOSPITAL INTEGRATION AND EFFICIENCY OF ACCOUNTABLE CARE ORGANIZATIONS

by

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Submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

2018

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ACKNOWLEDGMENTS

It has been a long journey, and there are many people I would like to thank for their support, mentorship, and encouragement during my time at BU. First and foremost, I would like to thank my academic advisor and Committee Chair, Dr. Kathleen Carey, for her guidance and devoted mentorship at every step throughout this process. It is her teaching excellence and passion for research that inspired my interest in health economics ten years ago. She made me a researcher instead of just earning the Ph.D. degree. I also owe a debt of gratitude to my supervisor at BMC and dissertation advisor, Dr. Amresh Hanchate, for his endless support and mentorship during the past seven years. He has challenged me to think deeply and come up with a solution when encountering research difficulties throughout this dissertation and that is something that I will carry with me into my future career. I would like to thank Dr. Austin Frakt, my dissertation advisor, for his attention to technical detail and input on framing research findings. His vast knowledge and skill in many areas are greatly appreciated. I am also grateful to Dr. Ted Stefos and Dr. Michael Shwartz for taking time out from their busy schedules to serve as my external readers. Each of you was generous with your time and expertise. In addition to my dissertation committee and external readers, I would like to thank Dr. James Burgess and Dr. Victoria Parker for their eminent support since I joined the MPH program. The unconditional support that they provided to every HSR student was much missed and appreciated by all of us. In particular, I want to thank Jim for his generosity to students, his passion about the research on various topics, and his positive attitude toward work.

I would also like to thank my colleagues at BMC. I give special thanks to Dr. Nancy Kressin for her guidance, essential support and flexibility during my time at BMC. She paved the way for me to become an independent researcher in the future. Also, many thanks to Lisa Marks and Meredith Manze for their support and cheers. Lisa, I truly appreciate that your office door is always open and that you are always willing to listen. Meredith, thank you for helping me jump through the hoods during my first tough year of the program. Both of you gave my student life much cheer.

Appreciation also goes to my fellow HSR peers for their friendship, much needed support, and all the fun times we had together. From the exams to the dissertation, I could not have made it through without the support of Jackie, Jake, Michal, and Marina. Also, Carolina and Kevin, thanks for your ideas about available data sources and programming tricks. You guys made the marathon much more joyful, and I was blessed to complete the journey with you.

Finally, I would also like to thank my family for being understanding and supportive even though I could not always be there with them. Their love, support, and belief in my potential mean the world to me. More importantly, I thank my partner who has always been a positive force in my life and a source of tremendous encouragement and love. Our life together has changed so much over the past two years, and I look forward to many more years to come.

PHYSICIAN-HOSPITAL INTEGRATION AND EFFICIENCY OF ACCOUNTABLE CARE ORGANIZATIONS

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ABSTRACT

Since the Patient Protection and Affordable Care Act (ACA) has dramatically reduced the number of uninsured, the U.S. healthcare system now faces a tougher challenge: to simultaneously improve quality of care and contain costs. Accountable Care Organizations (ACOs) that hold providers across settings collectively responsible for the quality and costs of care are currently the ACA's best hope for pursuing the dual goal. Accompanied by the ACO momentum, physicians are increasingly employed by hospitals, leading to greater physician-hospital integration. Though there is evidence that provider consolidation elevated prices, little is known about whether physician-hospital integration in ACOs improves the efficiency of healthcare delivery.

This dissertation comprises three studies that seek to understand the impact of physician-hospital integration on ACO efficiency through quantitative analyses of 16 commercial ACOs operating under the Alternative Quality Contract (AQC) launched by Blue Cross and Blue Shield of Massachusetts in 2009. Study 1, *Profiling AQC Participants According to Physician-Hospital Integration*, investigates whether there are systemic differences in organizational

structure, patient population, and composition of healthcare spending between low- and high-integrated AQC participants. The findings suggest that high-integrated organizations tend to be larger in scale, serve more affluent patients, but generally spend more.

Study 2, *The Impact of Physician-Hospital Integration on ACO Efficiency in Inpatient Care Delivery*, examines whether integration leads to improved ACO efficiency in inpatient care delivery. The results indicate that integration is correlated with a reduction in spending aggregated over an episode of inpatient care and a decline in length of stay, with no evidence of elevated readmission rates.

Study 3, *The Impact of ACO Physician-Hospital Integration on Health Care Spending and Delivery Patterns*, explores the association between integration and annual healthcare expenditures and utilization per person (inpatient, outpatient, and overall). The results suggest that integration is correlated with reduced utilization and increased expenditures; the latter is almost entirely driven by higher spending in outpatient settings.

The findings of this dissertation suggest that physician-hospital integration is associated with improved efficiency in inpatient settings. However, when considering a broader scope of health services, its impact on efficiency is mixed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

2SRI…………………………………………………..… Two Stage Residual Inclusion

2SLS……………………………………………………….… Two Stage Least Square

ACA………………………………………Patient Protection and Affordable Care Act

ACO……………………...…………………………Accountable Care Organization

ACS…………………………………………………... American Community Survey

AHA……………………………………………….………… American Hospital Association

AHRF…………………………………………….……….. Area Health Resource Files

AHRQ………………………………… Agency for Healthcare Research and Quality

APCD…………………………………………………………All Payer Claims Database

AQC……………………………………………………..…Alternative Quality Contract

BCBS……………………………………... Blue Cross Blue Shield of Massachusetts

BETOS……………………………………………..Berenson-Eggers Type of Service

CCS………………………………………………..… Clinical Classifications Software

CHIA……………………………….……. Center for Health Information and Analysis

CMS……………............................... Centers for Medicare and Medicaid Services

CPT……………………………………………….. Current Procedural Terminology

DRG……………………………………………….…… Diagnostic Related Groups

FE……………………………………………………………………...Fixed Effects

FFS……………………………………………………………….…Fee for Service

GLM…………………………………………………..…Generalized Linear Model

HEDIS………………………… Healthcare Effectiveness Data and Information Set

HHS-HCC………….. Health & Human Services Hierarchical Condition Categories

HMO……………………………………….……. Health Maintenance Organization

HOPD………………………………………………Hospital Outpatient Department

HPSA…………………………………………...Health Professional Shortage Area

IDS……………………………………………….……Integrated Delivery System

IV…………………………………………………………..…Instrumental Variable

LATE………………………………………………Local Average Treatment Effect

LOS……………………………………………………………………… Length of Stay

MA-RPO…………………....Massachusetts Registration of Provider Organizations

MSSP…………………………………...………. Medicare Shared Saving Program

NPI……………………………………………….…. National Provider Identifier

OOP……………………………………………………………………….. Out of Pocket

PCP………………………………………………………….…. Primary Care Physician

POS……………………………………………………………………..….Point of Service

PPO………………………………………………….. Preferred Provider Organization

PSE…………………………………………………… Patient Experience Survey

SES………………………………………………………………... Socioeconomic Status

CHAPTER 1: INTRODUCTION

Since the Patient Protection and Affordable Care Act (ACA) has dramatically reduced the number of uninsured, the U.S. healthcare system now faces a tougher challenge: to improve quality of care and contain costs simultaneously. Accountable Care Organizations (ACOs) that hold providers across settings collectively responsible for the quality and costs of care are currently the ACA’s best hope for pursuing the dual goal. Accompanied by the ACO momentum, physicians have been increasingly employed by hospitals, leading to greater physician-hospital integration. Although there is evidence that provider consolidation elevated prices and costs, little is known about whether physician-hospital integration in ACOs improves the efficiency of healthcare delivery. This dissertation examines the association of physician-hospital integration and ACO efficiency using a set of provider organizations that signed the Alternative Quality Contract (AQC) with Blue Cross Blue Shield of Massachusetts (BCBS), a commercial ACO program, between 2009 and 2013.

This chapter provides the conceptual basis and background of this study, including an overview of the development of ACOs, a brief summary of important features of the AQC program, findings from literature on its performance, and the ongoing integration between physicians and hospitals under the context of ACOs, along with a conceptual framework guiding three studies presented in the following chapters. Collectively, the subsequent chapters aim to answer the question: **whether the vertical integration of hospitals with physicians**

improves the efficiency of ACO in healthcare delivery? In Chapter Two, "*Profiling AQC Participants According to Physician-Hospital Integration*," I investigated whether there are systemic differences in organizational structure, patient population, and composition of healthcare spending between low- and high-integrated AQC participants. In Chapter Three, "*The Impact of Physician-Hospital Integration on ACO Efficiency in Inpatient Care Delivery,*" I examined whether integration leads to improved ACO efficiency in inpatient care delivery. In Chapter Four, "*The Impact of ACO Physician-Hospital Integration on Health Care Spending and Delivery Patterns,*" I explored the association between integration and annual health care expenditures and utilization per person, overall and stratified by inpatient and outpatient components. Finally, Chapter Five summarizes the findings of each study, presents the overall conclusions, and comments on future studies that develop a deeper understanding of the influence of hospital integration with physicians on ACO performance.

Accountable Care Organization

<u>Background and Definition</u>

For many economists and policymakers, tradeoffs between cost, quality, and access to care seem inevitable. Policies and interventions tailored to address one leg of the "iron triangle" may unintentionally weaken the others. Berwick and colleagues argued that improving the U.S. health care system requires simultaneous pursuit of three aims: improving the experience of care, promoting the health of populations, and reducing per capita costs of health care

(26). The idea of Accountable Care Organizations (ACOs) is considered by many scholars and delivery system leaders to be the most promising means of achieving the triple aim when the newly covered population imposes considerable pressure on the care delivery system to improve quality and lower costs. From a provider perspective, ACOs create incentives to practice more effectively and reap financial rewards resulting from improved efficiency. From a patient perspective, ACOs serve as one-stop-shops that find patients the services they need and the right person to provide it.

An ACO is defined as a group of providers who collectively accept responsibility for the care of a pre-defined patient population and who are accountable for the overall costs and quality of their care, across the entire care continuum. The concept was first introduced in 2007 by Fisher and colleagues (49). They argued that health policies on performance improvement and payment reform focusing on specific providers may deteriorate care coordination, particularly among patients with clinic illness, and suggested that extended hospital medical staff— a prototype of ACOs—may have the potential for improving quality and lowering the cost of health care. The extended hospital medical staff was defined as a hospital-associated multispecialty group practice established by physicians' direct or indirect referral patterns to a hospital. This idea of integrating different health care providers was not new in the U.S. since there have been several highly centralized health care systems operating in the private sector such as Kaiser Permanente, Geisinger Health System, and the

Mayo Clinic which own hospitals and employ salaried physicians. These integrated health systems organized into one-stop-shops for patient care have, in some instances, already provided the cost-effective, coordinated care embodied in the ACO concept. Some delivery system leaders and policy experts believe that similar results could be achieved through the formation of ACOs partnering physician practices and other clinicians with local hospitals. Later, the ACO concept became widespread nationally and culminated in incorporation into the Patient Protection and Affordable Care Act (ACA).

Development and Landscape

The Centers for Medicare and Medicaid Services (CMS) announced the establishment of the first cohort of Medicare ACOs (32 Pioneer ACOs) in late 2011. Although only nine of those had remained active until the program ended in 2016, there was a total of 477 Medicare ACOs serving nearly 22 percent of Medicare beneficiaries (8.9 million) then (10). Simultaneous to the CMS programs, ACOs were also forming in the private sector. Before the Pioneer ACO program, there had been over 150 ACOs operating or announced in the private sector. Private ACOs also have grown significantly during recent years and many of them now simultaneously contract with private payers and CMS (87). An early report gave a snapshot of recent ACO development (88). As of the end of January 2016, there were 838 active ACOs across the country operating in all 50 states and DC, covering about 28.3 million people. Though the number of covered lives in the Medicare ACO program had dramatically increased, the majority of ACO patients were served by providers contracting with private payers. Nationally, 8.9 percent of the population was served by ACOs; however, ACO penetration—the percentage of lives in a market covered by an ACO contract—varied.

In addition to studies documenting the growth and dispersion of ACOs, early ACO research mainly focused on identifying factors such as contract characteristics, organizational structures, capabilities, activities, and local environmental context that influence ACO formation, implementation, and performance (18, 39, 47, 61, 74). Higher Medicare per capita spending, fewer primary care physician groups, greater managed care penetration, lower poverty rates, and urban areas were found to be associated with the formation of ACOs (74). Hospitals that locate in an urban area, that are nonprofit, or have a small share of Medicare patients were more likely to join ACOs (39). Moreover, hospitals participating in ACOs tended to be large in scale, teaching hospitals, and not-for-profit, though these characteristics were not related to performance metrics (47). Other facilitators of successful formation of an ACO include the availability of comprehensive and timely data and analytic reports, payment tailored to providers' readiness for these contracts, and measurement of quality across multiple years and care settings (61). Another study found that, despite high willingness to participation, primary care clinics faced difficulties in joining ACOs because of limited technological and human resources and lower ACO penetration in rural areas (95).

Organization Structure and Payment Mechanism

The ACO concept is grounded in the observation that physicians' tie to hospitals to which they refer patients functions as a sort of informal network, and that patients receive most of their care within the network. Provider organizations consisting of hospitals and doctors who use the facilities could, therefore, be held accountable for the quality and spending on care received by the patient population they serve together (12). In general, ACOs are formed by the consolidation or alliance of pre-existing provider entities based on their willingness to accept accountability for the cost and quality of care that a defined population may need. The newly established structure facilitates providers who are previously disintegrated to jointly agree upon spending targets and quality goals and share in savings they generate. The success of ACOs in enhancing efficiency in healthcare delivery, to some extent, depends on the effectiveness of the new organization in promoting care coordination across providers and care settings. Therefore, understanding the performance of ACOs will benefit from taking an organizational perspective (116).

Previous studies have documented providers frequently involved in ACO formation and organizational characteristics associated with ACO participation. Though the formation and operation of ACOs usually involve various providers, a study categorizing ACOs into different models found that the most prevalent initiator is integrated delivery systems (IDS) defined as multi-specialty physician group practices with or without hospital affiliation (114). Another study identified characteristics correlated with physician groups' participation in ACOs, including practice size, membership of independent practice association (IPA) or physician-hospital organization (PHO), hospital ownership, and use of care management processes (113). For hospitals, the determinants of ACO participation include health care system membership, use of electronic health records, hospital type, patient mix, and nursing home affiliation (133).

In addition to organizational structure, the other essential element of ACOs is reimbursement mechanism. In general, ACOs share a certain amount of savings with payers but may bear varying degrees of financial risk if they fail to meet quality benchmarks or reduce spending below agreed-upon targets. The level of risk could range from none to partial or full capitation models. CMS offers several ACO programs varying in the proportion of savings that an ACO gets to retain and in the risk of financial loss in a case of overspending. In the Medicare Pioneer and Next Generation programs, CMS adopts a two-sided model—ACOs paid by an FFS model are subject to financial losses for overspending but entitled to upside shared savings for meeting cost and quality targets. However, there is no downside risk for ACOs participating in the Medicare Shared Savings program (MSSP). They only share in savings with CMS without being held accountable for spending above the targets. A variety of ACO contracts exist in the private sector as well. Private, commercial insurers are more energetic in moving away from volume-driven FFS based reimbursement. In addition to capitation payment with financial incentives to quality improvement and cost containment, global payment contracts that reward care coordination and quality outcomes by offering providers performance bonuses on top of a risk-adjusted budget are increasing across the U.S.

Criticisms and Challenges

Though ACOs have the potential to improve quality of care and reduce medical expenditures concurrently, a few challenges may prevent ACOs from achieving the dual goals. Despite the promising start of the ACO movement, many health economists have repeatedly expressed concerns about the potential unintended consequences of ACOs: provider consolidation encouraged by ACO contracts may eventually lead to higher health care prices and insurance premiums (19, 20, 42, 52). ACO formation, to some degree, implicitly promotes collusion between providers, particularly hospitals and physician groups. When negotiating together, hospitals and physicians may enhance their bargaining clout and therefore be able to settle higher payment rates with private payers. The elevated prices may later be passed along to consumers through increased premiums for commercial insurance plans. Several scholars have warned that hospitals might keep buying up physician practices in anticipation of ACO participation (69, 101). Moreover, previous studies have documented a positive correlation between provider concentration and health care prices (20, 21). In other words, ACOs' potential for bending the cost curve may be offset by the higher prices that integrated providers could negotiate with private payers.

In addition to the issue of concentrated market power, uncertainty about an ACO's success in fulfilling its promise results from its organizational components. An ACO may comprise various provider entities in local or regional geographic areas. Shortell and Casalino identified five types of provider organizations that could either itself serve as or lead an ACO or participate in an ACO led by other entities (111). ACOs that adopt different models vary in their ability to coordinate or manage care across the continuum, to prospectively plan budgets and resource allocation, and in the degree of provider inclusiveness and level of performance accountability (112). In local areas, the majority of care is delivered by primary care providers and their affiliated tertiary hospitals and specialists through referral patterns. Therefore, an ACO's capability to ensure accountability for quality and costs across the care spectrum may depend on the composition of participating providers. Moreover, for each ACO, the best approach of allocating savings among various providers may rely heavily on its organizational structure and leadership. Fair distribution of financial risks and rewards among different provider entities could be challenging for ACOs, especially one with loose organizational structure. Early critiques of the ACO proposal were pessimistic about its potential in reducing health costs and improving quality of care and argued that it might eventually fail like the Health Maintenance Organization (HMO) movement in the 1990s (78).

Alternative Quality Contract

In 2009, Blue Cross Blue Shield of Massachusetts (BCBS) launched Alternative Quality Contract (AQC)—a modified global payment arrangement that combines a global budget with substantial performance incentive payments. Chernew and colleagues gave a thorough explanation of the AQC, which is the most comprehensive payment reform among private payers in Massachusetts (34). The AQC does not require a specific organizational structure for providers to participate in the program. Some AQC participants are physician group practices, while others are IDSs that consist of both physician groups and hospitals. Provider organizations take responsibility for the full continuum of care received by a group of applicable BCBS members regardless of where they receive the care. In other words, a provider organization is responsible for services provided by hospitals or specialists that are out of its network. Under the contract, BCBS pays provider groups a fixed per-month payment adjusted annually for the health status of their patient population and inflation and offers providers performance incentives of up to ten percent of the total payment. These incentives are based on a set of clinical performance measures including process and outcomes of care and patient care experience and covering both inpatient and outpatient care. The AQC applies only to members with HMO or Point of Service (POS) coverage because these plans require enrollees to designate a primary care provider that allows BCBS to direct payments to the AQC organization with which each member's primary care provider is affiliated. Eligibility for the AQC requires that provider organizations include primary care physicians (PCPs) who collectively care for at least 5,000 BCBS's HMO or POS members. According to BCBS, the AQC included 85% of the physicians and hospitals in its HMO network by the end of 2013 (1). Similar to Medicare ACO programs, members are not formally notified when they select a PCP who is affiliated with an AQC participating organization and are free to seek care from other PCPs in the network. Also, enrollees' cost-sharing requirements are not affected by whether their PCPs participate in the AQC agreement.

Though the AQC is considered an analog of Medicare ACO program in the private sector, it differs from the MSSP in several aspects. First, it is a five-year contract which encourages providers to invest in long-term, lasting improvement initiatives. Second, its budget covers a broader scope of services, including outpatient prescription drugs which are absent from the MSSP. Third, it takes heterogeneity among providers into account by negotiating an annual growth rate in the budget with each provider group, while CMS applies the national average rate to every ACO. Fourth, regarding risk structure, the AQC adopts a two-sided model under which providers are subject to both savings and losses; by contrast, most MSSP ACOs do not receive a penalty for overspending in the first two years. Finally, compared to CMS' more conservative payment arrangement that tops the performance bonus at 50% of shared savings, BCBS provides a stronger incentive to quality improvement and cost containment by offering greater bonuses and more severe penalties, ranging from 50% to 100% of the aggregate savings or losses (34, 109).

Song et al. have conducted a series of studies evaluating the effects of the AQC on quality improvement and cost containment and presented promising findings (118, 119, 121). The AQC achieved a modest slowing of spending growth and improved quality of care in year one and more so in the later years—the estimated savings increased from 2.8 percent over the first two years to 6.8 percent in year four. Savings were derived mainly from shifting outpatient care toward providers with lower fees, while some savings were accounted for by reduced utilization. Though incentive payments to providers exceeded the achieved savings in early years, incremental savings surpassed incentive payments in 2012, generating net savings. A qualitative study echoed the findings as interviews with representatives of AQC participants showed that provider groups initially focused on building the infrastructure to help primary care providers earn quality bonuses and manage referrals to lower-cost settings (85). Although studies investigating overall changes in quality and spending gave promising results, findings from studies focusing on specific services or patient populations were mixed. The AQC was not associated with reduced use of drugs and ED services (13, 110) but was related to higher use of colonoscopies even though shifting volume to lower-priced facilities (120). Although the program was adult-oriented, studies found provider groups did respond to pediatric incentives and achieved small improvements in pediatric care quality tied to performance measures (35, 36). For behavioral health, utilization of mental health services among patients served by AQC providers declined slightly, but no change was found in mental health spending (24); on the other hand, the AQC was associated with increased use of tobacco cessation services (64). In summary, it appears that AQC providers achieved performance improvement mainly in outpatient care by lowering costs through the reduced use of procedures, imaging, and tests and providing more tobacco cessation treatment.

Vertical Integration between Physicians and Hospitals

In response to the ACO momentum and the prospect of more risk-based payment approaches, more than half of practicing U.S. physicians are now employees of hospitals, hospital systems, or an IDS (70). Financial integration between physicians and hospitals may help ACOs meet the challenges of new payment models but may also increase their negotiating leverage with health plans, leading to higher service prices, and as a result, increased premiums and spending among privately insured populations. Historically, hospitals' primary motivation for employing physicians has been to gain market share, typically through lucrative service-line strategies encouraged by the FSS payment system that rewards volume. In the ACO era, hospitals review physician employment as a way to prepare for payment reforms that shift from FFS to methods that make providers more accountable for the costs and quality of patient care. This consolidation may foster cooperation among providers across specialty and care settings and thereby reduce expenditures, but may also lead to higher expenditures through increased use of hospital-based ambulatory services and greater provider pricing leverage against health insurers.

Whether provider consolidation leads to better quality of care is not clear, there has been some empirical evidence that physician-hospital integration was related to higher prices and spending. A study investigating Medicare ACOs found that hospital centralization was related to a more substantial reduction in mortality, but tightly integrated hospital-physician arrangements were associated with increased mortality. Additionally, the observed quality improvement did not couple with lower cost growth (37). Robinson and colleagues found that hospital-owned physician organizations in California incurred higher expenditures for commercial HMO enrollees for various services than physician-owned organizations (105). They concluded that although organizational consolidation might, to some extent, increase care coordination, it was associated with higher total expenditures as well. Moreover, vertical integration of hospitals with physicians was found to be related to increased market share along with growth in prices and spending (20). Another recent study led by Neprash suggested that financial integration between physicians and hospitals was associated with higher commercial prices and spending for outpatient care (90).

Theoretically, ACOs with vertical integration between hospitals and physicians may offer better-coordinated care, but there is no evidence that they are more efficient in healthcare delivery than ACOs without such organizational structure in place. To gain market share hospital employment of physicians has continued in recent years to shore up referral bases and capture admissions. This ongoing trend is particularly prevalent among vertically integrated ACOs and has caused concerns for higher prices resulting from market share gains through hospital employment of physicians (68, 70, 93). When hospitals hire physicians or assimilate physician practice groups, their enhanced market power to negotiate higher payments and capability for exerting pressure on employed physicians to order more expensive services will be countervailing forces against the promise of ACOs to provide higher-quality care at lower costs.

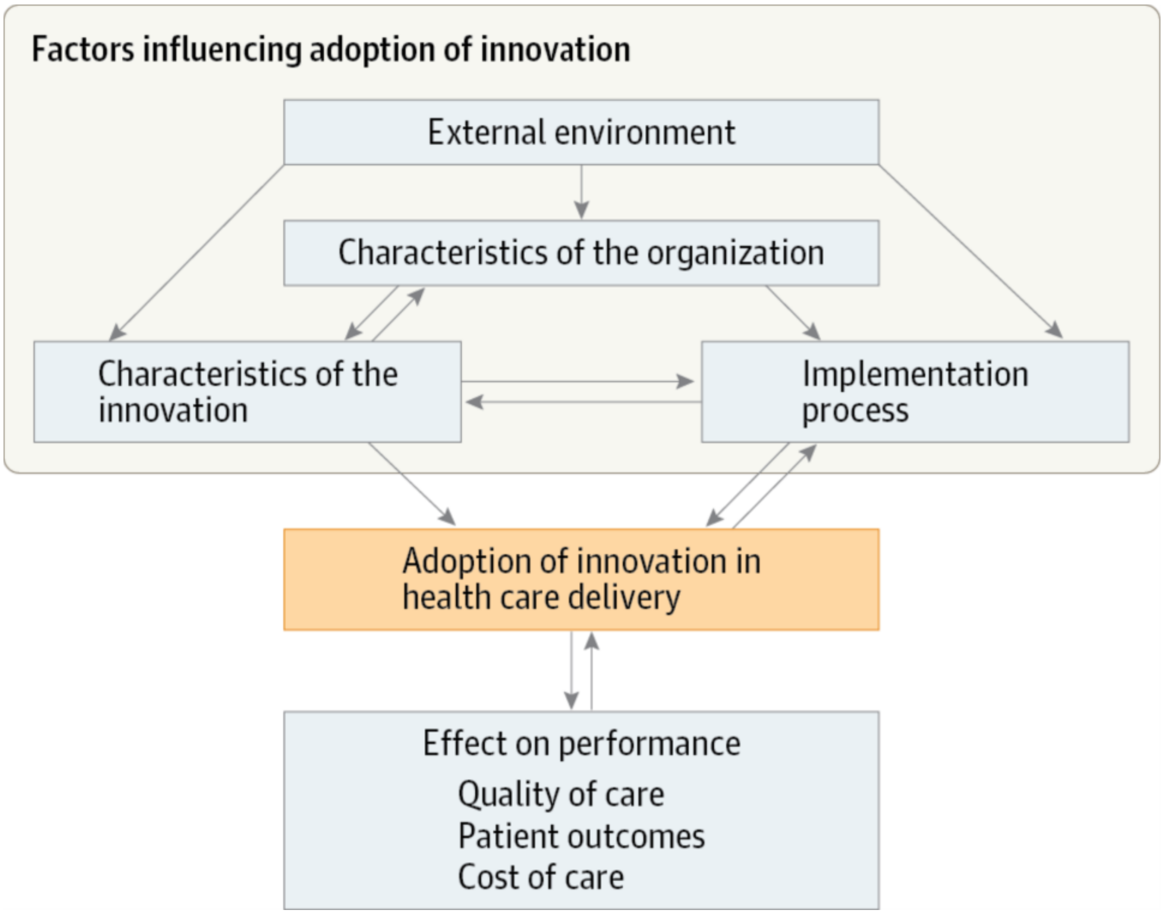
Conceptual Framework

Evaluation of ACOs

A big challenge for health services research on ACOs is to recognize the significant variation in organizational characteristics and external environment within which ACOs operate. Change in care delivery is complicated because it usually involves individuals with diverse backgrounds and from different organizational levels and sometimes influenced by factors beyond organizations' control. ACOs can vary in various attributes, such as the degree of risk shared with payers, the local market structure, and, most commonly, organizational structure. Therefore, the successful experience of ACO formation and implementation occurred in one case may not necessarily work in another. What works, why it works and how it works are questions that need to be answered to provide insights to inform future development and evolution of ACOs and accelerate the learning necessary to improve ACO performance. Implementation science applying a multidisciplinary approach provides a dynamic lens to understand the implementation and performance of ACOs.

To evaluate the impact of physician-hospital integration on ACO efficiency, I adopted the framework developed by Fisher et al. based on organizational theories (Figure 1.1) (50). The framework drawn from implementation science identifies four central concepts that interact with each other to influence the adoption of innovations. It conceptualizes the adoption of innovation or intervention as a function of characteristics of the *environment* external to the organization, characteristics of the *organization* itself, features of the *innovation*, and the actual *implementation process*. The external environment considers national, state, or local context that drives the form that an organization takes and how a new organizational form like an ACO will be adopted and become institutionalized. Furthermore, the environmental context including local policy and regulation may influence the characteristics of ACO contracts regarding the scope of incentives, the degree of risk, approaches to patient assignment and engagement. Contract structure along with the policy and practice environment jointly shape how provider organizations address the challenges they face in forming and operating ACOs. Initiating and managing an ACO can be incredibly complex considering the dynamic nature of the context within which it is launched and operates. What strategies and implementation activities ACOs pursue and how capable they are of reliably managing complexity and uncertainty dramatically depends on their organizational structure such as leadership, governance, culture, and professional network. Provider organizations may adopt various strategies to meet the targets set by ACO contracts and address challenges they face in the process of translating implementation initiatives into effective frontline care delivery. These four attributes not only influence the adoption and development of ACOs but also the performance in achieving desired cost, quality, and population health goals.

Figure 1.1: Framework for analyzing the adoption of innovations[1]



<u>ACO Structure and Capabilities</u>

According to the Fisher's framework, organizational features of ACOs are essential factors explaining the variations in performance. Without a full understanding of such heterogeneity, an observed correlation between one factor and outcomes could be confounded by other elements. To profile the 16 AQC

[1] Figure adapted from Fisher et al.; JAMA. 2016; 314(4):339-340.

participants under study, I applied the taxonomic concept developed by Shortell et al., which is grounded in two well-developed theories of organizations—resource dependency theory and institutional theories of organizations (114). The concept characterizes organizational structure of ACOs based on eight specific measures:

1) Size measured by the number of full-time clinicians,
2) Participation breadth measured by the number of different types of providers, such as hospitals, physicians, nursing homes et cetera,
3) Scope of services provided,
4) IDS status,
5) Percentage of primary care clinicians,
6) Institutional leadership type,
7) Physician performance management, and
8) Degree of prior experience with payment reform.

Shortell and colleagues constructed these measures using data from the first National Survey of ACOs to describe and understand early ACO development. Based on these organizational features, they then conducted cluster analysis to categorized ACOs into three distinct types—IDS, physician-led, and hybrid ACOs—and provided evidence of better performance of physician-led ACOs. I adopted a similar strategy by applying the taxonomic concepts to the conceptual framework of ACO evaluation described earlier. Specifically, I measured the construct of organizational characteristics by the eight features identified by

Shortell to explore the heterogeneity of ACOs in organizational features.

Health Care Efficiency

Based on Fisher's conceptual framework, one can evaluate ACO performance concerning the quality of care, patient outcomes, or costs of taking care of assigned patient populations. Recent studies evaluating the effects of AQC program have followed the scheme and presented evidence of quality improvement and cost containment (35, 118). Interventions that incorporate global budget and pay for performance bonuses, such as the AQC, have the potential to increase the value of health services defined as the higher quality of care at lower costs. The definition of value implies that health care costs and quality are intertwined—estimating one component independently of the other may lead to biased evaluations of performance. A recent article further argued that efficiency can be a better performance measure because it relates costs to quality of care and is equivalent to or directly related to overall value in some circumstances (27).

Researchers from RAND and Agency for Healthcare Research and Quality (AHRQ) developed an analytic framework of efficiency based on conventional economic theory. The framework conceptualizes efficiency as a relationship between a specific product of health care system (*outputs*) and the resources used to create the product (*inputs*). The framework adopts a societal perspective--considering health care providers, health plans, and purchasers collectively as a "firm" and evaluating efficiency relevant to both the healthcare firm that delivers health services and individuals who receive health care. A healthcare firm transforms inputs measured by physical (e.g., clinical practitioners, medical supply) and financial *resources* (e.g., wages, medical costs) used into outputs defined as *health services* (e.g., hospital discharges, office visits, and procedures) or *health outcomes* (e.g., post-admission mortality rate, functional status, and quality-adjusted life years) (80).

Given that health services research generally considers outcomes of care as quality measures (46), Palmer and Torgerson took the RAND/AHRQ framework further by incorporating the concept of quality into the efficiency equation that relates resource inputs to either health services or health outcomes (96). In response to the development of value-based medicine, evaluation of efficiency in health care is shifting from an input- and output-oriented framework to approaches focusing on health outcomes and taking care quality into account. To achieve better health outcomes via more efficient allocation of scarce resources, health economists have advocated for the critical role of quality in evaluating efficiency in health care (27, 53). Therefore, I defined healthcare efficiency as a function of inputs, outputs, and quality of care following the concept framed by Palmer and Torgerson.

Guided by Fisher's framework, this dissertation investigates the effects of physician-hospital integration on ACO performance by comparing outcomes between AQC participants with low versus high integration levels.

Selecting AQC participants as the study sample effectively minimizes the confounding effects of operating environment and contractual features because these commercial ACOs are subject to similar contract terms and operate in the same state. Furthermore, I incorporated the ACO taxonomic concept and the conception of efficiency into the innovation adoption model to recognize the heterogeneity of ACOs in organizational features and avoid the distortion resulting from not taking quality into account. Together, this dissertation develops a deeper understanding of the influence of physician-hospital integration on ACO performance and the mechanisms through which ACOs achieve performance improvement.

CHAPTER 2: PROFILING AQC PARTICIPANTS ACCORDING TO PHYSICIAN-HOSPITAL INTEGRATION

Summary

A challenge for health services research on Accountable Care Organizations (ACOs) is to recognize the significant variation in organizational characteristics and external environment within which ACOs operate. Without a full understanding of such heterogeneity, an observed correlation between a factor and ACO performance could be confounded by other elements. In this dissertation, the factor of interest is physician-hospital integration. To properly assess its impact on ACO performance, it is essential to explore the potential variations between more and less integrated organizations. Analysis of this chapter is twofold. First, I measured hospital integration with physicians for each ACO and categorized them into high- versus low-integrated providers. Second, I conducted descriptive analyses to identify differences between the two groups. Findings from this chapter serve as the foundation for further examining the association of integration with ACO performance in the following chapters.

Research Question

The question addressed in this chapter is: what are the systemic differences in organizational structure, patient population, and composition of healthcare spending between low- and high-integrated AQC provider organizations?

Background

In 2009, Blue Cross Blue Shield of Massachusetts (BCBS) launched the Alternative Quality Contract (AQC) program, a comprehensive payment reform that combines a modified global payment with substantial performance incentives (34, 122). The AQC program is a commercial ACO contract and pays providers a fixed per-member-per-month fee adjusted for case mix and inflation. It allows providers to keep the savings if their year-end spending is under the pre-determined budget and offers additional bonuses for achieving quality improvement. According to the BCBS, by the end of 2013, the program covered 85% of the physicians in its HMO network, and 16 provider organizations participated in the AQC (1).

Vertical integration of physicians with hospitals has become more prevalent in recent years. Several recent studies have documented a growing trend of hospital employment of physicians and acquisition of practices (29, 55, 97, 108). In the ACO movement, providers may pursue further consolidation to strengthen their capacity to foster clinical integration and care coordination among multiple providers with a view to improve quality of care and reduce expenditures. However, prior research shows that integrated delivery systems resulted in limited improvement in the quality of care (31, 65, 108). On the other hand, there is evidence suggesting vertical integration was associated with higher medical spending in various settings (20, 65, 105). While physician-hospital integration has the potential to increase care coordination across the clinical spectrum, it may be associated with higher total expenditures due to enhanced negotiating leverage to increase prices. As the development of ACO evolves, the trade-off between the gains of better clinical coordination from integration and the threat of higher prices through increased bargaining power is a significant policy concern (21, 52, 73, 106).

This dissertation investigates how physician-hospital integration impacts the performance of ACOs and strategies that they adopt to improve quality and reduce costs. AQC participants make an ideal study sample for the study question for two reasons. First, physician organizations can participate in AQC as a solo entity or in combination with other medical groups or hospitals and thus demonstrate varying degrees of physician-hospital integration. Second, they operate in the same state and under similar contracts, which significantly reduces the complexity of evaluating ACO performance. However, these commercial ACOs may differ in other organizational attributes, besides integration level, and in characteristics of their patient population. This heterogeneity may have an impact on the strategic priorities and specific clinical activities that ACOs establish. Furthermore, it may influence the degree to which ACOs achieve changes in the patient care process required to improve quality and measurably lower costs. Therefore, to explore the potential impact of physician-hospital integration on ACO performance, a thorough understanding of their organizational structure and patient population may serve as a roadmap for identifying factors that mediate or confound the relationship between integration level and performance.

I performed two analyses. First, I measured hospital integration with physicians, specifically primary care physicians (PCPs), for each AQC entity and categorize them into high- versus low-integrated providers. Second, I conducted descriptive analyses to examine differences in organizational characteristics, patient population, and spending between the two groups.

Methods

Study Sample

Based on literature review and BCBS press releases, I identified 16 provider organizations that signed up for AQC between 2009 and 2013 (Table A1 and Figure A1). AQC only applies to members of a health maintenance organization (HMO) or point-of-service (POS) plan because they are required to designate a PCP. Each enrollee can, therefore, be attributed to a particular provider organization through their designated PCP. The study sample included non-elderly adult (18-64 years of age) BCBS members who met the following inclusion criteria: 1) continuous enrollment in an HMO or POS plan for at least one year during 2009 to 2013; 2) designation of a PCP affiliated with an AQC entity during the enrollment period. Figure A2 illustrates the process of identifying AQC physicians and enrollees.

Data Sources

This study used data from four sources: Massachusetts All-Payer Claims Database (APCD, R3.0) of 2009-2013, Massachusetts Registration of Provider

Organizations (MA-RPO) Program (2015 initial registration), Area Health Resource Files (AHRF), and American Community Survey (ACS).

The primary data source is APCD which contains health claims data from all private payers and Medicaid in Massachusetts. Individuals are followed longitudinally for as long as they enrolled in a health plan offered by carriers operating in Massachusetts. Claims data are available for dates of service from January 1, 2009 to December 31, 2013 as paid through June 2014. Additionally, APCD includes information on enrollment, insurance plan, and providers who render health services. The APCD data was used to identify BCBS members who enrolled in an HMO or POS plan for at least one year between 2009 and 2013 and aged 18 to 64 during their enrollment.

The MA-RPO program collects information about the corporate, contracting, and clinical relationships of Massachusetts' health care providers. Provider organizations are required to submit an annual file, reporting their internal structure—including corporate affiliates, licensed facilities, and physicians—and their clinical and contracting relationships with other providers. Year 2015 is the first year of this program, and all the submitted data files are publicly accessible (9). The annual filing includes a Physician Roster that contains information about each physician on whose behalf the provider organization establishes at least one contract with payers. Using the Physician Roster, I identified 18,603 physicians who were affiliated with one of the 15 AQC participants at the end of 2015.[2] Approximately 86% of the AQC physicians were identified in the APCD data by National Provider Identifier (NPI).

The APCD member file included non-elderly adult members of BCBS from January 2009 through December 2013. Of the 1,816,373 enrollees in HMO or POS plans, I excluded 58,072 who did not continuously enroll for at least one year. Among the remaining eligible enrollees, I selected those who designated an AQC physician as their PCPs, resulting in a sample of 950,505 AQC enrollees. Lastly, I further excluded 34,670 individuals whose designated PCP affiliated with multiple AQC entities because of ambiguity in AQC attribution. The remaining 915,835 members comprised the study sample—HMO/POS members who continuously enrolled for at least one year and received care from an AQC physician. Figure A3 illustrates the process of selecting study sample.

To compare characteristics of the patient population served by low- versus high-integrated organizations, I linked zip code of enrollee residence to data from the 5-year ACS to obtain information on SES. Variables of interest include median household income, poverty rate, and unemployment rate. The AHRF was used to obtain data on Health Professional Shortage Area (HPSA) designation, an indicator of county-level supply of primary care physicians (131). Information about the organizational structure of individual AQC entities was retrieved from

[2] Hampden County Physician Associates (abbreviated to Hampden) shut down in late 2014 and, therefore, did not submit data to the MA-RPO program in 2015. Its affiliated physicians were determined by the affiliation element in the APCD provider file. I identified 96 physicians whose affiliated organization suggesting Hampden (NPI: 17576719).

the MA-RPO Program. The Institutional Review Board at Boston University Medical Campus reviewed and approved this study.

Study Variables

Physician-hospital integration

Many previous studies that investigate the effect of physician-hospital integration on health care measure the degree of integration from the hospital perceptive using American Hospital Association (AHA) Annual Survey (15, 20, 59). In this survey, hospitals report information on their relationships with physicians and number of physicians covered by each type of relationships. Different models of physician-hospital affiliations suggest a varying degree of integration, with an employment arrangement implying greater integration between a hospital and its affiliated physicians than a contractual arrangement. Though the hospital-physician arrangement may serve as a proxy for integration between two entities, this hospital-based measure provides limited insight into the extent of integration at a higher level of an organization’s hierarchy. For example, if a provider organization operates two hospitals, in which one employs physicians and the other establishes contractual relationships with physician practices. In this case, the overall degree of physician-hospital integration at the parent organization level cannot be measured by summing hospital-specific integration metrics. The issue becomes more challenging as the number of affiliated hospitals increases.

Another approach used the SK&A survey to assess physician-hospital integration (23). In contrast to the AHA survey that assesses ownership pattern from hospital's perspective, the SK&A survey samples office-based physicians and asks whether or not the physician is part of a practice that is owned by a hospital. This physician-based measure makes it feasible to compute a composite measure of integration at the organizational level by aggregating data from individual physicians. However, SK&A surveys only a sample of physicians and excludes hospital-based physicians, which limits its ability to accurately estimate the overall degree of integration at the provider organization level. Moreover, a study comparing ownership patterns drew from the AHA and SK&A documented disagreement between the two surveys, and suggested that the appropriate measure of integration depends on research questions (22). For this study, the question of interest is the general degree of physician-hospital integration within an AQC entity. Considering that an AQC entity may include multiple hospitals with each establishing different relationships with physician practices, summing a physician-based integration measure to the AQC level better reflects the organizational structure.

To measure physician-hospital integration of each AQC entity, I calculated the proportion of PCPs billing predominantly in a Hospital Outpatient Department (HOPD) setting, following the studies of Neprash and colleagues (90, 92). The rationale behind this approach is that Medicare reimburses services provided by a hospital-owned physician practice at a reduced professional fee and an additional facility fee. The total payment usually exceeds what a physician would receive for rendering the same service in an office setting. Physicians of practices owned by hospitals could legally bill Medicare at the higher HOPD rate even if the practice is off the hospital campus. The payment difference gives hospital-owned physicians a financial incentive to bill outpatient services at the HOPD rate by changing the place-of-service code from office to HOPD. In addition to hospital's ownership of physician practices, another arrangement suggesting a high level of physician-hospital integration is hospital-based physician. Given that they practice in a hospital setting, physicians directly employed by or contracted with a hospital almost exclusively bill outpatient claims with an HOPD code. Therefore, for an AQC entity, the share of physicians billing outpatient claims predominantly with an HOPD code reflects its overall level of physician-hospital integration. In this study, I specifically measured integration between PCPs and hospitals because a closer tie between them may improve coordination across care settings, especially in the context of ACOs.

The AQC-level measure of integration was composed based on each PCP's share of outpatient care billed with an HOPD place of service code. First, for each AQC entity in each year, I calculated each PCP's share of medical claims for outpatient care that was billed with an HOPD code. Then, I considered PCPs to be practicing in a highly integrated setting if they billed 100% (or 95%, 75% as sensitivity analysis) of their outpatient care with an HOPD code. From the physician-level measure, I then calculated the share of PCPs in each AQC entity who displayed billing patterns implying a high level of integration. I excluded PCPs with small numbers of claims defined as physicians in the bottom decile (or quintile, quartile as sensitivity analysis) by annual professional claims count.

Figure A4 shows the proportion of PCPs who billed the majority of their outpatient claims with an HOPD code at two entities demonstrating a high versus low level of integration. It suggests that the physicians' billing pattern is consistent over time. Also, this pattern is not sensitive to the number of physicians excluded from the analysis because of lack of sufficient claims. Other AQC entities (not shown) exhibit a similar pattern of consistency. For each AQC, the share of PCPs who showed this billing pattern slightly varied across years. Therefore, I defined the global level of physician-hospital integration of each AQC as the five-year average of the proportion of PCPs who exclusively billed outpatient claims with an HOPD setting code. I then ranked the 16 AQC entities based on the composite measure and grouped them into lower versus higher integrated organizations.

Characteristics of Medical Group

To measure participation breadth, I assessed numbers of medical groups affiliated with each AQC entity, defined as the number of distinct NPIs of medical groups reported in the MA-RPO physician roster. Size of medical group measured by the number of distinct NPIs of member physicians, PCP status, and hospital-employed status of each physician were extracted from the same data source.

Member Characteristics

To compare the difference in patient population served by AQC entities with low versus high integration level, I examined patient socio-demographic characteristics, including age, gender, and SES. I also created a health risk score using HHS-Hierarchical Condition Categories (HHS-HCC) Risk Adjustment Modeling Software (version 3.0), a federally certified risk adjustment methodology for the Marketplaces implemented under the ACA (127). It uses an individual's demographics and diagnoses to determine a risk score, which is a relative measure of how costly the individual is anticipated to be (66). In contrast to Medicare's HCC (CMS-HCC) that predicts medical spending based on diagnoses reported in the preceding year, HHS-HCC relates current-year spending to current-year diagnoses and demographic information. Moreover, it is designed for individuals younger than 65 years of age and more detailed than the CMS-HCC. To assess comorbidity, I adapted the Elixhauser Comorbidity Software (version 3.7) to diagnoses listed in both inpatient and outpatient claims related to individual enrollees (2). Finally, I measured out-of-pocket (OOP) costs incurred by each enrollee in each year based on their total cost-sharing for a set of frequently used services, following a previous study (90). This set of services is determined by Current Procedural Terminology (CPT) codes for office visits (99201-5, 99211-5, and 99241-55) and the 100 most common Diagnostic Related Groups (DRG).

Spending

For each member, I calculated aggregate spending in each quarter from 2009 through 2013 by summing BCBS payment to AQC participants and enrollee cost sharing from medical claims. I did not include pharmaceutical claims because not all the enrollees had prescription drug benefits offered by BCBS. In addition to total spending, I distinguished outpatient care from inpatient care using place-of-service codes and grouped spending by Berenson-Eggers Type of Service (BETOS) categories (version 2013) from CMS (6). Spending was measured according to site of services (inpatient or outpatient), type of claim (institutional or professional), and category of care defined by the BETOS, following studies evaluating the AQC (118, 119, 121). Medical spending was adjusted for inflation and presented in 2013 dollars using the Producer Price Index for medical care services from the Bureau of Labor Statistics (7).

Statistical Analyses

To better understand the heterogeneity among AQC participants, I summarized the organizational structure of individual entities. Characteristics of interest include when each entered the AQC, size (number of enrollees served), participation breadth (number of affiliated hospitals and medical groups), IDS status, PCP volume, and share of employed physicians. For patient characteristics, because an individual enrollee could be followed over time, I defined time-variant variables, such as age and residence, at the beginning of the first enrollment during the study period.

To assess differences between organizations with lower and higher degree of integration, I defined each ACO according to whether its 5-year average was above or below the mean of all 16 organizations as high- versus low-integrated ACO. Bivariate analysis was used to assess the differences in organizational characteristics and patient population between two groups. For categorical variables, I examined differences across groups using Chi-square test. If any group had a small cell count defined by less than five, Fisher's exact test was used instead. For continuous variables, I examined distributions for normality using Kolmogorov-Smirnov test and used the two-tail t-test for normally distributed variables. If non-normality was detected, a non-parametric equivalent, Wilcoxon-Mann-Whitney test, was used. I reported 2-sided p-values with a significance threshold of 0.05.

Results

<u>Study Population</u>

AQC Provider Organizations

The 16 AQC entities varied in size, number of covered beneficiaries, services score, and organizational form (Table A2). The number of attributed AQC members ranged from 8,000 to 243,000. Five organizations also participated in Medicare ACO programs during the study period. Three of them were for-profit, and two of them were not formally affiliated with any acute-care hospital. Among those with hospital affiliation, the number of hospital beds ranged from 2.7 to 28.9 per 1,000 attributed AQC enrollees. Four entities included nursing facilities in their networks and three operated federal qualified health centers or rural health clinics. Four AQC entities had more than 200 participating medical groups, and seven organizations had a network with more than 1,000 physicians. Collectively, around 60% of physicians were employed by physician groups or hospitals but with considerable variation, ranging from 16.5 to 91.5 percent. Roughly one-fourth of physicians were PCPs. Though solo and small practices (five or fewer physicians) accounted for the majority of participating medical groups, more than 70 percent of the physicians practiced in a large group with at least 20 doctors (Figure A5)

AQC Physicians

Among the 18,603 AQC physicians listed in the MA-RPO physician roster (physicians affiliated with 15 AQC, excluding Hampden), 16,053 physicians were identified in the APCD data. The overall identification rate was 86.3%, ranging from 95.2% for Atrius Health to 83.5% for Signature Healthcare Corporation (Table A3). Combining Hampden physicians resulted in 16,141 physicians participating in the AQC in total. On average, 26.6 percent of AQC physicians practiced as a PCP. Though a majority of physicians were affiliated with a single AQC, around 10 percent of physicians were affiliated with multiple entities.[3]

AQC Enrollees

There were 915,835 HMO/POS enrollees receiving care from one of the

[3] Among the 16,141 AQC physicians, 1,639 (10.2%) were affiliated with multiple organizations. 87.4% and 10.5% was affiliated with 2 and 3 AQC entities respectively, the remaining was connected with four or more organizations.

16 AQC provider organizations with at least one year of continuous enrollment from 2009 through 2013. 8.8 percent of the sample switched between AQC entities—initially designated a PCP affiliated with one AQC and later another doctor associated with a different entity. Among those who switched, 94 percent changed to another provider organization, and another 5 percent received care from three different organizations. As a result of the shifting, the total number of subjects exceeds 915,835. Characteristics of the population by cohort (defined by the first year a provider organization entered the AQC) are shown in Table 2.1. Among all the subjects, the mean age was 39, approximately half the sample was female, and the health risk scores ranged from 0.22 to 194.76 (mean±standard deviation, 1.48±3.86). The average age, the sex distribution, and the average health risk scores did not differ substantially across cohorts. However, given the large sample sizes, there were significant differences in the characteristics of these cohorts. OOP cost-sharing presented a skewed distribution (mean=12.6%, median=7.5%), with minor fluctuations across cohorts.

Table 2.1: Characteristics of study sample

	Cohort[a]					
	2009	2010	2011	2012	2013	Total
Provider Organizations (no.)	7	2	1	5	1	16
PCPs	997	541	455	1,697	342	4,032
Specialists/both	3,194	2,293	1,898	8,131	1,096	16,612
Affiliated acute-care hospitals	5	11	0	12	4	32
Members (no.)[b]	303,823	170,535	108,694	333,498	84,994	1,001,544
Age (yr)[c]	38.8±13.1	39.7±13.1	39.2±12.5	38.6±13.4	39.8±13.4	39.0±13.2
Female (%)	53.4	52.1	54.6	54.7	51.1	53.5
Health Risk Score[d]						
Mean	1.45	1.51	1.54	1.49	1.48	1.48
Median	0.74	0.74	0.74	0.74	0.74	0.74
IQR	0.41-1.03	0.43-1.03	0.43-1.05	0.41-1.03	0.41-1.03	0.41-1.03
Cost Sharing (%)[e]						
Mean	12.9	13.2	13.0	12.0	11.9	12.6
Median	7.9	8.1	8.1	6.9	7.0	7.5
IQR	3.4-16.9	3.6-17.1	3.6-16.9	2.9-15.3	3.1-15.1	3.2-16.3

Abbreviations: IQR, Inter-quarter Range; PCP, Primary Care Physician.

Notes:

[a] Five cohorts of AQC entities that were defined by their first contract year.

[b] The total number of AQC members exceeds 915,835 because some members selected a PCP working in an AQC entity and later another working in a different organization. Age and health risk score were based on the first year when the member was attributed to a specific AQC provider.

[c] Plus-minus values are means-/+standard deviations.

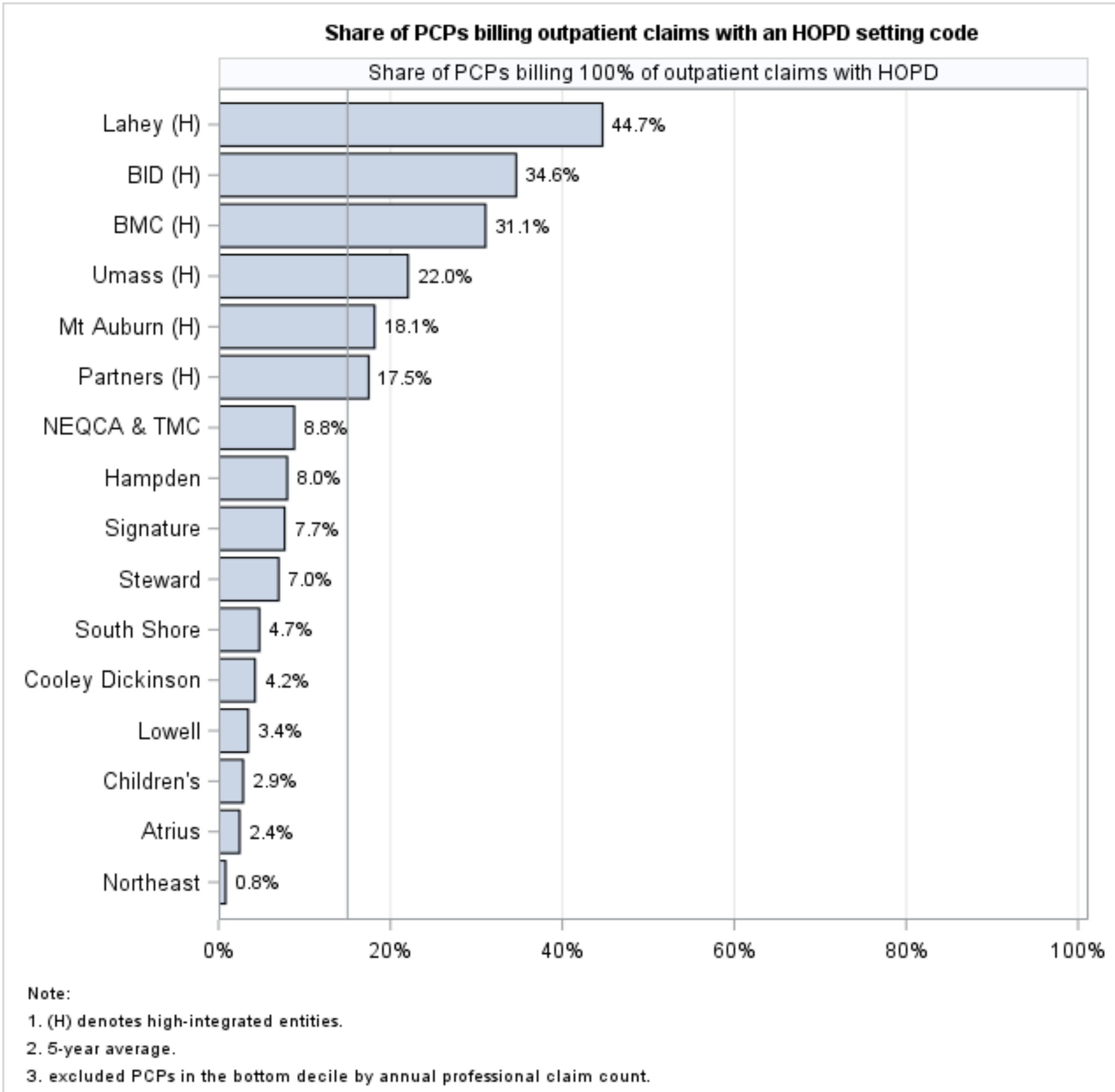
[d] It is calculated with the using of HHS-HCC risk adjustment modeling software. The health risk score takes into account the health status of the member and expected spending, with a higher value indicates poorer health status and higher expected spending.

[e] Proportion of spending paid by AQC members annually, pooled across all the members during 2010-2013. Members attributed to multiple AQC entities were excluded from this analysis.

Physician-Hospital Integration

Among the 16 entities, the proportion of PCPs with billing patterns consistent with financial integration with hospitals ranged from 0.8 to 44.7 percent (Figure 2.1). In order of the measure of physician-hospital integration, six physician networks that demonstrated a closer tie with hospitals and defined as high-integrated entities were: Mt. Auburn Cambridge IPA, Beth Israel Deaconess Care Organization, Partners HealthCare, Boston Medical Center Health System, Lahey Clinic, and UMass Memorial Health Care. On average, 22.8 percent of their PCPs either treated patients exclusively in a hospital setting or hospital-owned practices, compared to less than 5 percent of PCPs affiliated with the remaining networks. The classification was not sensitive to the threshold used to determined physicians' close tie to a hospital (Figure A6). Moreover, further exclusion of PCPs with small numbers of claims, increased from the lowest decile to quintile and quartile of annual professional claim counts, did not change the categorization.

Figure 2.1: Level of physician-hospital integration



<u>Difference between High- and Low-Integrated Entities</u>

Table 2.2 summarizes organizational characteristics of the 16 entities according to the level of physician-hospital integration. Two-thirds of high-integrated organizations were members of an integrated delivery system (IDS). They had a relatively lower percent of PCPs but a higher proportion of employed

physicians. Moreover, their provider networks were bigger, with more acute-hospital beds and physicians than their low-integrated counterparts. However, differences in the attributes mentioned above between high- and low-integrated provider organizations were not statistically significant due to small sample size.

Medium and large practices collectively accounted for a higher proportion of participating medical groups among high-integrated organizations, compared to low-integrated counterparts (22.5% vs. 18.7%, p=0.042). It is noteworthy that although the difference in medical group composition was somewhat small, the concentration of participating physicians in large medical groups was more prominent among high-integrated entities. Medical groups of 20 or more clinicians covered 83 and 59 percent of physicians participating in high- and low-integrated organizations, respectively (p<0.0001).

Mean medical spending per enrollee was significantly higher among high-integrated entities overall and across clinical categories (per quarter per member total expenditure, $1236 vs. $1075, p<0.0001). More integrated entities spent more on inpatient services (inpatient professional, $54.1 vs. $49.1, p<0.0001; inpatient facility, $255.6 vs. $241.8, p<0.0001) and on outpatient facility ($468.8 vs. $316.3, p<0.0001) but less on outpatient professional services ($417.2 vs. $425.7, p<0.0001) and ancillary ($40.6 vs. $42.2, p<0.0001).

Table 2.2: Organizational characteristics of 16 AQC entities, by integration level

	Integration Level		
	high	low	p-value[a]
Provider organization (no.)	6	10	
IDS (%)	66.7	40.0	0.608
Share of PCPs (%)	19.7	23.2	0.373
Share of employed physicians (%)	61.0	43.8	0.280
Acute care hospitals (no.)	15	17	
# of DSH	7	9	
# acute hospital beds / 1k enrollees (mean)	11.3	13.2	0.694
Medical group[b] (no.)	880	1,318	
solo (%)	51.6	54.7	0.042
small (%)	25.9	26.6	
medium (%)	13.5	12.8	
large (%)	9.0	5.9	
Physician (no.)	12,513	8,131	
PCPs	2,202	1,830	
Specialists	10,311	6,301	
Size of practice (%)[c]			
solo	3.6	9.2	<.0001
small	5.1	13.0	
medium	8.6	19.9	
large	82.7	57.9	
Quarterly spending[d] ($)	1236.3	1075.1	<.0001
Spending by BETOS category[e] ($)			
Evaluation & management	262.7	238.3	<.0001
Procedure	290.5	250.0	<.0001
Imaging	149.6	119.2	<.0001
Test	127.8	98.7	<.0001
Durable medical equipment	13.7	11.5	<.0001
Other	90.2	75.7	<.0001
Exceptions or unclassified	301.8	281.7	<.0001
Spending by site & type of care ($)			
Inpatient			
Professional services	54.1	49.1	<.0001
Facility services	255.6	241.8	0.267

Outpatient			
Professional services	417.2	425.7	<.0001
Facility services	468.8	316.3	<.0001
Ancillary	40.6	42.2	<.0001

Abbreviations: IDS, Integrated Delivery System; PCP, Primary Care Physician; DSH, Disproportionate Share Hospital.
Notes:
[a] For continuous variables, differences were tested using two-tail t-test for normally distributed variables or Wilcoxon-Mann Whitney test for non-normally distributed variables. For categorical variables, differences across groups were tested using Chi-square test.
[b] Small: 2-5 physicians, Medium: 6-20 physicians, Large: 20+ physicians.
[c] Based on 20,258/20,644 physicians with non-missing practice size.
[d] Average medical spending per member per quarter, combining BCBS spending and member cost sharing during 2010-2013. Members attributed to multiple AQC entities in a specific quarter were excluded. Spending is inflation-adjusted to 2013 dollars.
[e] Berenson-Eggers Type of Service classification, 2013 version.

Table 2.3 presents characteristics of AQC patients served by high- and low-integration organizations. For the study sample of 915,835 nonelderly HMO/POS enrollees receiving care from the 16 AQC entities, about 52 percent were served by a high-integrated organization sometime during the study period. They were, on average, slightly older (39.5 vs. 38.5 years) and sicker (higher risk score, 1.51 vs. 1.45), more likely to be female (54.5% vs. 52.5%), and lived in high-SES areas (high-income zip codes, 56.1% vs. 50.5%) compared to those served by a less integrated entity. Mean annual OOP cost was $361 and $331 for high- and low-integrated AQC patients respectively. These observed differences in demographic characteristics, health risk, and annual OOP payment between two groups were statistically significant.

Table 2.3: Characteristics of study population, by integration level

	Integration Level		
	high	low	p-value[a]
Enrollees (no.)[b]	523,049	478,495	
Age (yr), means±SD	39.5±12.9	38.5±13.5	<.0001
Female (%)	54.5	52.5	<.0001
Zip-level SES[c] (%)			
Income			<.0001
Low	15.1	17.4	
Middle	28.8	32.2	
High	56.1	50.5	
Poverty rate			<.0001
Low	51.3	49.4	
Middle	22.3	27.0	
High	26.4	23.7	
Unemployment rate			<.0001
Low	33.8	24.1	
Middle	42.3	46.5	
High	24.0	29.4	
Share of minority population			<.0001
Low	33.2	43.5	
Middle	45.8	40.4	
High	21.0	16.1	
Out-of-pocket cost[d] ($)			<.0001
Mean	361.0	331.0	
Median (IQR)	140.0 (44.2-423.9)	129.2 (44.2-380.4)	
Disease burden			
Health risk score[e]			<.0001
Mean	1.51	1.45	
Median (IQR)	0.74 (0.41-1.03)	0.74 (0.43-1.03)	
Count of HCCs (%)[f]			<.0001
0	88.7	89.4	
1	9.4	8.8	
2+	2.0	1.8	

Abbreviations: SES, Socioeconomic Status; IQR, Inter-quarter Range; HCC, Hierarchical Condition Categories.

Notes:

[a] For continuous variables, differences were tested using two-tail t-test for normally distributed variables or Wilcoxon-Mann Whitney test for non-normally distributed variables. For categorical variables, differences across groups were tested using Chi-square test.

[b] The total number of AQC members exceeds 915,835 because some members selected a PCP working in an AQC entity and later another working in a different organization. Age and health risk score were based on the first year when the member was attributed to a specific AQC provider.

[c] SES measures were based on 2009-2013 5-year ACS, including median household income, % of population whose income in the past 12 months below poverty level, unemployment rate among population 20 to 64 years, and proportion of non-white population.

[d] Average annual out-of-pocket cost were polled across all the enrollees during 2010-2013. Members attributed to multiple AQC entities were excluded from this analysis. Spending is inflation-adjusted to 2013 dollars.

[e] Average HHS-HCC risk score during study period.

[f] Non-zero hierarchical condition categories captured by the HHS-HCC risk adjustment models.

Discussion

There is considerable heterogeneity in organizational structure, patient population, and composition of healthcare spending between more and less integrated AQC organizations operating in a single state and subject to a similar ACO contract, though differences are modest in magnitude. First, provider organizations with a higher level of physician-hospital integration are typically members of an IDS, of large size, have a higher inpatient care capacity but a lower share of PCPs, and employ physicians directly or through an affiliated hospital or physician group. These attributes are similar to the characteristics of “larger IDS ACOs” categorized by Shortell and colleagues (114, 115). ACOs self-identified as an IDS, in general, have more physicians and hospital beds but relatively low percent of primary care clinicians. Also, they are less likely to be led by physician groups, implying physician employment by affiliated hospitals or the health system. Though practices of 20 or more physicians only represent a small share of medical groups participating in the commercial ACO program, a considerable proportion of physicians practice in these large practices, reflecting the recent movement from small to large group practices (89). Moreover, the observed higher concentration among high-integrated organizations echoes the concerns that providers will seek consolidation in response to the increasing complexity and uncertainty of payment incentives and regulations in the ACO era (19, 69). Except for Mt. Auburn Cambridge IPA, other high-integrated providers entered the AQC in later years probably because they are large health system involving a broader physician network and multiple hospitals and, therefore, it took them longer to negotiate contract terms with BCBS.

Second, high-integrated entities differ from their low-integrated counterparts in the demographic composition of patient population: the majority of their patients live in affluent areas, a higher proportion are female, and more lived in neighborhoods with a higher minority population. The observed differences may be due to their locations and counties covered by their provider networks. Five of the six high-integrated providers are located in the greater Boston area which has a dense minority population. Except for BMC, provider networks of these entities also cover wealthy suburbs in adjacent counties. This is consistent with findings from an early study documenting that ACO presence is associated with lower poverty rates and urban location (75). Though patients of high-integrated providers did not seem to be socially disadvantaged, they assumed a greater health burden and encountered higher OOP payments. In general, patients' choice of health care provider reflects their underlying health needs. As every high-integrated provider has a teaching hospital in their network, they may be more attractive to patients with chronic conditions or poor health status. In other words, patients' selecting a PCP of a high-integrated entity may be triggered by the doctor's affiliation with a teaching hospital.

Third, medical expenditure of patients served by high-integrated organizations was higher overall and consistently higher across clinical categories. The observed differences in spending concentrated mostly in inpatient care and outpatient facility services. Higher total and inpatient spending may result from the clinical burdens of high-integrated providers by providing care to sicker patients. However, the much higher expenditure on outpatient facility may merely reflect the nature of how integration was measured. By definition, a larger share of PCPs at high-integrated entities practiced in a hospital setting or a hospital-owned practice and therefore eligible to bill ambulatory care services with hospital outpatient department codes. The billing pattern results in an additional facility fee which is not available to freestanding clinics and increases in the corresponding component of outpatient spending. The association between physician-hospital integration and higher medical spending has been widely documented in previous studies (20, 23, 77, 105). Also, the vertical integration was found to change referral pattern by shifting more patients to the owner hospital or health system (23, 32, 59). Because integrated providers can exercise enhanced bargaining power to gain higher reimbursement rates, the inflated prices may consequently lead to higher medical expenditure if physicians tend to refer patients to their employer or owner.

This study has several limitations. First, physician's affiliation to an AQC entity was determined in 2015 because of the lack of early-year data. Practically, physician organizations could join or leave a payment contract with payers over time, and selection bias is a concern if there were massive physician departures from BCBS. However, BCBS is the largest insurance carrier in Massachusetts and has been successful in keeping physicians in its network for a long time. Moreover, the fact that most physicians listed on the 2015 roster were identified in earlier years alleviates this concern. Nevertheless, the affiliation of an individual physician or medical group with a network could change for various reasons regardless of the stable long-term relationship between BCBS and contracted networks. Potential reasons for change in physician affiliation include physicians joining a different medical group or network, closure or merger of medical groups, or network acquisition of medical groups. Any significant change in physician association with provider organizations may impose difficulty with appropriately attributing enrollees to an AQC entity. However, no large-scale merger, acquisition, or shutdown of medical groups occurred during 2009 and 2013. An early AQC participant went bankrupt in 2014, postdating the study period. Although another participant was sold to a private entity during the study period, the acquiring company did not close any hospitals or medical groups but postponed the contract start date to the following year.

Second, the integration metric may involve a few measurement errors that led to underestimating the actual level of integration. Physicians of a hospital-owned practice may not bill with a HOPD setting code regardless of their eligibility and financial incentive to do so. In addition to direct employment or ownership of physician practices, hospitals can also connect with physicians through a contractual relationship, partnership agreements for example, which can potentially achieve higher integration between two parties but is not detectable by the measure that I used. Third, this study uses a very small sample, including only 16 organizations. The observed differences in organizational and patient characteristics between two groups may simply be random. Finally, the adopted measure may well reflect the extent to which physicians and hospitals are organizationally and financially integrated but not necessary clinical integration. However, under a global budget contract coupled with quality bonus, aligning economic incentives between hospitals and physicians may facilitate clinical integration by encouraging collaboration and eliminating competition between the two (67).

In summary, high-integrated entities differ from their low-integrated counterparts in organizational structure, demographic and clinical characteristics of their population, and medical spending. They tend to be larger in scale, serve more affluent patients, but spend more in general. Understanding the heterogeneity of these entities identifies potential confounders that should be addressed in studies that investigate the impacts of integration on performance.

CHAPTER 3: THE IMPACT OF PHYSICIAN-HOSPITAL INTEGRATION ON ACO EFFICIENCY IN INPATIENT CARE DELIVERY

Summary

During the movement of accountable care organizations (ACOs), the pre-existing trend of hospital employment of physicians continues, leading to greater physician-hospital integration. Moreover, some of the quality measures adopted by pay-for-performance programs, such as Hospital Readmission Reduction Program and Hospital Value-Based Purchasing Program, may implicitly encourage integration between physicians and hospitals. However, little is known about whether physician-hospital integration in ACOs is improving the efficiency of healthcare delivery brought about by improved coordination of services across care settings. This chapter investigates the association between physician-hospital integration and improvement in efficiency of ACOs using an instrumental variable approach. The focus is on inpatient care, considering hospitalization is the most expensive type of health services and therefore has greater potential for better care coordination success in bending the health care cost curve.

Research Question

This chapter examines empirically whether physician-hospital integration is associated with improved efficiency of ACOs in inpatient care delivery by assessing accumulated medical spending over an episode of inpatient care.

Background

Since the development of managed care in the 1990s, integration between various health care providers has been a common approach to attempt to achieve greater efficiency through better care coordination (19). There has been accumulating evidence that the lack of continuity of care is associated with poor patient outcomes and satisfaction (60, 124, 128). Vertical integration between physicians and hospitals has been argued to equip provider organizations better to improve care continuity across settings. Under the Patient Protection and Affordable Care Act (ACA), the Centers of Medicare and Medicaid Services (CMS) is experimenting the ACO model, an innovative new payment and delivery model which holds providers accountable for managing the health of their patients across health care settings and controlling gross health care costs. Compared to hospitals and hospital systems, individual physician practices, especially small physician offices, usually lack resources and infrastructure for setting up information and administrative systems required for financial risk management and care coordination. In response to the ACO momentum and the prospect of more risk-based payment approaches, more than half of practicing U.S. physicians are now employed by hospitals or integrated delivery systems (70). In Massachusetts, only 23 percent of all physicians identify as independent, making the Commonwealth one of the 10 states dominated by employed physicians (117).

While hospital employment of physicians has continuously increased in recent years, effects of such vertical integration are ambiguous, both theoretically and empirically. Theoretically, physician-hospital integration may improve efficiency by facilitating care coordination; on the other hand, it can also increase medical spending through enhanced market power. For example, integrated providers can leverage market share to negotiate higher prices from payers or raise competitors' costs by charging a higher price, which may limit rivals from entering the market, further strengthening their market dominance. Empirical studies assessing the impact of physician-hospital integration on quality and costs of care have provided mixed, somewhat negative findings. Early studies found that integration of physicians with hospitals in the 1990s was associated with increased prices and higher treatment intensity (41, 77). However, another study using California data found no evidence suggesting that integration led to change in prices (38). One recent study examining the effects of hospital ownership of physician practices has documented an association of integration with higher prices and spending (90); while another study has found that contractual integration reduced inpatient care utilization, though the observed effect was relatively small (20). The conventional wisdom is that decisions made by physicians directly drive the majority of health services consumed, which collectively account for a significant share of the total health care expenditures. Though previous studies provide insights into the potential impacts of physician-hospital integration on health care delivery, the estimated effects vary by measurement/definition of integration and the environment in which providers operate. Furthermore, several researchers have argued that reductions in health care spending and utilization achieved by alternative payment models that implicitly encourage integration could be offset by higher prices negotiated by consolidated provider organizations from the insurers (19, 105). Given that the ACO initiative may further foster the ongoing trend of hospital acquisition of physician practices, it is critically important to investigate whether the vertical integration leads to efficiency gains in the context of ACOs.

This study explores whether hospital consolidation of physician practices improves ACO efficiency by examining the association of hospital-primary care physician (PCP) integration with expenditure and outcomes of hospital inpatient care. The focus on acute inpatient care is grounded in the consideration that hospitalizations are the most expensive of health services and that better coordination and management of care can successfully bend the health care cost curve. Accordingly, the study targets integration between hospitals and PCPs because better coordination between them may lead to greater continuity of care, which subsequently improves quality of care and reduces costs occurred during an episode of inpatient care. Earlier studies investigating the effects of integration failed to adequately account for two potential sources of endogeneity: selection bias resulting from unmeasured differences in patient characteristics that may influence patient selection into a high-integrated provider, and the endogenous relationship between an ACO's integrative strategies and its quality and costs. This study addresses selection bias using an instrumental variable (IV) approach.

The identified IV—difference in proximity to high- versus low-integrated providers—influences provider selection but is effectively random concerning observed patient risk and unobserved confounders. To adjust for endogeneity between integration and outcomes, a composite measure of ACO quality was included in IV estimations to isolate the component of treatment variation attributable to the IV.

Methods

Data Source

The primary data source was the Massachusetts All-Payer Claims Database (APCD, Release 3.0) (3), which includes information on member eligibility, medical claims, insurance plans, and providers. The study used discharge-level claims data to identify admissions to acute care hospitals in Massachusetts between 2009 and 2013. The hospital discharge data was supplemented with patient and hospital characteristics from corresponding files of the APCD. Secondary data sources included the Massachusetts Registration of Provider Organization (MA-RPO, 2015 initial registration) from the Massachusetts Health Policy Commission (9), American Community Survey (ACS) from the Census Bureau (4), Area Health Resource Files (AHRF) from the Health Recourses & Services Administration (HRSA) (5), and Annual Report on the Performance of the Massachusetts Health Care System from the Center for Health Information and Analysis (CHIA) (11). MA-RPO data were used to establish patient attribution and construct physician-hospital integration measure

(Methods in Chapter 2). I obtained data on socio-demographics and provider availability from ACS and AHRF respectively and used measures of provider quality from the state-issued annual performance report. This study was reviewed and approved by the Institutional Review Board at Boston University Medical Campus.

<u>Study Population</u>

The study sample was composed of 15 commercial ACOs established in Massachusetts during 2009 and 2013. I started by identifying physicians who were affiliated with each of the ACOs using publicly accessible databases (9). Provider organizations are required by the Commonwealth to submit an annual filing on the provider organization’s internal structure, including affiliated physicians, and clinical and contracting relationships with other providers (8). On average, nearly 90% of the listed physicians were successfully found in the APCD data files. Next, I defined patients attributed to the 15 ACOs based on the following inclusion criteria: 1) non-elderly adults (aged 18 to 64); 2) enrollment in a health maintenance organization (HMO) or point-of-service (POS) plan with the insurance carrier that signed the commercial ACO contract with providers; 3) designation of PCP who was affiliated with one of the ACOs during their HMO/POS enrollment. From this sample, I excluded members whose designated PCP who affiliated with multiple ACOs, as exclusive attribution of patients to an ACO was not feasible. Additionally, I excluded members who were not continuously attributed to an ACO or ACOs for at least one calendar year (from

January to December) to ensure completeness of outcome measures. Finally, to create a more homogeneous and consistent study population, non-MA residents were excluded. These inclusions and exclusions yielded a cohort of 527,594 members.

I then selected hospital admissions associated with the study sample. The discharge-level sample included all admissions to a general acute-care hospital in Massachusetts, excluding children's or specialty hospitals. To define index hospitalizations, I excluded patients discharged in January of 2009 because of lack of data to confirm no prior admission in the preceding 30 days. Hospitalizations that occurred after October of 2013 were excluded as well to allow sufficient follow-up required to measure outcomes of interest. Moreover, discharges that were not eligible for the readmission measure, one of the primary outcomes, were dropped. The exclusion criteria included in-hospital death, discharges to another acute-care hospital or against medical advice, new-born admission, admissions for cancer treatment, obstetric diagnoses, primary psychiatric disease, or rehabilitation care. Finally, same-day discharges and hospitalizations with a length of stay greater than 30 days were excluded because they generally are considered to be observation stay and long-term stay, respectively. After the exclusions mentioned above, the final sample included 33,535 hospital admissions, which were further grouped into five mutually exclusive admission cohorts based on ICD-9-CM procedure and diagnosis codes using the AHRQ Clinical Classifications Software (CCS) grouper

(58) (Figure B1). Cohort assignment proceeded first by procedure code, and then by diagnosis code. First, patients with a procedure code indicative of having had a major surgery during hospitalization were assigned to the Surgery/Gynecology cohort. Then, remaining patients were assigned to one of the four other cohorts based on their principal diagnosis code. Patients were assigned to the Medicine cohort when their conditions did not correspond to any of the three more narrowly defined cohorts (Cardiorespiratory, Cardiovascular, and Neurology).

Integration

Following previous studies (83, 90, 92), I categorized ACOs into high- versus low-integrated providers based on a claims-based measure of physician-hospital integration. Hospital-owned practices or practices in hospital outpatient departments are permitted to bill as hospital outpatient facilities and receive higher reimbursement by filing outpatient services claims with a Hospital Outpatient Department (HOPD) setting code. A hospital-owned practice can legally do so even if it does not locate on a hospital campus, which provides strong financial incentives to bill in this manner. Therefore, for an ACO, the proportion of its physicians who predominantly billed outpatient services with an HOPD code indicates the overall level of integration between physicians and hospitals. In this study, I specifically measured integration between PCPs and hospitals because a closer tie between them may foster coordination and collaboration across care settings, especially in the context of ACO. For each ACO, I calculated each PCP’s share of annual medical claims for outpatient care that was billed with an HOPD code during the study period. From the physician/year level measure, I then calculated the proportion of PCPs at each ACO who exclusively followed this billing pattern in each year. Finally, to facilitate interpretation of results, I defined each ACO according to whether its 5-year average was above or below the mean of all 15 organizations as high- versus low-integrated ACO (Methods in Chapter 2).

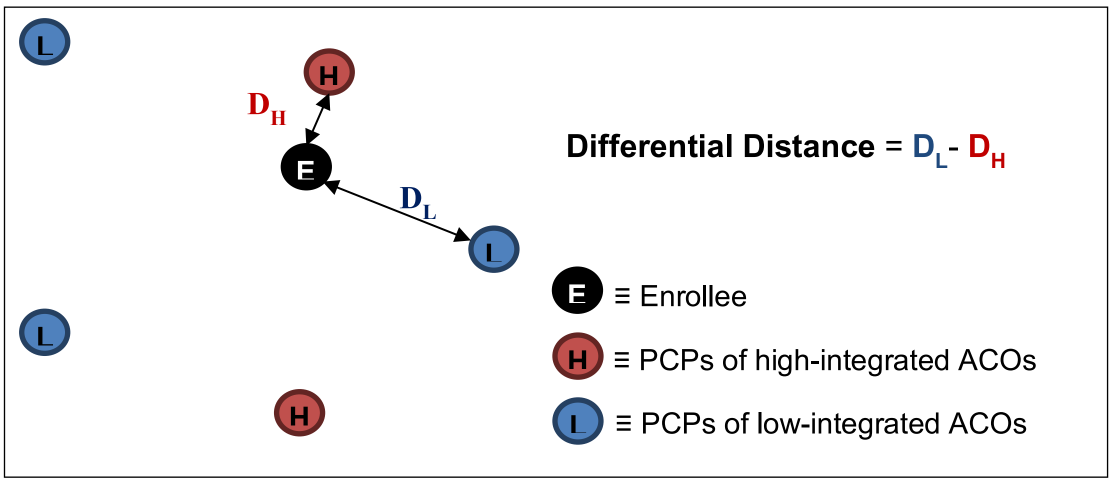
Outcome Variables

This study explored the impact of integration on three patient discharge-level outcomes. The first outcome was the total medical spending associated with a hospitalization, combining insurer payments to providers and patient out-of-pocket payments. In practice, providers may file multiple claims for services rendered during a hospital stay or even after patients were discharged, which imposes technical difficulty in inclusively calculating expenditure associated with a particular hospitalization. To overcome the challenge, I summed paid medical claims over the entire episode of care, defining the episode as 30, 45, and 60 days from the admission date of an index hospitalization. These measures captured spending of inpatient care, subsequent outpatient services after discharge, and readmissions if occurred. The second outcome was the length of stay (LOS) of the index admission, defined as the number of days between admission and discharge dates. Patients discharged on the same day of admission were excluded because they were probably kept in a hospital for observation. The third outcome is all-cause unplanned readmission to an acute-care hospital within 30 days of discharge from the index hospitalization. I followed the hospital-wide all-cause unplanned readmission measure developed by Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation, which excludes planned readmissions such as bone marrow or organ transplant, maintenance chemotherapy or rehabilitation, and potentially planned procedures (132).

<u>Other Variables</u>

To adjust for observed and unobserved differences in patient mix between ACOs with high and low level of integration, I used differential distance as an instrument of receiving care from a high-integrated ACO. This was defined as the difference in miles between the distances from the centroid of a patient's home zip code to the nearest PCP practice affiliated with a high-integrated ACO ("high-PCP") to the nearest practice of a low-integrated entity ("low-PCP"), based on geocoded practice address (Figure 3.1). The rationale behind this strategy is that the proximity of an individual's residence to a physician practice is, in general, an important determinant of their selection of a PCP. Given that the share of high-PCPs varied across counties (Figure B2), for each enrollee, the probability of being a high-integrated ACO patient is proportional to the relative accessibility to a high-PCP, suggesting proximity a natural candidate for being an instrumental variable (IV). The IV ranged from a negative to a positive value, depending on if the patient's residency is closer to a low- or high-PCP. A positive value suggests the patient resides in a high-integrated ACO serving area (more high-PCPs) and, therefore, higher probability of being cared by a high-integrated ACO. To ease presentation, I refer to the zip-code level IV as the differential distance throughout the rest of this dissertation. Table 3.3 is a summary of the differential distance. The mean differential distance was positive among high-integrated ACO patients, indicating the higher prevalence of high-PCPs (hospital-owned or affiliated PCPs).

Figure 3.1 Definition of IV (differential distance)



In addition to the IV, I included measures of patient age, sex, overall health status, and comorbidities as covariates. For health status, I created a health risk score using HHS-Hierarchical Condition Categories (HHS-HCC) Risk Adjustment Modeling Software (version 3.0), a federally certified risk adjustment methodology for the ACA Marketplaces (127). It uses an individual's demographics and diagnoses in a given year to determine a risk score, which is a relative measure of how costly the individual is anticipated to be (66). To access comorbidity, I applied the Elixhauser Comorbidity Software (57) to diagnoses listed on claims filed during each hospital stay, which generated a set of 29 indicator variables for physical and mental comorbidity and then total number of comorbid conditions.

As has been noted previously, validity of instrumental variable, especially that based on area-level indicators, may be compromised by other sources of confounding (54). First, integration level may be related to unobservable organizational characteristics that influence both ACO's integration decision and patient outcomes; for instance, hospitals with higher quality may adopt structures and practices including better physician-hospital integration. These confounders will result in an overestimation of treatment effect: the confounded IV estimate incorrectly attributes the positive effect of other ACO features on outcomes to physician-hospital integration. To address the potential endogeneity, I included a composite quality measure for each ACO, combining a set of variables of process quality and patient-reported experience obtained from the CHIA (11). The process quality domain included 13 Healthcare Effectiveness Data and Information Set (HEDIS) measures of the process of care rendered to adult patients. The patient experience domain included six measures from the Patient Experience Survey (PES) for adult primary care. Both sets of measures were rated on a scale from 0 to 100, with 100 as the best quality or the most favorable response. To avoid over-specification, I averaged individual metrics to create the composite quality score representing the overall quality of ACOs. Table B1 lists the individual measures of each domain.

The second source of confounding results from the correlation of IV to outcomes under study through an unadjusted third variable—an “instrument-outcome confounder,” leading to biased estimates of treatment effect (54). Given this study used an IV defined at the zip-code level, there is a potential of area-based confounding, such as provider availability and socioeconomic status (SES). People living in areas with PCP shortage and, thus, lack of regular primary care providers were reported to have worse health outcomes and to use more hospital and emergency care (56, 76). Moreover, there is ample evidence that less affluent area of residence is associated with a variety of poor health outcomes, including risky health behaviors, high prevalence and incidence of diseases, and increased mortality rates (45, 86, 98). Therefore, without adjusting for these social determents of health, the IV estimates may be confounded. To account for the potential confounding, I included zip-code level measures of income (average per capita income) and poverty (proportion of individuals living below the Federal Poverty Line) from the 2009-2013 5-years ACS and a county-level measure of provider availability (2010 HRSA designation of PCP shortage). Then, I divided zip codes into tertiles based on the SES measures and dichotomized counties by whether it was a whole or part shortage county.

Statistical Models

I estimated the effect of physician-hospital integration on ACO performance by comparing outcomes of patients served by high- versus low-integration ACOs based on the following equation:

$$G(Y_{ijt}) = \beta_0 + \beta_1 High + \beta_2 X_i + \beta_3 H_j + \beta_4 Yr_t + \beta_5 Z + \varepsilon_{ijt} \quad (1)$$

where *i* indexes the patient discharge, *j* indexes the hospital, and *t* indexes year. Equation (1) represents a generalized linear model (GLM), in which G is a function linking the three outcomes (Y_{ijt})—medical spending, LOS, and readmission—to its natural logarithm. GLM was selected for two reasons. First, outcomes of interest are either nonlinear (LOS and readmission) or highly right-skewed and kurtotic (aggregate medical spending). In this case, logarithmic transformation is commonly applied to make the outcome distribution more symmetric and approximate normality. Figure B3 shows that log-transformed spending variables demonstrate the features of a normal distribution. Secondly, GLM avoids bias introduced during retransformation of results from the log scale to the original scale by directly estimating the average value of outcome conditional on covariates. In particular, I accommodated each outcome using different combinations of link and distribution functions. A GLM with Gamma distribution/log link, Poisson distribution/log link, and binomial distribution/logit link was used to estimate the impact of integration on aggregate medical spending, LOS, and readmission rates, respectively. The independent variable of interest is *High*, which is a dummy variable indicating patient's receiving care from a high-integrated ACO. The GLMs adjusted for a set of patient demographic and clinical characteristics (X_i), including age, sex, health risk score, 29 indicators for comorbidities, diagnostic category dummies, hospital fixed effects (H_j), and year fixed effects (Yr_t)[4]. Finally, *Z* represents a vector including measures of ACO quality, area-level SES and provider availability to further control for potential confounders. We estimated standard errors robust to heteroscedasticity using the Huber-White estimator of variance clustered at the hospital level.

Because patient's receipt of care from a high-integrated ACO may not be random but associated with observed and unobservable characteristics, I estimated Equation (1) using an IV approach. The IV approach estimates a pair of simultaneous equations: treatment equation and outcome equation. The treatment equation models the likelihood of receiving care from a high-integrated ACO relative to that from a low-integrated provider; the outcome equation estimates the relationship between an outcome measure (average spending, LOS, and readmission of the index hospitalization) and receipt of care from a high-integrated ACO and other control variables. Because both equations are nonlinear models, I used the two-stage residual inclusion (2SRI) technique (125, 126) to estimate IV specifications. 2SRI is an extension to nonlinear regression contexts of the commonly adopted two-stage least square (2SLS) for linear IV estimations. 2SRI estimator is similar to 2SLS estimator except that in the second stage regression, the endogenous variables are not replaced by the first-stage predictors. 2SRI was selected over 2SLS because it is not only applicable to nonlinear models but also allows for direct testing the presence of

[4] Year fixed effects were not included in the estimations of LOS and readmission rates, given year was not a significant predictor of these outcomes in bivariate analyses.

endogeneity. Applying 2SRI, I regressed *High* on *Proximity* and all other covariates from Equation (1) in the first-stage logistic regression and calculated residuals on the raw scale (*Resid*) based on Equation (2).

$$Pr(High_i = 1) = \beta_0 + \beta_1 Proximity + \beta_2 X_i + \beta_3 H_j + \beta_4 Yr_t + \beta_5 Z + \varepsilon_{ijt} \quad (2)$$

In the second stage, I estimated Equation (1) fitting a GLM with outcome-specific distribution and link functions and including the first-stage residuals as an additional regressor, following Equation (3).

$$G\left(Y_{ijt}\right) = \beta_0 + \beta_1 High + \beta_2 X_i + \beta_3 H_j + \beta_4 Yr_t + \beta_5 Z + \beta_6 Resid + \varepsilon_{ijt} \quad (3)$$

Interest lies in the coefficient on *High*, β_1, which measures the impact of receiving care from high-integrated ACOs. The exponentiated value of β_1 represents the local average treatment effect (LATE) of physician-hospital integration on outcomes studied. Since the two equations are estimated sequentially I obtained standard errors for the estimates from the outcome equation using bootstrapping with 1000 replications. In addition to assessment using the full sample, I also conducted stratified analyses to explore the potential heterogeneity of integration impact. I estimated the models for each of the admission cohorts and subsamples defined by the quartile of health risk score. The effects of integration may vary by illness leading to hospital admission and the general health status of patients, indicating variation in underlying opportunities for efficiency gains. Statistical analysis was done using Stata (version v14.2).

Results

The initial cohort included 49,213 index admissions at 54 general acute-care hospitals from January 2009 to December 2013, eligible for the 30-day unplanned readmission measure. After exclusions (Figure B1), the final sample comprised 33,535 admissions for 26,907 patients served by the 15 commercial ACOs in the Commonwealth. Table 3.1 describes characteristics of the study sample. The mean age at admission was 49 years; women comprised 53.3% of the sample; the mean health risk score was 14.1. Around one-fourth of the sample had no comorbid conditions while 22.5% had three or more comorbidities. The more prevalent comorbid conditions included hypertension (37.8%), obesity (14.4%), electrolyte disorders (12.3%), chronic pulmonary disease (12.1%), depression (11.5%), and diabetes without chronic complications (11.5%). Admissions for surgical or gynecological procedures and medicine treatment accounted for 50.3% and 32.5% of the sample, respectively; while the other admission cohorts—cardiorespiratory, cardiovascular, and neurology—collectively made up the rest 18%. The average aggregate spending in 30 days of admission was $24,601. Medical expenditure increased to $26,447 and $28,043 when expanding episode of care to 45 and 60 days of admission, respectively. The average LOS was 3.5 days, and 30-day unplanned readmission was 5.4%.

Table 3.1: Summary of study sample

Sample characteristics	Total (n = 33,535)
Age at admission, mean (SD)	48.6 (11.0)
Female	53.3%
Health risk score[1], mean (SD)	14.1 (20.2)
Comorbidities[2]	
No of comorbid conditions	
0	26.1%
1	29.1%
2	22.3%
3+	22.5%
Congestive heart failure	3.3%
Valvar disease	2.3%
Pulmonary circulation disease	1.2%
Peripheral vascular disease	1.8%
Paralysis	1.0%
Other neurological disorders	3.5%
Chronic pulmonary disease	12.1%
Diabetes w/o chronic complications	11.5%
Diabetes w/ chronic complications	2.1%
Hypothyroidism	7.6%
Renal failure	3.2%
Liver disease	3.6%
Peptic ulcer Disease x bleeding	0.0%
Acquired immune deficiency syndrome	0.1%
Lymphoma	0.7%
Metastatic cancer	2.4%
Solid tumor w/out metastasis	1.3%
Rheumatoid arthritis/collagen vas	2.1%
Coagulopathy	2.4%
Obesity	14.4%
Weight loss	1.1%
Fluid and electrolyte disorders	12.3%
Chronic blood loss anemia	0.7%
Deficiency Anemias	6.6%
Alcohol abuse	4.3%
Drug abuse	1.8%

Psychoses	2.2%
Depression	11.5%
Hypertension	37.8%
ACO quality measure[3], mean (SD)	85.4 (0.8)
Admission cohorts	
Surgery/Gynecology	50.3%
Cardiorespiratory	6.1%
Cardiovascular	7.7%
Neurology	3.5%
Medicine	32.5%
Outcomes	
Spending in 30 days of admission, mean (SD)	24,601 (23,137)
Spending in 45 days of admission, mean (SD)	26,447 (25,611)
Spending in 60 days of admission, mean (SD)	28,043 (27,978)
Length of stay, mean (SD)	3.5 (3.2)
30-day readmission	5.4%

Notes:
1. Based on HHS-HCC risk score.
2. Based on Elixhauser Comorbidity Index.
3. Based in selected Healthcare Effectiveness Data and Information Set measures and patient-reported experiences.

The first two columns of Table 3.2 compare demographic and clinical characteristics for patients served by low-integrated ACOs, compared with high-integrated ACO patients. Individuals who received care from a high-integrated ACO were slightly older (49.0 vs. 48.4 years), more likely to be female (54.1% vs. 52.9%), and relatively sicker (health risk score: 15.3 vs. 13.5; had three or more comorbidities: 24.3% vs. 21.7%). They also encountered higher medical spending, compared to low-integrated ACO serving patients. To address the selection bias and other unobserved factors that influence patient’s chance of receiving care from a high-integrated ACO, this study adopted an IV approach using differential distance as an instrument. Table 3.3 summarizes the differential distance used in IV estimations. Among patients served by low-integrated ACOs, the mean differential distance was negative (-2.50, interquartile range [IQR], -3.46 to 0.00), indicating the higher prevalence of PCP affiliation to a low-integrated ACO. The corresponding statistics for high-integrated ACO serving patients was 0.49 (IQR, -0.40 to 0.78), suggesting proximity to PCPs affiliated with a high-integrated ACO.

Differential distance is a valid instrument if it is strongly correlated with patients' receiving care from a high-integrated ACO and uncorrelated with the error term in Equation (1). To test the first prerequisite of correlation with receipt of care from high-integrated ACOs, I followed the commonly used criterion proposed by Staiger and Stock (123) of F-statistic exceeding the threshold of 10. The first-stage of estimates in Table 3.4 shows the coefficient on differential distance was 0.228 (95% confidence interval [CI], 0.212 to 0.245), and the F statistic of 1535 (data not shown) far exceeds the standard threshold. Moreover, the c-statistics for the first-stage logistic regression is 0.856 (95% CI, 0.851 to 0.860; data not shown), indicating attribution to a high-integrated ACO was strongly predicted by differential distance along with other covariates. The second assumption of no correlation to the error term is not directly testable. However, it is feasible to examine if the IV is uncorrelated with observed patient characteristics, suggesting study sample is randomized by differential distance.

To test so, I divided study sample into two groups by the median of differential distance and examined patient characteristics for those with a differential distance above and below the median. These results are displayed in the last two columns of Table 3.2. Compared to the first two columns, patient demographic factors and general health status are more similar in the last two columns; the difference in prevalence in each comorbid condition between two groups shrinks, suggesting two groups become closely balanced when categorizing patients by the IV. One exception to this balance is the differential distance to PCPs who were affiliated with a high-integrated ACO by whether the patient had diabetes without chronic complications or hypertension. Patients with diabetes or hypertension tended to have a shorter differential distance, comparted to their counterparts. To control for the imbalance, I included a set of comorbidity dummies in the IV estimations.

Table 3.2: Patient characteristics by ACO and by differential distance between nearest PCP of a low-integrated ACO and nearest PCP of a high-integrated ACO

Sample characteristics	Low-integrated ACO (n = 22,921)	High-integrated ACO[4] (n = 10,614)	IV < median (n = 16,518)	IV >= median[4] (n = 17,017)
Age at admission, mean (SD)	48.4 (11.1)	49.0 (10.8) **	48.6 (11.0)	48.5 (11.0)
Female	52.9%	54.1% **	53.2%	53.3%
Health risk score[1], mean (SD)	13.5 (19.7)	15.3 (21.2) **	14.0 (20.4)	14.1 (20.0)
Comorbidities[2]				
No of comorbid conditions				
0	26.6%	25.0% **	25.8%	26.4%
1	29.5%	28.3%	29.1%	29.1%
2	22.2%	22.4%	22.8%	21.7%
3+	21.7%	24.3%	22.3%	22.8%
Congestive heart failure	3.2%	3.4%	3.3%	3.2%
Valvar disease	2.1%	2.5% **	2.2%	2.3%
Pulmonary circulation disease	1.0%	1.5% **	1.2%	1.1%
Peripheral vascular disease	1.8%	1.9%	2.0%	1.7%
Paralysis	0.9%	1.0%	1.0%	0.9%
Other neurological disorders	3.3%	3.9% **	3.4%	3.6%
Chronic pulmonary disease	12.4%	11.6% **	12.5%	11.8% **
Diabetes w/o chronic complications	11.6%	11.2%	12.3%	10.6% **
Diabetes w/ chronic complications	1.9%	2.4% **	2.0%	2.2%
Hypothyroidism	7.4%	8.0%	7.3%	7.8%
Renal failure	3.0%	3.7% **	3.1%	3.3%
Liver disease	3.0%	4.7% **	3.0%	4.1% **

Peptic ulcer Disease x bleeding	0.0%	0.0%	0.0%	0.0%
Acquired immune deficiency syndrome	0.1%	0.2% **	0.1%	0.2% **
Lymphoma	0.7%	0.9%	0.7%	0.8%
Metastatic cancer	2.4%	2.5%	2.4%	2.5%
Solid tumor w/out metastasis	1.4%	1.2%	1.4%	1.2%
Rheumatoid arthritis/collagen vas	1.9%	2.6% **	2.1%	2.1%
Coagulopathy	2.3%	2.5%	2.4%	2.4%
Obesity	14.2%	14.8%	14.5%	14.3%
Weight loss	1.1%	1.2%	1.1%	1.2%
Fluid and electrolyte disorders	12.3%	12.3%	12.3%	12.3%
Chronic blood loss anemia	0.7%	0.7%	0.7%	0.7%
Deficiency Anemias	6.2%	7.3% **	6.6%	6.6%
Alcohol abuse	4.1%	4.6%	4.2%	4.3%
Drug abuse	1.6%	2.0% **	1.7%	1.8%
Psychoses	2.3%	2.2%	2.3%	2.1%
Depression	11.0%	12.4% **	11.1%	11.8% **
Hypertension	37.7%	38.0%	38.3%	37.3%
ACO quality measure[3], mean (SD)	85.4 (0.8)	85.3 (0.8) **	85.3 (0.8)	85.5 (0.8) **
Admission cohorts				
Surgery/Gynecology	49.9%	51.3% **	49.8%	50.9% **
Cardiorespiratory	6.3%	5.6%	6.5%	5.7%
Cardiovascular	7.8%	7.3%	7.5%	7.8%
Neurology	3.3%	3.7%	3.7%	3.3%
Medicine	32.6%	32.1%	32.5%	32.4%

Outcomes				
Spending in 30 days of admission, mean (SD)	23,659 (22,446)	26,634 (24,441) **	24,174 (23,303)	25,015 (22,968) **
Spending in 45 days of admission, mean (SD)	25,399 (24,753)	28,711 (27,235) **	25,970 (25,662)	26,910 (25,553) **
Spending in 60 days of admission, mean (SD)	26,922 (27,093)	30,465 (29,657) **	27,544 (28,174)	28,528 (27,778) **
Length of stay, mean (SD)	3.5 (3.2)	3.6 (3.2) **	3.5 (3.2)	3.5 (3.1)
30-day readmission	5.5%	5.3%	5.3%	5.6%

Notes:

1. Based on HHS-HCC risk score.
2. Based on Elixhauser Comorbidity Index.
3. Based in selected Healthcare Effectiveness Data and Information Set measures and patient-reported experiences.
4. ** indicates statistically significant differences between two groups (low-integrated ACO vs. high-integrated ACO; IV<median vs. IV>=median) at the 5% level.

Table 3.3: Summary of differential distance between closest low-integrated ACO PCP and closest high-integrated ACO PCP for each patient

	Low-integrated ACO patients	High-integrated ACO patients
n	22,921	10,614
IQR	(-3.46, 0)	(-0.40, 0.78)
Mean	-2.50	0.49
SD	4.50	3.29

Abbreviations: IQR, inter-quartile range; SD, standard deviation

Table 3.4: First-stage logistic: receiving care from a high-integrated ACO compared with low-integrated ACO (n = 32,957)

Explanatory variables[1]	Co-efficient	p < |t|	95% confidence interval	
Instrument				
Differential distance	0.228	0.000	0.212	0.245
Demographic characteristics				
Age at admission (ref=18-39)				
40-49	0.160	0.001	0.069	0.252
50-59	0.206	0.000	0.117	0.296
60-64	0.193	0.000	0.085	0.300
Female	0.106	0.001	0.043	0.170
Health risk score[2]	0.001	0.359	-0.001	0.003
Comorbidities[3]				
No of comorbid conditions (ref=none)				
1	-0.026	0.646	-0.136	0.084
2	-0.008	0.930	-0.182	0.166
3+	-0.022	0.879	-0.300	0.257
Congestive heart failure	0.011	0.906	-0.172	0.194
Valvar disease	0.064	0.523	-0.133	0.262
Pulmonary circulation disease	0.250	0.069	-0.019	0.519
Peripheral vascular disease	-0.018	0.870	-0.231	0.195
Paralysis	0.088	0.566	-0.212	0.388
Other neurological disorders	0.135	0.129	-0.039	0.308
Chronic pulmonary disease	0.021	0.723	-0.094	0.135
Diabetes w/o chronic complications	0.039	0.520	-0.080	0.158
Diabetes w/ chronic complications	0.045	0.677	-0.167	0.257

Hypothyroidism	0.005	0.944	-0.125	0.134
Renal failure	0.013	0.885	-0.165	0.191
Liver disease	0.120	0.151	-0.044	0.284
Peptic ulcer Disease x bleeding	-0.622	0.367	-1.972	0.728
Acquired immune deficiency syndrome	1.056	0.007	0.295	1.816
Lymphoma	0.094	0.570	-0.231	0.419
Metastatic cancer	-0.136	0.181	-0.336	0.063
Solid tumor w/out metastasis	-0.331	0.016	-0.598	-0.063
Rheumatoid arthritis/collagen vas	0.388	0.000	0.179	0.598
Coagulopathy	0.048	0.637	-0.153	0.250
Obesity	0.100	0.091	-0.016	0.216
Weight loss	-0.001	0.995	-0.296	0.294
Fluid and electrolyte disorders	-0.003	0.958	-0.124	0.117
Chronic blood loss anemia	0.086	0.639	-0.275	0.448
Deficiency Anemias	0.155	0.020	0.024	0.286
Alcohol abuse	0.005	0.954	-0.167	0.177
Drug abuse	0.319	0.009	0.080	0.558
Psychoses	-0.010	0.929	-0.229	0.209
Depression	0.092	0.123	-0.025	0.209
Hypertension	0.029	0.575	-0.073	0.132
ACO quality measure[4]	-0.805	0.000	-0.851	-0.759
Area socioeconomic characteristics				
Income (ref=low)				
Medium	0.161	0.001	0.063	0.259
High	0.943	0.000	0.839	1.048
Poverty (ref=low)				
Medium	0.158	0.000	0.081	0.236
High	0.645	0.000	0.547	0.744
PCP shortage	0.107	0.029	0.011	0.202

Notes:
1. Hospital fixed effects and diagnostic category fixed effects were not shown.
2. Based on HHS-HCC risk score.
3. Based on Elixhauser Comorbidity Index.
4. Based in selected HEDIS measures and patient-reported experiences.

Table 3.5 presents estimates of the effect of physician-hospital integration on individual outcomes. The coefficient on *High*, β_1 in Equation (3), is negative and highly significant for all three expenditure measures, suggesting integration is associated with a decrease in spending regardless of the definition of an episode of care. Patients receiving care from high-integrated ACOs had 10.6% ($p<0.001$) lower medical expenditures over the first 30 days of care, compared to their low-integrated ACO counterparts. The change is equivalent to a decrease of $2,616 in spending per hospitalization on a base of $24,601[5]. The corresponding reductions for 45 and 60 days of admission are 9.7% ($p<0.001$) and 9.6% ($p<0.001$), representing a saving of $2,555 and $2,693 per hospital discharge, respectively. I further explored the context for spending changes by examining how LOS varies by integration level. Higher physician-hospital integration was associated with a decline in LOS by 15.7% ($p<0.001$), corresponding to a decrease of approximately one half day based on the average LOS of 3.5 days. Finally, I examined whether integration level affects patient outcomes, specifically unplanned readmission to an acute-care hospital within 30 days of discharge. The coefficient of interest is not statistically different from zero, indicating physician-hospital integration is not associated with change in rates of 30-day unplanned readmission. Considering providers may reduce medical expenditure on an episode of inpatient care by shortening LOS or/and avoiding readmission, these findings collectively suggest that the observed reduction in spending among high-integrated ACO patients was largely driven by a shorter hospital

[5] Estimated effects of physician-hospital integration on individual outcomes were computed by multiplying the sample means by corresponding LATE reported in Table 3.5.

stay. Moreover, no change in readmission rate implies that decrease in LOS did not affect quality of care.

Table 3.5: Effect of physician-hospital integration on medical spending following hospital admission, length of stay of hospitalization, and readmission

Outcomes	LATE[1]	p < |t|	95% CI	
Spending in 30 days of admission	10.6%	<0.001	15.1%	5.9%
Spending in 45 days of admission	9.7%	<0.001	14.2%	4.9%
Spending in 60 days of admission	9.6%	<0.001	14.3%	4.7%
Length of stay	15.7%	<0.001	22.6%	8.2%
30-day readmission	10.3%	0.668	45.4%	-47.4%

Abbreviations: LATE, Local Average Treatment Effect; CI, Confident Interval.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].

To examine the heterogeneous effect of physician-hospital integration, I performed the IV estimations separately by category of illness and health status of patients. First, analyses stratified by five clinically-defined cohorts (Table 3.6) indicates the observed saving in medical spending was mainly driven by patients treated for illness other than cardiorespiratory, cardiovascular, or neurologic conditions and received no surgical procedure. The estimated effect of integration on expenditure in 30, 45, and 60 days of hospital admissions is a saving of $2,014 (p=0.013), $2,032 (p=0.029), and $2,029 (p=0.048) per hospitalization, respectively.[6] Estimates of the effect of integration on LOS and readmission are small and not statistically significant across five admission cohorts. Secondly, analyses stratified by quartile of health risk scores (Table 3.7) suggests saving associated with high-integrated ACOs mostly concentrated in

[6] Heterogeneous effects of physician-hospital integration on individual outcomes were computed by multiplying the relevant cohort-specific means by corresponding LATE reported in Table 3.7.

patients in the third quartile of the HHS-HCC risk score. Higher integration is related to a reduction in medical expenditure ranging from $3,060 (p=0.001) for an episode of 30 days to $3,454 (p<0.001) for a 60-day episode. The estimated effects are somewhat weaker among patients with relatively better health status. Patients in the second quartile experienced a decrease in spending ($1,718 per admission, p=0.036) only within the first 30 days of hospital admission. The observed saving vanishes when expanding the length of an episode to 45 and 60 days. I found no evidence for heterogeneous effects of physician-hospital integration on LOS or readmission by patient health status.

To examine if the findings are sensitive to the nonlinear IV specification, I repeated the primary analyses using 2SLS. In all cases, specifying IV in linear function did not qualitatively change the results (Table B2). Using 2SLS, the estimated effects of integration are much stronger than those from 2SRI estimations. The deviation is due to the failure of linear estimations to deal adequately with skewed data and distribution of count and binary outcomes. Also, linear models, in general, are sensitive to extreme values, which may lead to overestimation of treatment effects.

Table 3.6: Heterogeneous effects by admission condition

Admission Cohorts	Mean[1]	LATE[2]	$p < \lvert t \rvert$	95% CI	
Surgery/Gynecology (n = 16,884)					
Spending in 30 days of admission	30,828	2.8%	0.217	6.9%	-1.6%
Spending in 45 days of admission	32,344	2.0%	0.386	6.3%	-2.5%
Spending in 60 days of admission	33,666	1.6%	0.510	6.1%	-3.1%
Length of stay	3.5	0.0%	1.000	10.5%	-11.7%
30-day readmission	4.1%	-30.0%	0.292	20.1%	-111.5%
Cardiorespiratory (n = 2,034)					
Spending in 30 days of admission	17,736	1.6%	0.927	30.2%	-38.7%
Spending in 45 days of admission	19,955	5.5%	0.736	32.2%	-31.7%
Spending in 60 days of admission	22,068	16.0%	0.339	41.2%	-20.1%
Length of stay	4.1	7.0%	0.583	28.3%	-20.6%
30-day readmission	7.2%	26.1%	0.592	75.5%	-123.2%
Cardiovascular (n = 2,572)					
Spending in 30 days of admission	23,774	9.0%	0.336	24.9%	-10.3%
Spending in 45 days of admission	25,359	10.0%	0.248	24.6%	-7.6%
Spending in 60 days of admission	27,050	11.4%	0.170	25.5%	-5.3%
Length of stay	2.7	4.8%	0.658	23.4%	-18.4%
30-day readmission	4.8%	14.7%	0.850	0.163	4.473
Neurology (n = 1,162)					
Spending in 30 days of admission	23,617	14.4%	0.188	32.2%	-7.9%
Spending in 45 days of admission	26,994	15.5%	0.157	33.2%	-6.7%
Spending in 60 days of admission	29,366	17.8%	0.114	35.5%	-4.8%
Length of stay	3.6	9.1%	0.627	38.1%	-33.5%

30-day readmission	5.6%	-73.5%	0.561	72.9%	-1011.2%
Medicine (n = 10,883)					
Spending in 30 days of admission	16,525	12.2%	0.013	20.9%	2.7%
Spending in 45 days of admission	18,711	10.9%	0.029	19.7%	1.2%
Spending in 60 days of admission	20,530	9.9%	0.048	18.7%	0.1%
Length of stay	3.5	5.0%	0.459	17.1%	-8.9%
30-day readmission	7.3%	-2.4%	0.950	51.7%	-117.3%

Abbreviations: LATE, Local Average Treatment Effect; CI, Confident Interval.
Notes:
1. Cohort-specific average.
2. LATE is equal to [exponentiated β1 in Equation (3) - 1].

Table 3.7: Heterogeneous effects by patient health status

HHS-HCC risk score	Mean[1]	LATE[2]	p < |t|	95% CI	
Lowest quarter (n= 8,312)					
Spending in 30 days of admission	18,389	5.2%	0.079	10.5%	-0.6%
Spending in 45 days of admission	18,789	4.3%	0.126	9.5%	-1.2%
Spending in 60 days of admission	19,117	3.1%	0.310	9.1%	-3.0%
Length of stay	2.4	11.2%	0.024	20.0%	1.5%
30-day readmission	1.3%	38.7%	0.453	82.9%	-120.3%
2nd quarter (n= 8,326)					
Spending in 30 days of admission	19,348	8.9%	0.036	16.5%	0.6%
Spending in 45 days of admission	20,056	6.6%	0.145	14.7%	-2.3%
Spending in 60 days of admission	20,648	5.0%	0.302	13.7%	-4.7%
Length of stay	2.6	-1.8%	0.721	8.0%	-12.6%
30-day readmission	2.5%	6.7%	0.892	65.5%	-152.7%

3rd quarter (n= 8,430)					
Spending in 30 days of admission	23,119	13.2%	0.001	20.0%	6.0%
Spending in 45 days of admission	24,318	12.3%	0.001	18.7%	5.4%
Spending in 60 days of admission	25,427	13.6%	0.000	20.4%	6.3%
Length of stay	3.5	7.4%	0.318	20.4%	-7.7%
30-day readmission	4.5%	9.6%	0.834	65.0%	-133.0%
Highest quarter (n= 8,467)					
Spending in 30 days of admission	37,340	8.7%	0.168	19.7%	-3.9%
Spending in 45 days of admission	42,370	7.7%	0.233	19.1%	-5.3%
Spending in 60 days of admission	46,683	8.0%	0.194	18.8%	-4.3%
Length of stay	3.5	6.1%	0.408	19.2%	-9.0%
30-day readmission	13.0%	-32.6%	0.293	21.7%	-124.6%

Abbreviations: LATE, Local Average Treatment Effect; CI, Confident Interval.

Notes:

1. Cohort-specific average.
2. LATE is equal to [exponentiated β1 in Equation (3) - 1].

Discussion

Using 15 provider organizations that signed up an ACO-like contract with a private payer in Massachusetts during 2009 and 2013, I found that physician-hospital integration was associated with improved efficiency in inpatient care delivery (a reduction in aggregate spending of $2,616 per inpatient episode, with no change in odds of 30-day readmission). This finding was based on an IV statistical model adjusting for patient characteristics and provider quality of care and adopting differential distance as a source of quasi-randomization. The observed relationship of vertical integration with reduced spending and utilization fills the knowledge gap that whether physician-hospital integration leads to efficiency gain under alternative payment models with incentives to shift away from volume-driven practice.

Under a global budget with quality bonus, ACOs have incentives to reduce costs of inpatient care by shortening hospital stays while being held responsible for patient outcomes. The decrease in hospital LOS provides evidence that hospital-PCP integration induced more efficient task allocation between hospitals and outpatient settings. From a hospital's perspective, shifting the management of patients away from high-cost inpatient settings provides an opportunity to reduce costs. From a physician perceptive, employed or hospital-owned PCPs have incentives to accept patients quicker and sicker since they can share the saving from shorter hospital stays. Despite incentives to lower intensity of services rendered during hospitalization, the global payment mechanism also makes providers accountable for the costs associated with hospital-acquired conditions and readmissions. In other words, vertical integration between hospitals and PCPs contributes to the creation of added value for patients and cost-effective inpatient care delivery in the context of ACO with downside risk.

Previous studies that examined the effects of integration on medical spending and healthcare utilization differ by study sample and measure of integration, but consistently document a positive relationship between integration and spending/utilization. In early 1980s, research documented that vertical integration between hospitals and primary care practices was associated with increased hospital utilization and market share, along with a more favorable outpatient payer mix (129). Another early study defined integration by types of hospital-physician affiliations and concluded that vertical integration was associated with higher treatment intensity and inpatient spending among Medicare beneficiaries with a diagnosis of acute myocardial infarction (77). Robinson and Miller categorized physician organizations by physician employment and found that hospital-owned physician organizations in California incurred higher total expenditures for individuals with private HMO coverage (105). Baker and colleagues defined vertical integration by hospitals' contractual or ownership relationship with physician groups and observed association of integration with higher hospital prices and spending among a national sample of privately insured (20). They also investigated the effects of physician-hospital integration on hospital admissions of Medicare beneficiaries and found that hospital's ownership of physician groups increased the likelihood of referring patients to the owner hospitals (23). A recent study measured financial integration between physicians and hospitals by doctors' billing pattern and found integration was related to higher commercial prices and spending for outpatient care (90). Though studies using various integration measures came to a consistent conclusion, none of the previous investigations assessed the impact of physician-hospital integration on health care delivery in a context where providers lack incentives to render excess services. As the ongoing payment reform shifts greater risk toward providers, studies overlooking the disincentives embedded in reimbursement fail to shed light on the real effects of provider consolidation in the era moving away from volume-based care.

This study provides empirical evidence for improved efficiency related to increased integration between physicians and hospitals of a provider organization. The finding is different from those of previous studies for several reasons. First, my study evaluated the impact of integration on provider efficiency under an ACO context within which providers are incentivized to limit utilization. Studies that found higher integration was associated with higher spending or utilization mostly conducted investigations in a fee-for-service (FFS) environment. Under the most common payment framework, though hospitals are reimbursed by inpatient stays, physicians are paid on an FFS basis. It suggests that integrated hospitals only partially take the financial risk associated with inpatient expenditure, while most risk is retained at the payer level. On the contrary, providers may be more prudent under an ACO contract as they have financial incentives to contain the costs of care delivered to their patients, especially when operating under a global budget.

Second, two studies evaluating Medicare ACO programs concluded that financial integration between physicians and hospitals was not related to improved efficiency (83, 84). Both studies, along with many previous inquiries, defined integration based on the intermediary organizational structure between the two parties. Theoretically, these structures may foster hospital collaboration with physicians. It is, however, not clear to what extent organization arrangements lead to financial and clinical integration. This study explicitly defined financial integration between PCPs and hospitals based on billing pattern that implies hospital employment of physicians or ownership of physician practices using claims data. Although economic integration does not guarantee achievement of clinical integration, aligning financial incentives and sharing risk between medical staff and hospitals may facilitate greater cooperation in care delivery (67). An early study documented that greater reduction in medical spending achieved by Medicare ACOs consisted of independent primary physician groups under a contract without downside risk (84). This study extends the knowledge base by providing evidence that hospital-PCP integration was associated with a considerable saving in hospital inpatient expenditure under a two-sided ACO contract.

Third, differences in study sample may help explain the discrepancy in the findings related to impacts of integration between this study and early research. To evaluate the overall effects of ACO, researchers of early studies analyzed spending and utilization of health services of Medicare beneficiaries residing in different states and receiving care from various provider organizations. There is enormous variation in use of health care that exist by providers and by geographic region. Even under the ACO umbrella, variations in organizational characteristics and external environment within which providers operate has been widely documented in the previous literature (75, 115). The observed heterogeneity imposes considerable difficulty in disentangling the impacts of integration from other factors that potentially influence ACO performance. Recognizing the complexity, I conducted analyses using a commercial ACO sample that operated in the same state and signed a similar contract with a private payer. Furthermore, I specifically estimated spending and outcomes of hospital inpatient care to avoid potential confounders resulting from differences in clinical pathways and patterns of care delivery by care settings. Given the abovementioned strategies, this study was better tailored to estimate the improved efficiency of ACO related to physician-hospital integration.

One may expect to find efficiency gain in care delivery related to diseases and procedures that usually consume more resources, as it suggests potential opportunities for improvement. This study found no evidence of improved efficiency among patients admitted for cardiorespiratory, cardiovascular, or neurological conditions, probably because sample sizes of these cohorts are relatively small. Although admissions for surgical or gynecological procedures were most costly, the lack of evidence that integration leads to increased efficiency suggests that integration with clinicians other than PCPs may play a more important role. Stratified analyses by health status of patients show that the observed effects of integration were primarily seen among enrollees with higher, but not the highest, risk. It implies that efficiency gain occurred when there was room for improvement, and it may take providers longer to further optimize care delivery for patients with the most severe conditions.

This study has several limitations. First, there might be unmeasured variables that are correlated with PCP designation and outcomes, which lead to inconsistent IV estimates of the actual integration effects. To control for the potential confounders, I included several controls for provider quality and regional SES and PCP availability. It is true that the included variables could not explicitly control for all potential confounders. However, for an omitted factor to bias the estimates, it has to be highly correlated with the IV and uncorrelated with ACO quality, area-level income, poverty, and PCP availability. Second, to account for patient selection, this study applied an IV approach which estimates local average treatment effect of physician-hospital integration. Though it allows for causal inference, the estimated treatment effects are based on marginal enrollees who selected a PCP affiliated with a low-integrated ACO only because the doctor’s office was closer to their residency. These enrollees may differ from those who select their PCPs according to other reasons. However, it is a reasonable assumption that, for most people, accessibility is the primary factor influencing their PCP choice. Finally, the study sample only contains insured individuals with coverage from a commercial carrier. They are a largely employed population and live in Massachusetts. Lack of heterogeneity limits the capability of this study to generalize findings to other states and populations with public coverage or private coverage from different carriers.

In summary, financial integration between physicians and hospitals is associated with a reduction in medical spending during an episode of inpatient care and a decline in LOS, with no evidence of elevated readmission rates. Collectively, these findings suggest physician-hospital integration results in improved efficiency in inpatient settings. The results have significant policy implications as payment reforms push for higher-quality, more cost-effective care requiring an organization-wide focus on efficiency improvement. To succeed in the ACO era, particularly under contracts with downside risk, hospitals are more dependent on doctors who make almost every decision on what tests, treatments, and medications patients get. Although physician employment aligns incentives between hospitals and physicians, it is just one piece in the process of building a coordinated care network to achieve the common goal of improving value. Further investigation into the effects of vertical integration on provider behaviors outside of hospital settings is warranted and will inform the ongoing development of ACOs.

CHAPTER 4: THE IMPACT OF ACO PHYSICIAN-HOSPITAL INTEGRATION ON HEALTH CARE SPENDING AND DELIVERY PATTERNS

Summary

Accountable care organizations (ACOs) have been anticipated to bend the spending curve through better management and coordination of health services rendered by providers across settings, particularly bridging gaps between ambulatory care and hospital inpatient care. Vertical integration between physicians and hospitals has been argued to equip ACOs better to achieve the triple goals of improving patient care experience, promoting population health, and reducing health care costs. However, evidence of better ACO performance from physician-hospital integration is limited, mainly focusing on Medicare ACOs that only partially assume the financial risk of enrollee healthcare utilization. This chapter examines the association between physician-hospital integration and productive efficiency of ACOs with shared risk using an instrumental variable approach. In addition, it explores whether provider organizations achieve cost savings through altering care delivery patterns.

Research Question

This chapter assesses whether annual medical spending per enrollee and use of associated inpatient and outpatient services are lower among individuals served by ACOs demonstrating a higher level of physician-hospital integration.

Background

Several provisions of the Patient Protection and Affordable Care Act (ACA), including the creation of Medicare Accountable Care Organizations (ACOs), that hold providers responsible for costs and quality of care rendered to their patients could implicitly encourage consolidation. Researchers have expressed concern that provider consolidation triggered by the financial risk associated with payment models may lead to higher prices negotiated with health plans, especially with private payers (19, 51, 69). Although there is no clear evidence that consolidation is related to ACO formation or participation, a recent study found potential defensive consolidation in response to new payment mechanisms (92). During the development of managed care in the 1990s, the primary motivation of hospitals for employing physicians has been to gain market share and increase the flow of referrals to their facilities. The concentrated market power generally leads to less competition and higher prices (costs), which are observed in many high-cost markets dominated by local providers who exercise market power, including Massachusetts. A report released by the Attorney General's office suggests that high prices and price variation are correlated mainly with market share rather than the quality of care, patient-mix, or disproportionate share of a socioeconomic disadvantaged patient population (94). As the ongoing integration between physicians and hospitals continues into the ACO era, investigations into whether integrated provider organizations, in fact, achieve the stated benefits of better coordination will contribute to the evidence base to guide ongoing payment and delivery system reforms.

Evidence on efficiencies from provider integration is limited and provides mixed results due to variation in the measurement of integration, outcomes under study, and patient population. Studies of integrated delivery systems (IDS), a more comprehensive consolidation involving providers across care settings, found that integration was related to a marginal improvement in a few quality measures, referral patterns favoring parent facilities, and higher costs per discharge (31, 32, 59). Research on the impact of integration between physicians and hospitals has mainly focused on inpatient care, likely because of the high costs of hospital services. Though many studies documented an association of integration with higher spending, costs, and prices (16, 20, 41, 77, 105), one study found no such evidence (38). Contrary to the inconclusive findings on spending, hospital-physician integration was consistently found to increase utilization of inpatient services, including slightly higher procedure rates and more admissions to owning hospitals (22, 77, 100). Though previous investigations suggested that integration did not lead to improved efficiency or quality of care in inpatient settings (41, 108), a recent study found that integration was associated with lower spending per inpatient episode and shorter length of stay with no evidence of elevated readmission rates. Few studies have explored the impact of physician-hospital integration on outpatient. One study observed a correlation of integration with higher spending in outpatient care (90); another found a positive association between integration and appropriate emergency department use

(31). Although the effects of physician-hospital integration on various aspects of health care delivery have been documented, less is known about its impact on the efficiency of provider organizations in managing care of a population across care settings. Moreover, none of the previous studies examines the causal association between physician-hospital integration and spending, outcomes, quality, or use of healthcare. As ongoing payment reform shifts greater risk toward providers, it is critically important to investigate whether vertical integration leads to efficiency gains in the context of ACOs.

This study explores whether hospital consolidation of physician practices improves ACO efficiency by examining the association between hospital integration with primary care physicians (PCPs) and health care spending and utilization. The focus on integration between hospitals and PCPs is grounded in the concept that better coordination between them may lead to enhanced management of the health of their patients across sites of care. It is expected that greater continuity of care between inpatient and outpatient settings subsequently improves quality of care and reduces costs. Accordingly, the study decomposes overall expenditures into spending in ambulatory care and hospital care settings and quantifies the use of corresponding services to shed light on the mechanism that drives spending reductions achieved by ACOs. Earlier studies of the effects of integration failed to adequately account for two potential sources of endogeneity: selection bias resulting from unmeasured differences in patient characteristics that may influence patient selection into a high-integrated provider, and the endogenous relationship between an ACO's integrative strategies and its quality and costs. This study addresses selection bias using an instrumental variable (IV) approach. The identified IV—difference in proximity to high- versus low-integrated providers—is based on similar instruments used in prior studies since it is likely to influence provider selection and be independent of patient health status (observed and unobserved) (17, 71, 79). To adjust for endogeneity between integration and outcomes, several ACO characteristics, including quality, are included in IV estimations to isolate the component of treatment variation attributable to the IV.

Methods

Data Source

The primary data source was the Massachusetts All-Payer Claims Database (APCD, Release 3.0) from 2009 to 2013. Medical claims were used to calculate the annual inpatient and outpatient spending[7] per enrollee and utilization of associated healthcare services. Secondary data sources included the Massachusetts Registration of Provider Organization (MA-RPO, 2015 initial registration) from the Massachusetts Health Policy Commission (9), American Community Survey (ACS) (4), and Annual Report on the Performance of the Massachusetts Health Care System from the Center for Health Information and Analysis (CHIA) (11). MA-RPO data was used to establish patient attribution and

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[7] Pharmaceutical claims were not included because not all the study sample had prescription drug benefits offered by the Blue Cross Blue Shield of Massachusetts.

construct physician-hospital integration measures (Methods in Chapter 2). I obtained data on socio-demographics, including income, poverty, and educational attainment, from ACS and used measures of provider quality from the state-issued annual performance report. This study was reviewed and approved by the Institutional Review Board at Boston University Medical Campus.

Study Population

The study sample was composed of 15 commercial ACOs[8] established in Massachusetts between 2009 and 2013. I started by identifying physicians who were affiliated with each on required by the Commonwealth to submit an annual filing on the provider organization's internal structure, including affiliated physicians, and clinical and contracting relationships with other providers (8). On average, nearly 90% of the listed physicians were identified in the APCD data files. Next, I defined patients attributed to the 15 ACOs based on the following inclusion criteria: 1) non-elderly adults (aged 18 to 64); 2) enrollment in a health maintenance organization (HMO) or point-of-service (POS) plan with the insurance carrier that signed the commercial ACO contract with providers; 3) designation of PCP affiliated with the ACOs during their HMO/POS enrollment. From this sample, I excluded enrollees whose designated PCP was affiliated with

[8] Though Children's Hospital Integrated Care Organization was included in Chapter 2, it was excluded from Chapter 3 and 4 because its patient population, mainly children, is very different from that of other ACOs.

multiple ACOs, as exclusive attribution of patients to an ACO was not feasible[9]. Additionally, I excluded enrollees who were not continuously attributed to an ACO for at least one calendar year (from January to December) to ensure completeness of outcome measures. Finally, to create a more homogeneous and consistent study population, non-MA residents and enrollees who switched to a different ACO[10] in a given year were excluded. The above exercise resulted in a cohort of 516,413 enrollees (Figure C1).

Integration

Following previous studies (83, 90, 92), I categorized ACOs into high- versus low-integrated providers based on a claims-based measure of physician-hospital integration. In this study, I specifically measured integration between PCPs and hospitals because a closer tie between them may foster coordination and collaboration across care settings, especially in the context of ACO. For each ACO, I calculated each PCP's share of annual medical claims for outpatient care[11] that was billed with a hospital outpatient department (HOPD) code during the study period. From the physician/year level measure, I then calculated the proportion of PCPs at each ACO who exclusively followed this billing pattern in

[9] Approximately 10 percent of the identified physicians were affiliated with multiple provider organizations, leading to an exclusion of 3.6 percent of the eligible patient population.

[10] Switched enrollees were excluded because of the explanatory difficulty resulting from holding multiple ACOs collectively responsible for a patient's annual spending and use of health services.

[11] Outpatient care was defined by professional claims of physician services rendered in a hospital outpatient department (place of service code=11) or doctor's office (place of service code=22).

each year[12]. Finally, given physicians' billing pattern was consistent over time, to facilitate interpretation of results, I defined each ACO according to whether its 5-year average was above or below the mean of all 15 organizations as high- versus low-integrated ACO (Methods in Chapter 2).

Outcome Variables

This study explored the impact of integration on annual per-enrollee spending on inpatient and outpatient care and utilization of relevant services. Following the previous research, inpatient and outpatient services were defined by Diagnosis Related Group (DRG) and Current Procedural Terminology (CPT) codes, respectively (90). For inpatient care, I determined annual, individual-level utilization by counting unique combinations of DRG and admission date and for each enrollee in each year. Additionally, hospitalizations for ambulatory care-sensitive conditions (ACSC), conditions for which timely and appropriate ambulatory care may have prevented the need for hospital admission, were labeled and counted separately (14). For each hospitalization, the associated spending was calculated by aggregating payments for facility and professional claims of services rendered during the hospital stay. The annual, individual-level inpatient expenditure was then defined by aggregating admission-level spending over a year for each enrollee. I limited inpatient care to admissions to a general

[12] Alternative thresholds (95% and 75%) were used as sensitivity analysis and led to the same set of ACOs categorized as high- versus low-integrated providers.

acute care hospital[13] for two reasons. First, the study sample was a non-elderly population and therefore had limited use of inpatient care in post-acute care settings[14]. Second, limiting to admissions to general acute care hospitals enables this study to investigate whether the observed change in inpatient care utilization was due to improved outpatient care by examining hospitalizations for ACSCs.

Outpatient care was determined by services delivered in a doctor's office or HOPD, with services identified by CPT codes. The primary outcomes were annual spending on outpatient services and counts of outpatient encounters (visits to a physician office or HOPD) per enrollee; the secondary outcomes were setting-specific spending and utilization. I adopted a claim-day methodology following previous studies that estimated commercial spending in healthcare services using claims data (81, 91). First, I calculated service-level spending by aggregating all professional fees associated with a service (defined by a CPT code) for a given person on a given date. The additional facility fees for services rendered in an HOPD were explicitly matched by CPT codes. Next, I defined an office or HOPD visit as the set of services received by an individual at a single location on a single day. The corresponding spending was calculated by aggregating payments for all services rendered during the encounter. Finally, for each enrollee in each year, I calculated spending by summing payments for each

[13] General acute care hospitals were defined by a healthcare provider taxonomy code of 282N00000X.

[14] General acute care hospitals accounted for around 80 percent of the inpatient admissions associated with the study sample.

visit and created a utilization measure equal to the sum of annual visit counts.

Spending measures described in the previous section included payment from the private insurer and patient out-of-pocket (OOP) cost and were adjusted for inflation and presented in 2013 dollars using the Producer Price Index for medical care services (7). In addition to site-specific spending, I calculated annual medical expenditure per enrollee by combining the inpatient and outpatient spending mentioned above for each enrollee. Enrollees without a positive value for a given expenditure measure were coded as having no spending for the corresponding component for that year[15].

Other Variables

To adjust for observed and unobserved differences in patient mix between ACOs with high and low level of integration, I used differential distance as an instrument of receiving care from a high-integrated ACO. The instrument variable (IV) was defined as the difference in miles between the distances from the centroid of a patient's home zip code to the nearest PCP practice affiliated with a high-integrated ACO to the nearest practice of a low-integrated entity, based on geocoded practice address. The rationale behind this strategy is that the proximity of an individual's residence to a physician practice is, in general, an important determinant of their selection of a PCP. In addition, this study accounted for patient-level heterogeneity by including measures of age, sex, and

[15] Only 4% of the sample had non-zero inpatient spending and roughly 16% of the sample had no outpatient spending, collectively leading to 15% of the sample had annual spending of $0.

overall health status. For health status, I created a health risk score using HHS-Hierarchical Condition Categories (HHS-HCC) Risk Adjustment Modeling Software (version 3.0), a federally certified risk adjustment methodology for the ACA Marketplaces (127).

As has been noted previously, validity of IV, especially that based on area-level indicators, may be compromised by other sources of confounding (54). First, integration level may be related to unobservable organizational characteristics that influence both ACO's integration decision and patient outcomes. For instance, hospitals with higher quality may adopt structures and practices including better physician-hospital integration. To address the potential endogeneity, I included a composite quality measure for each ACO, combining a set of variables of process quality and patient-reported experience obtained from the CHIA[16] (11) (Table B1) along with indicators of for-profit status and IDS membership. The second source of confounding results from the correlation of IV to outcomes under study through an unadjusted third variable—an "instrument-outcome confounder," leading to biased estimates of treatment effect (14). Given this study used an IV defined at the zip-code level, there is a potential of area-based confounding, such as provider availability and socioeconomic status (SES). To account for the potential confounding, I included zip-code level

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[16] The process quality domain included 13 Healthcare Effectiveness Data and Information Set (HEDIS) measures of the process of care rendered to adult patients. The patient experience domain included six measures from the Patient Experience Survey (PES) for adult primary care. Both sets of measures were rated on a scale from 0 to 100, with 100 as the best quality or the most favorable response.

measures of income (average per capita income), poverty (proportion of individuals living below the Federal Poverty Line), and educational attainment (percent of population 25 years and over with high school diploma and those with college degree) from the 5-years ACS (2009-2013) and county indicators. Zip codes were divided into tertiles based on income and poverty.

Statistical Models

To describe the estimation model of the effect of physician-hospital integration on health care spending and utilization, I first introduce a standard naive model without instrumental variables:

$$G\left(Y_{ijt}\right) = \beta_0 + \beta_1 High + \beta_2 X_i + \beta_3 C_j + \beta_4 Yr_t + \beta_5 Z + \varepsilon_{ijt} \qquad (1)$$

where *i* indexes the individual enrollees, j indexes the county, and *t* indexes year. Equation (1) represents a generalized linear model (GLM), in which G is a function linking the outcomes (Y_{ijt})—measures of expenditure and utilization—to its natural logarithm. GLM was selected for two reasons. First, outcomes of interest are either nonlinear (utilization measures) or highly right-skewed and kurtotic (aggregate medical spending). In this case, logarithmic transformation is commonly applied to make the outcome distribution more symmetric and approximate normality. Figure C2 shows that log-transformed spending variables demonstrate the features of a normal distribution except for the existence of excess zeros representing individuals used no health services. Secondly, GLM avoids bias introduced during retransformation of results from the log scale to the original scale by directly estimating the average value of outcome conditional on covariates. In particular, I accommodated spending and utilization outcomes using different combinations of link and distribution functions. A GLM with Gamma distribution/log link and Poisson distribution/log link was used to estimate the impact of integration on annual medical spending and utilization, respectively. The independent variable of interest is *High*, which is a dummy variable indicating patient's receiving care from a high-integrated ACO. The GLMs adjusted for a set of patient demographic and clinical characteristics (X_i), including age, sex, the interaction between age and sex, health risk score, and disease burden[17], county fixed effects (C_j), and year fixed effects (Yr_t). Finally, Z represents a vector including measures of ACO features (quality, for-profit status, and IDS membership) and area-level SES to further control for potential confounders. I estimated standard errors robust to heteroscedasticity using the Huber-White estimator of variance clustered at the ACO level (63, 130).

Because patient's receipt of care from a high-integrated ACO may not be random but also associated with unobservable characteristics, I estimated Equation (1) using an IV approach. The IV approach estimates a pair of simultaneous equations: treatment equation and outcome equation. The treatment equation models the likelihood of receiving care from a high-integrated ACO relative to that from a low-integrated provider; the outcome equation estimates the relationship between an outcome measure (annual healthcare

[17] Disease burden was defined by counts of non-zero hierarchical condition categories captured by the HHS-HCC risk adjustment model.

spending and utilization of individual enrollees) and receipt of care from a high-integrated ACO and other control variables. Because both equations are nonlinear models, I used the two-stage residual inclusion (2SRI) technique (125, 126) to estimate IV specifications. 2SRI is an extension to nonlinear regression contexts of the commonly adopted two-stage least square (2SLS) for linear IV estimations. The 2SRI estimator is similar to the 2SLS estimator except that in the second stage regression, the endogenous variables are not replaced by the first-stage predictors. 2SRI was selected over 2SLS because it is not only applicable to nonlinear models but allows for direct testing the presence of endogeneity. Applying 2SRI, I regressed *High* on *Proximity* and all other covariates from Equation (1) in the first-stage logistic regression and calculated residuals on the raw scale (*Resid*) based on Equation (2).

$$Pr(High_i = 1) = \beta_0 + \beta_1 Proximity + \beta_2 X_i + \beta_3 C_j + \beta_4 Yr_t + \beta_5 Z + \varepsilon_{ijt} \quad (2)$$

In the second stage, I estimated Equation (1) fitting a GLM with outcome-specific distribution and link functions and including the first-stage residuals as an additional regressor, following Equation (3).

$$G\left(Y_{ijt}\right) = \beta_0 + \beta_1 High + \beta_2 X_i + \beta_3 C_j + \beta_4 Yr_t + \beta_5 Z + \beta_6 Resid + \varepsilon_{ijt} \quad (3)$$

Our interest lies in the coefficient on *High*, β_1, which measures the impact of receiving care from high-integrated ACOs. The exponentiated value of β_1 represents the local average treatment effect (LATE) of physician-hospital integration on outcomes studied. I obtained standard errors for the estimates from the outcome equation using bootstrapping with 1000 replications.

To test the robustness of findings to model specification, I conducted a series of sensitivity analyses. First, the distributions of annual per-enrollee expenditure and utilization are substantially skewed with a large mass at zero. Although the GLM, in general, accommodate skewness well, it does not explicitly address the issue of excess zeros. Moreover, it is reasonable to expect heterogeneous treatment effects between individuals who used and those who did not use health services. Distinguishing users from non-users is particularly crucial to analyses of inpatient care as the overwhelming majority of enrollees did not use any inpatient services and had zero spending in a given year (roughly 96% of the sample). Therefore, I performed separate estimations of Equation (3) to explicitly evaluate the impact of integration on use of health services and level of utilization. Estimates from the dual assessments were reported separately. Specifically, I first modeled the propensity that an enrollee consumed any health services with a logit model using the full sample. Then, I estimated the level of utilization and spending with a GLM on the subset of people with non-zero outcomes. This approach has been used in several empirical work of health services research in recent years (33, 48, 72). Second, given that utilization outcomes are count variables, I re-estimated the GLMs using a negative binomial distribution function to address over-dispersion that possibly presented in utilization measures of outpatient services (Figure C3). Though Poisson and negative binomial models naturally accommodate zero counts, it is not clear whether findings are sensitive to excess zeros, particularly inpatient care utilization. I, therefore, repeated analyses of utilization using zero-inflated Poisson and zero-inflated negative binomial models as they are also frequently used in studies examining counts of health service use (30, 43, 99). Third, distributions of both spending and utilization were highly right-skewed, suggesting a very small fraction of study sample consumed a considerable amount of health services. It was not clear whether observations with extreme values were outliers in any real sense. To avoid over-fitting extreme observations, I top-coded annual overall (outpatient) spending at $50,000 and inpatient spending at $150,000[18]. I applied a similar procedure to utilization outcomes using a threshold to top-code the top 0.1 percent of the sample. Annual visits to an outpatient facility, doctor's office, and HOPD were top-coded at 80, 70, and 30, respectively. Statistical analysis was done using Stata (version 14.2).

Results

The initial cohort included 915,835 HMO/POS enrollees receiving care from the 15 commercial ACOs with at least one year of continuous enrollment from 2009 through 2013. After exclusions (Figure C1), the final sample comprised 1,100,112 person-year observations from 516,413 individuals aged 18 to 64 who resided in the Commonwealth. Table 4.1 describes characteristics of the study sample. The mean age was 40.8 years; women comprised 52.9% of

[18] The maximum values of annual overall, inpatient, and outpatient spending were $924,527, $924,335, and $417,215, respectively. Top-coding led to a drop of 5,300, 465, and 594 observations for analyses of overall, inpatient, and outpatient spending, respectively.

the sample; the median health risk score was 1.7. Around 86% of the sample had no chronic conditions identified by the HHS-HCC risk adjustment software while enrollees with one and two or more conditions accounted for 11% and 3% of the sample, respectively. This privately insured population generally resided in relatively affluent neighborhoods (zip codes). The average poverty rate was 9%, per-capita income was $38,711, and more than 40% of residents have a college degree. The average medical spending was $2,975 per enrollee per year, including inpatient spending of $998 and outpatient spending of $2,035. Among the outpatient expenditures, the share of spending between office-based and HOPD visits was roughly equal. For inpatient care utilization, the average hospital admission rate was 47.4 per 1,000 person-year and admissions for ACSCs was 53.6 per 10,000 person-year. For outpatient services, the mean number of outpatient visits was 7.3 per person-year, with a significant proportion of visits occurring in office settings (6.1 office visits vs. 1.2 HOPD visits).

Table 4.1: Summary of study sample

	Total
Member characteristics	
No. of enrollees	516,413
Age, mean (SD)	40.8 (12.9)
Female	52.9%
Health risk score[1], mean (SD)	1.7 (4.2)
No of chronic conditions[1]	
0	86.1%
1	11.4%
2+	2.5%
Area socioeconomic characteristics[2]	
Below federal poverty level	9.3%

Average per capita income ($), mean (SD)	38,711 (13,220)
Residents with high school diploma	90.9%
Residents with college degree	42.5%
ACO quality measure[3], mean (SD)	85.4 (0.9)
Outcomes	
No. of observations (person-year, p-y)	1,100,112
Expenditure[4]	
Overall ($), mean (SD)	2,975 (9,794)
Acute inpatient care ($), mean (SD)	940 (7,770)
Outpatient care ($), mean (SD)	2,035 (4,461)
Office	1,037 (2,218)
HOPD	998 (3,488)
Utilization	
Acute inpatient care	
No. of hospitalizations per 1,000 p-y	47.4
No. of ACSC hospitalizations per 10,000 p-y	53.6
Outpatient care	
No. of outpatient visits per p-y	7.3
No. of office visits per p-y	6.1
No. of HOPD visits per p-y	1.2

Abbreviation: SD, standard deviation; ACSC, ambulatory care-sensitive condition; HOPD, Hospital Outpatient Department.
Notes:
1. Based on HHS-HCC risk adjustment model.
2. Based on zip-code level measures.
3. Based in selected HEDIS measures and patient-reported experiences.
4. Annual per-enrollee spending in 2013 dollar.

The first two columns of Table 4.2 compare demographic and clinical characteristics for patients served by low-integrated ACOs, compared with high-integrated ACO patients. Individuals who received care from a high-integrated ACO were slightly older (41.7 vs. 40.1 years), more likely to be female (53.9% vs. 52.3%), and slightly sicker (mean health risk score: 1.9 vs. 1.6; had one or more chronic conditions: 15.4% vs. 12.8%). They also encountered higher medical spending and used more outpatient but fewer inpatient services, compared to low-integrated ACO serving patients. To address the selection bias and other unobserved factors that influence patients' chance of receiving care from a high-integrated ACO, this study adopted an IV approach using differential distance as an instrument. Table 4.3 summarizes the differential distance used in IV estimations. Among patients served by low-integrated ACOs, the mean differential distance was negative (-2.44, interquartile range [IQR], -3.53 to 0.00), indicating the higher prevalence of PCP affiliation to a low-integrated ACO. The corresponding statistics for high-integrated ACO serving patients was 0.83 (IQR, -0.31 to 0.85), suggesting proximity to PCPs affiliated with a high-integrated ACO.

Differential distance is a valid instrument if it is strongly correlated with patients' receiving care from a high-integrated ACO and uncorrelated with the error term in Equation (1). To test the first prerequisite of correlation with receipt of care from high-integrated ACOs, I followed the commonly used criterion proposed by Staiger and Stock (123) of F-statistic exceeding the threshold of 10. The first-stage of estimates in Table 4.4 shows the coefficient on differential distance was 0.196 (95% confidence interval [CI], 0.193 to 0.199), and the F statistic of 17063 (data not shown) far exceeds the standard threshold. Moreover, the c-statistic for the first-stage logistic regression is 0.898 (95% CI, 0.897 to 0.899; data not shown), indicating that attribution to a high-integrated ACO was strongly predicted by the differential distance along with other covariates. The second assumption of no correlation with the error term is not directly testable. However, it is feasible to examine if the IV is uncorrelated with observed patient characteristics, suggesting that the study sample is randomized by differential distance. To test so, I divided the study sample into two groups by the median of differential distance and examined patient characteristics for those with a differential distance above and below the median. These results are displayed in the last two columns of Table 4.2. Compared to the first two columns, patient demographic factors and general health status are more similar in the last two columns; there is no the difference in proportion of enrollees with chronic conditions between two groups, suggesting that the two groups become closely balanced when categorizing patients by the IV. The significant differences between two groups by zip-level SES measures indicate the existence of instrument-outcome confounding. Enrollees who lived in areas with social advantage tended to have a shorter differential distance to PCPs affiliated with a high-integrated ACO, compared to their counterparts. To control for the confounder, I included these SES factors in the IV estimations.

Table 4.2: Patient characteristics by ACO and by differential distance between nearest PCP of a low-integrated ACO and nearest PCP of a high-integrated ACO

Sample characteristics	Low-integrated ACO (n = 303,490)	High-integrated ACO[5] (n = 217,476)	IV < median (n = 258,140)	IV >= median[5] (n = 258,273)
Age, mean (SD)	40.1 (13.0)	41.7 (12.6) **	41.0 (13.0)	40.6 (12.8)
Female	52.3%	53.9% **	52.8%	53.0%
Health risk score[1], mean (SD)	1.6 (4.0)	1.9 (4.5) **	1.7 (4.2)	1.7 (4.2)
No of chronic conditions[1]				
0	87.2%	84.6% **	86.2%	86.1%
1	10.6%	12.5%	11.3%	11.4%
2+	2.2%	2.9%	2.5%	2.5%
Area socioeconomic characteristics[2]				
Below federal poverty level	9.2%	9.4% **	8.7%	9.8% **
Average per capita income ($), mean (SD)	37,099 (11,952)	40,991 (14,529) **	37,033 (11,870)	40,388 (14,249) **
Residents with high school diploma	90.3%	91.6% **	90.4%	91.4% **
Residents with college degree	39.4%	46.8% **	39.0%	45.9% **
ACO quality measure[3], mean (SD)	85.5 (0.8)	85.2 (0.9) **	85.4 (0.8)	85.4 (0.9)
Outcomes				
No. of observations (person-year, p-y)	734,506	365,606	594,091	506,021
Expenditure[4]				
Overall ($), mean (SD)	2,857 (9,575)	3,212 (10,215) **	2,940 (9,779)	3,016 (9,811) **
Acute inpatient care ($), mean (SD)	927 (7,628)	966 (8,048)	949 (7,812)	930 (7,720)
Outpatient care ($), mean (SD)	1,930 (4,298)	2,246 (4,765) **	1,991 (4,390)	2,086 (4,542) **
Office	1,074 (2,227)	962 (2,198) **	1,050 (2,182)	1,022 (2,259) **
HOPD	855 (3,263)	1,284 (3,885) **	941 (3,406)	1,064 (3,580) **

Utilization				
Acute inpatient care				
No. of hospitalizations per 1,000 p-y	48.2	45.6 **	48.8	45.6 **
No. of ACSC hospitalizations per 10,000 p-y	56.7	47.3 **	61.1	44.7 **
Outpatient care				
No. of outpatient visits per p-y	7.3	7.4 **	7.4	7.2 **
No. of office visits per p-y	6.3	5.7 **	6.3	5.9 **
No. of HOPD visits per p-y	1.0	1.7 **	1.1	1.3 **

Abbreviation: SD, standard deviation; ACSC, ambulatory care-sensitive condition; HOPD, Hospital Outpatient Department.

Notes:

1. Based on HHS-HCC risk adjustment model.
2. Based on zip-code level measures.
3. Based in selected HEDIS measures and patient-reported experiences.
4. Annual per-enrollee spending in 2013 dollar.
5. ** indicates statistically significant differences between two groups (low-integrated ACO vs. high-integrated ACO; IV<median vs. IV>=median) at the 5% level.

Table 4.3: Summary of differential distance between closest low-integrated ACO PCP and closest high-integrated ACO PCP for each patient

	Low-integrated ACO patients	High-integrated ACO patients
n	734,506	365,606
IQR	(-3.53, 0)	(-0.31, 0.85)
Mean	-2.44	0.83
SD	4.42	3.54

Abbreviations: IQR, inter-quartile range; SD, standard deviation

Table 4.4: First-stage logistic: receiving care from a high-integrated ACO compared with low-integrated ACO (n = 1,092,967)

Explanatory variables[1]	Coefficient	p < |t|	95% CI	
Instrument				
Differential distance	0.196	<0.001	0.193	0.199
Demographic characteristics				
Age (ref=18-39)				
40-49	0.130	<0.001	0.110	0.149
50-59	0.131	<0.001	0.111	0.150
60-64	0.119	<0.001	0.088	0.149
Female	0.135	<0.001	0.118	0.153
Age*Female				
40-49	0.016	0.223	-0.010	0.043
50-59	0.033	0.015	0.006	0.060
60-64	0.080	<0.001	0.038	0.122
Health risk score[2]	0.000	0.756	-0.001	0.002
No of chronic conditions[2] (ref=none)				
1	0.085	<0.001	0.068	0.102
2+	0.167	<0.001	0.127	0.208
Area socioeconomic characteristics				
Income (ref=low)				
Medium	0.077	<0.001	0.055	0.099
High	0.232	<0.001	0.203	0.261
Poverty (ref=low)				
Medium	0.027	<0.001	0.012	0.041
High	0.108	<0.001	0.088	0.128
% resident with high school diploma	-0.028	<0.001	-0.030	-0.026
% resident with college degree	0.023	<0.001	0.022	0.024

ACO characteristics				
Quality measure[3]	-0.709	<0.001	-0.718	-0.701
IDS	-0.077	<0.001	-0.090	-0.064
For-profit status	1.452	<0.001	1.436	1.468

Abbreviations: IDS, integrated delivery system; CI, Confident Interval.
Notes:
1. Year fixed effects and county fixed effects were included but not shown.
2. Based on HHS-HCC risk score.
3. Based in selected HEDIS measures and patient-reported experiences.

Table 4.5 presents estimates of the effect of physician-hospital integration on individual outcomes. The coefficient on *High*, β1 in Equation (3), is positive and highly significant for annual total spending (sum of inpatient and outpatient expenditures), suggesting members served by high-integrated ACOs, on average, spent more in a given year. The adjusted per-enrollee spending was around 7% (p<0.001) higher in high-integrated ACOs, compared to their low-integrated counterparts. The difference is equivalent to an increase of $205 per person-year in expenditures on services delivered in inpatient and outpatient settings on a base of $2,975[19]. The higher total spending was mainly driven by outpatient expenditures. High-integrated ACO serving members had nearly 9% (p<0.001) higher expenditures on ambulatory care, constituting an increase of $181 per-person over a year. Mean annual spending on acute inpatient care was similar between two groups. I further explored the mechanisms by which ACOs with financial integration between physicians and hospitals have had higher spending by examining utilization of relevant health services. In high-integrated ACOs, though the observed lower inpatient spending was insignificant, adjusted

[19] Estimated effects of physician-hospital integration on individual outcomes were computed by multiplying the sample means by corresponding LATE reported in Table 4.5.

hospital admission rates were 20.4% lower (p=0.010), equivalent to an annual reduction of approximately ten hospitalizations per 1000 people. The commensurate inpatient spending and lower hospitalization rates collectively imply that either inpatient services are generally more expensive or use of costly procedures during hospitalizations is more common in high-integrated entities. Moreover, the comparable hospital admission rates for ACSCs between the two ACO groups suggest that the reduced inpatient care utilization was likely not driven by enhanced outpatient care. For ambulatory care use, high-integrated ACOs serving enrollees experienced a reduction of 6.1% (p<0.001) in outpatient visits, equal to a decrease of almost half a visit per person-year, which is inconsistent with the observed increase in outpatient spending. To investigate the seemingly contradictory findings, I disaggregated outpatient utilization into office-based visits and HOPD visits and stratified analyses of spending in and use of outpatient care by setting.

Table 4.5: Effects of physician-hospital integration on healthcare expenditures and utilization, overall and by service type

Outcomes	LATE[1]	p > |z|	95% Confident Interval	
Expenditure				
Overall	6.9%	<0.001	3.1%	10.8%
Inpatient	-13.1%	0.117	-27.1%	3.6%
Outpatient	8.9%	<0.001	5.7%	12.1%
Utilization				
Hospitalization	-20.4%	0.010	-33.0%	-5.4%
ACSC hospitalization	3.7%	0.810	-23.1%	39.9%
Outpatient visits	-6.1%	<0.001	-7.8%	-4.3%

Abbreviations: LATE, Local Average Treatment Effect; ACSC, ambulatory care-sensitive condition.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].

Estimates from the stratified analyses indicate that enrollees served by high-integrated ACOs had 16.7% (p<0.001) fewer visits to doctor's office, roughly a decrease of one visit for an average enrollee in a given year (Table 4.6). The effects of integration on associated spending were proportionately similar to that on utilization—17.7% (p<0.001) lower annual expenditures on office-based visits. In contrast, higher integration was associated with a higher level of outpatient utilization and expenditures in HOPDs. Annual counts of HOPD visits and associated spending per enrollee were 59.8% (p<0.001) and 51.8% (p<0.001) higher, respectively, in high-integrated ACOs. Although high-integrated ACO serving enrollees consumed fewer outpatient services overall (combining office-based and HOPD encounters), they had outpatient visits to an HOPD much more commonly. Considering that HOPD visits, in general, are more expensive than office-based encounters, findings above collectively suggest that the observed higher expenditures on outpatient care among high-integrated ACO patients was driven mainly by extensive use of outpatient care rendered in an HOPD. In other words, potential saving from the reduced use of outpatient services was offset by the higher share of visits occurring in higher-priced hospital-based clinics.

Table 4.6: Effects of physician-hospital integration on outpatient spending and utilization by care setting

Outcomes	LATE[1]	p > |z|	95% Confident Interval	
Expenditure				
Office	-17.7%	<0.001	-20.0%	-15.3%
HOPD	51.8%	<0.001	44.1%	59.9%
Utilization				
Office	-16.7%	<0.001	-18.4%	-15.0%
HOPD	59.8%	<0.001	54.7%	65.1%

Abbreviations: LATE, Local Average Treatment Effect; HOPD, Hospital Outpatient Department.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].

To examine whether the findings are sensitive to model specification, I repeated the primary analyses using models separately estimating non-zero spending and spending level, functional forms addressing over-dispersion and excess zeros, and top-coded outcomes. Estimations modeling zero and positive expenditures separately (Table C1) shows that vertical integration was associated with lower odds of having any spending (overall and both inpatient and outpatient components). However, among those with positive spending, high integration was associated with a higher level of spending overall and in outpatient care. The opposite effects of high integration on the odds of consuming any outpatient services and level of consumption may jointly lead to the higher outpatient spending found in the primary analyses. High-integrated ACO serving enrollees were less likely to use outpatient care delivered in office settings, although average spending among those who had office visits was similar between the two groups. Both the propensity of using hospital-based outpatient care and per-person expenditures on HOPD visits among users were higher for the cohort served by high-integrated providers. While I found a few minor changes in statistical significance with the models using alternative functional forms (Table C2) and top-coded outcomes (Table C3), in all cases, the results remained qualitatively similar.

Discussion

Using 15 provider organizations that signed up an ACO-like contract with a private payer in Massachusetts during 2009 and 2013, the association between higher physician-hospital integration and ACO efficiency varied with the outcome measure. The adjusted total annual per-person expenditure, calculated by summing expenditures in hospitalizations and outpatient visits, was higher in ACOs with higher financial integration between physicians and hospitals. However, integration was associated with a reduction in utilization of both inpatient and outpatient services. These findings were based on an IV statistical model adjusting for patient characteristics and provider quality of care and adopting differential distance as a source of quasi-randomization. The observed relationship of integration with increased spending and decreased utilization echoes the growing concern that vertical integration may, in fact, increase health expenditures through higher prices even in the context of ACOs.

Adjusted annual spending was higher for individuals receiving care from high-integrated ACOs, consistent with previous research of physician-hospital consolidation (82, 84, 105). Theoretically, integration between physicians and hospitals could realize efficiencies by better care coordination and management across settings and more effective control of inputs of care. However, findings from this study and other recent researches have suggested an association of vertical integration with higher medical expenditures among commercially insured or Medicare populations. The prevailing payment system that rewards volume over value may explain why integration was not associated with improvement in efficiency. Under FFS payments, instead of reducing utilization of health services, provider consolidation was found to prompt provision of profitable services and, as a result, increase in health care expenditures (25, 44, 104). However, under alternative payment models that disincentivize volume-driven practice, a positive correlation between vertical integration and spending was observed in both Medicare ACOs in prior research (82, 84) and commercial ACOs in this study. It suggests that payment methods did not wholly explain the lack of evidence of improved efficiency from physician-hospital integration. To further investigate the mechanisms leading to high expenditures of integrated providers, this study further estimates the effects of physician-hospital integration on use of and spending on health care by type of service.

Assessment limited to spending and utilization of acute hospital care found that integration had no impact on spending in inpatient settings but lowered hospitalization rates, adding information to existing knowledge. Recent studies examining the effects of physician-hospital integration on inpatient care found that consolidation had either no or relatively small impact on utilization among individuals with private coverage (20, 90). This study also used a privately insured sample but identified a sizable decrease in the frequency of hospital admissions among enrollees served by high-integrated ACOs. The difference between this and early studies is likely due to the ACO contract that financially incentivizes providers to limit the use of excess services. However, there was no evidence suggesting that the reduced needs for acute care were the result of better management and coordination of ambulatory care, consistent with findings from Medicare ACOs (83, 84). Regarding spending, previous studies have consistently documented an association of hospital ownership of physician practices with higher expenditures on hospital inpatient care (20, 41, 59, 77). Some of them also observed higher hospital prices associated with vertical integration (20, 41), implying the increase in inpatient spending was possibly driven by elevated prices instead of increased utilization. Consistent with prior research, this study found a considerable reduction in the use of hospital inpatient care with no change in corresponding expenditures, suggesting the existence of a non-negligible increase in price that could have potentially offset the impact of reduced utilization on spending.

For ambulatory care measured by office or HOPD visits, physician-hospital integration was correlated with a higher outpatient expenditure which was almost entirely due to visits to more-costly HOPDs. In contrast to a positive correlation with spending, integration was associated with a reduction in the frequency of outpatient visits in general. The observed associations of integration with increased spending and reduced utilization collectively implied a sizable increase in prices, consistent with findings of prior studies assessing the impact of physician consolidation on commercial prices of outpatient services (21, 107). Most previous studies of physician-hospital integration either examined total medical expenditures or mainly focused on spending and utilization in inpatient settings. To date, only one study explicitly investigated the impact of financial integration between physicians and hospitals on health care delivery in outpatient settings (90). The study concluded that vertical integration was associated with higher prices and spending for outpatient care but did not find a similar correlation between integration and utilization. The authors argued that efficiency gains from the reduced use of health services may only manifest under alternative payment models which rewards value over volume. However, other researchers have argued that reductions in health care spending and utilization achieved by alternative payment models that implicitly encourage integration could be offset by higher prices resulting from such consolidation (19, 105). This study provides empirical evidence supporting the assumptions mentioned above—under an ACO contract, organizations with financial integration between physicians and hospitals were able to achieve efficiency gain in outpatient care delivery by reducing utilization; however such improvement was significantly weakened, if not entirely offset, by the higher price of services rendered in HOPDs.

This study has several limitations. First, there might be unmeasured variables that are correlated with PCP designation and outcomes, which lead to inconsistent IV estimates of the actual integration effects. To control for the potential confounders, I included several controls for provider quality and organizational characteristics along with regional SES and variations in provider availability and practice patterns. It is true that the included variables could not explicitly control for all potential confounders. However, for an omitted factor to bias the estimates, it must be highly correlated with the IV and uncorrelated with important ACO attributes, area-level sociodemographic factors, and regional variations in provider practice and availability. Second, enrollee-level annual expenditures were calculated by summing spending on individual services defined by DRG and CPT codes for inpatient and outpatient care, respectively. For services delivered in hospital-based clinics, the additional facility fees billed with an HOPD setting code may be a bundled payment for multiple related services with a distinct CPT code or sometimes without a CPT code. Matching corresponding facility fees with physician claims by CPT codes would therefore underestimate spending on services rendered in HOPDs. However, the measurement error tends to bias the estimated effects of physician-hospital integration on spending downward. Third, identification of integration effects was based on cross-sectional differences across ACOs—examining variations in efficiency among provider organizations after entering the ACO contract. If level of integration changed as a result of ACO contracts, the estimated effects of integration may be biased by not capturing the pre-post change. Nevertheless, previous study found little evidence that provider consolidation was associated with participation in ACOs (92). Also, for each ACO, year-specific measures of integration indicate negligible changes over time. Fourth, the differential distance is based on the zip code of patient’s residence because the street address is not available. The measure is less accurate because zip codes are large and may contain many PCPs but everyone who lives in the same zip code was assigned a common value regardless. However, it is not clear whether the inaccuracy introduces any systematic bias regarding proximity to high-integrated providers. Finally, the study sample only contains insured individuals with coverage from a commercial carrier. They are comprised of a largely employed population and live in Massachusetts. Lack of heterogeneity limits the capability of this study to generalize findings to other states and populations with public coverage or private coverage from different carriers.

In summary, financial integration between physicians and hospitals is correlated with a decline in utilization and an increase in expenditures which is almost entirely driven by higher spending on ambulatory care. Collectively, these findings suggest that the higher expenditures associated with physician-hospital integration may result from higher prices of outpatient services, specifically HOPD visits. Despite the increased expenditures, this study does not preclude the possibility that vertical integration might have improved ACO efficiency by avoiding unnecessary services. Though ACO contracts with downside risk have the potential of bending the cost curve by controlling utilization, such reimbursement models address only the first half of the spending equation. Given that spending is the product of price and quality, effects of reduced utilization could be offset by that of elevated prices. In addition to regulations explicitly managing the setting-related price differentials, bundled payments that cover all services delivered by providers across settings for an episode of care may be a more feasible strategy for achieving efficiency gains from better care coordination.

CHAPTER 5: CONCLUSION

Now that eight years have passed since the ACA was signed into law, the U.S. health care system is still exploring a better way to effectively allocate scarce health resources across the spectrum of provider types. While ACO is a seemingly promising concept, it is also highly complex, involving numerous variables that would be likely to influence its formation, implementation, and performance. In addition to whether ACO works, how it works, and under what conditions it achieves desired goals are more important questions that should be answered by studies evaluating ACOs. However, such focuses are often absent from the literature probably due to the complexity in operational strategies and local contexts. Without proper recognition of the intricacy, reliance on models linking a specific variable to outcome measures risks creating the impression that the observed outcome is determined primarily by the variable of interest. This dissertation addresses this issue by adopting an IV approach and analyzing a set of commercial ACOs that are relatively homogeneous concerning contract characteristics and operating environment.

A closer tie between physicians and hospitals has been postulated to better equip ACOs with improving the efficiency of healthcare delivery. This work provides convincing evidence that vertical integration between physicians and hospitals did improve ACO efficiency in inpatient care. However, when considering a broader scope of health services, its impact on efficiency is mixed. It is important to bear in mind that the positive association between integration and efficiency gains was observed only in inpatient settings among a non-elderly population served by commercial ACOs contracting with a market-dominant carrier. There may be causes beyond integration enhancing efficiency among Medicare, Medicaid, and other commercial ACOs. The consensus about dynamics between the private and public sectors and across markets suggests caution in generalizing findings from this work to ACOs operating under different conditions. A few factors limit the generalizability of this study. First, ACO contract characteristics, such as scope and requirements for participation, incentive design, and patient attribution, could play a vital role in mediating the relationship between integration and performance. For example, the AQC provides participating organizations with strong financial incentives to reduce duplication and avoid unnecessary services, which likely explains the discrepancy in findings between this work and previously published literature. Second, the context in which ACOs operate, such as local market structure, policy environment, and regulatory requirement, could influence ACO performance as well. These ACOs operate in Massachusetts where operations of healthcare organizations are heavily regulated, and growth of health care spending is closely monitored. Whether physician-hospital integration could replicate its successful experience reported here in other states warrants further investigation.

The answer to whether vertical integration between physicians and hospitals improve ACO efficiency may largely depend on efficiency measures and the unit of analysis based on which health care outputs are conceptualized. According to Palmer and Torgerson, efficiency is concerned with the relationship between resources inputs (commonly measured by costs) and either intermediate outputs (health services received by patients) or final health outcomes (lives saved or quality-adjusted life years). The second study of this dissertation explicitly examines efficiency in inpatient care delivery by estimating LOS, aggregated spending during an inpatient care episode, and the relevant health outcome (readmission). The observed shorter LOS and lower expenditures, with no change in quality of care, present direct evidence of enhanced technical and productive efficiency associated with integration. Analyses stratified by patient health status also provide suggestive evidence of improved allocative efficiency among ACOs with physician-hospital integration in place. The third study further expands the efficiency measure by incorporating outpatient care and considering overall resources consumed by an individual in a given year. The detected decrease in use of both inpatient and outpatient care implies that high-integrated ACOs achieved better quality of care, assuming that reduction in utilization of care results from improved health status. The observed lower utilization rate could be considered a sign of technical efficiency gains; however, a definite conclusion requires a deep understanding of the reasons behind the phenomenon. The higher annual per-person medical spending implies productive inefficiency among high-integrated ACOs. When interpreting results of health expenditures, it is critical to take the considerable variation in spending into account. Aggregate spending measures frequently mask individual-level dynamics that may be important for determining the propensity of incurring any spending and the amount of spending, if one did consume health services. It is possible that patients served by high-integrated ACOs were less likely to receive specific care, as suggested by lower rates of hospitalization and outpatient visits, but consumed more services during clinical encounters. Previous literature have documented that integration was associated with higher rates of use of certain procedures (55, 77, 100). Another potential explanation for the higher expenditure along with lower utilization is a higher price. Again, to draw a conclusion, further investigation into the efficiency dynamics is needed, especially when considering a variety of health care rendered over a long period of time.

Although patients are the central figure of health care, what services they need and where they receive the needed care are, in general, guided by their physicians. Independent of treatment itself and intensity, patients' spending on a clinical encounter, particularly ambulatory care visits, depends on where their doctors' practices are located. According to Medicare Payment Advisory Commission, services rendered in an HOPD-based office visit could cost 70% more than when the same services are provided in community-based settings (40). Following Medicare's payment schemes, commercial insurers reimburse services delivered in an HOPD at a higher rate as well (102). Moreover, community-based physician practices owned by hospitals can legally bill at these higher HOPD rates. The third study finds that patients served by high-integrated ACOs received a disproportionate share of ambulatory care in an HOPD. It is because their PCP practices either locate in a hospital-based setting or a hospital-owned clinic. Previous research has found that the difference in prices for outpatient visits between independent physicians and physicians integrated with hospitals were substantially more among individuals with private coverage than Medicare beneficiaries (90). The additional facility fees associated with HOPD visits could be a leading source of inefficiency if the quality of care is comparable across settings. On the other hand, high-integrated ACOs would be able to justify the higher cost of care delivered in HOPDs, if HOPDs are proven to be of better value.

This dissertation opens the door for several critical areas for further research. First, in June 2017, MassHealth announced partners with 18 healthcare organizations (most of them are also AQC participants) across the state to participate in its ACO program beginning January 2018. Roughly half of the 1.9 MassHealth members are anticipated to receive care from these Medicaid ACOs. In practice, it may be more challenging to manage and incorporate care for vulnerable populations who are either clinically at-risk or socially disadvantaged. For example, individuals with behavioral health needs may require additional clinical and cultural support, and, to achieve desired health outcomes, providers may need to invest extra resources in addressing social determinants of health. Medicaid ACOs provide a unique opportunity to assess further whether high-integrated providers demonstrate greater efficiency in managing the health of a challenging population. Second, considering that the majority of hospitalizations start with an ED visit, how integration influences the use of ED care, which itself is costly and usually leads to expensive hospital inpatient care, is another area for further exploration. Also, addressing primary-care treatable conditions in EDs is usually much more costly than delivering the same services in outpatient clinics, suggesting the suboptimal use of health resources. Therefore, it is essential to investigate the impact of integration on eliminating such inefficiency. Third, given that attribution of patients to provider organizations relies heavily on PCP designation, future research should explore the association of integration with efficiency improvement among individuals covered by Preferred Provider Organizations (PPO) plans which do not “bind” patients to a specific PCP. Previous research has suggested that patients receive better care from and have more trust in physicians they have known for a long time, compared with those they have just met (62). Whether binding patients to a specific physician is a prerequisite for integration to achieve efficiency gains deserves further investigation. Finally, policymakers and relevant stakeholders would benefit from further understanding the mechanism through which high-integrated ACOs improve efficiency in healthcare delivery. Previous literature has documented several strategies that foster care coordination and provider integration, including the use of care management processes, disease registries, trained patient educators (103), and development of better financial conditions for physicians (28). In this case, qualitative interviews with ACO executives could be more effective in soliciting information on explicit strategies adopted to achieve efficiency improvement.

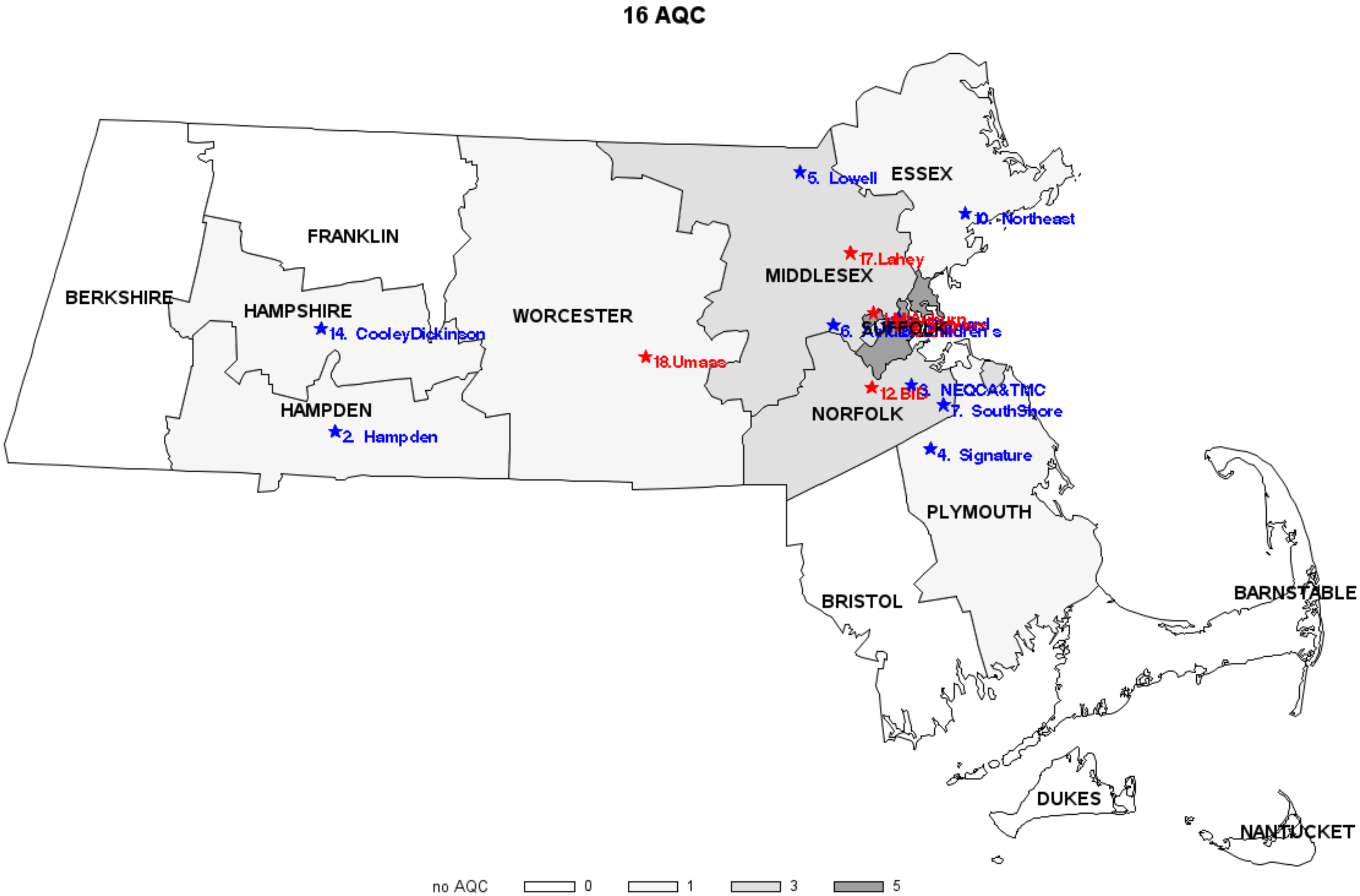
APPENDIX A: SUPPLEMENTAL MATERIALS FOR CHAPTER 2

Table A1: List of 16 provider organizations that signed up for the AQC between 2009 and 2013

AQC entity	Short name	Press release date	Cohort[a]	# of hospitals[b]
Mt. Auburn Cambridge IPA & Mt Auburn Hospital	Mt Auburn	2009-01-14	2009	1
Hampden County Physician Association	Hampden	2009-01-14	2009	0
New England Quality Care Alliance & Tufts Medical Center	NEQA & TMC	-	2009	1
Signature Healthcare Corperation	Signature	2009-03-24	2009	1
Lowell General PHO	Lowell	2009-05-11	2009	1
Atrius Health	Atrius	2009-07-20	2009	0
South Shore PHO	South Shore	-	2009	1
Steward Health Care System	Steward	2009-11-27	2010	6
Northeast Health System PHO	Northeast	2010-05-25	2010	1
Beth Israel Deaconess Care Organization	BID	2010-12-10	2011	0
Partners HealthCare	Partners	2011-10-05	2012	7
Cooley Dickinson PHO	Cooley Dickinson	2011-10-27	2012	1
Children's Hospital Integrated Care Organization	Children's	2012-01-24	2012	1
Boston Medical Center Health System	BMC	2012-03-29	2012	1
Lahey Clinic	Lahey	2012-05-14	2012	1
Umass Memorial Health Care	Umass	2013-02-27	2013	5

Abbreviations: IPA, Independent Practice Association; PHO, Physician Hospital Oranization.
Source: Press release from Blue Cross Blue Shield of Massachusetts and author's web searches.
Notes:
[a] Cohort was defined by the first year of the contract.
[b] Hospitals that involved in the AQC.

Figure A1: Location of 16 provider organizations that signed up for the AQC between 2009 and 2013



High/low-integrated entities are shown in red/blue.

Figure A2: Identification of AQC physicians & enrollees

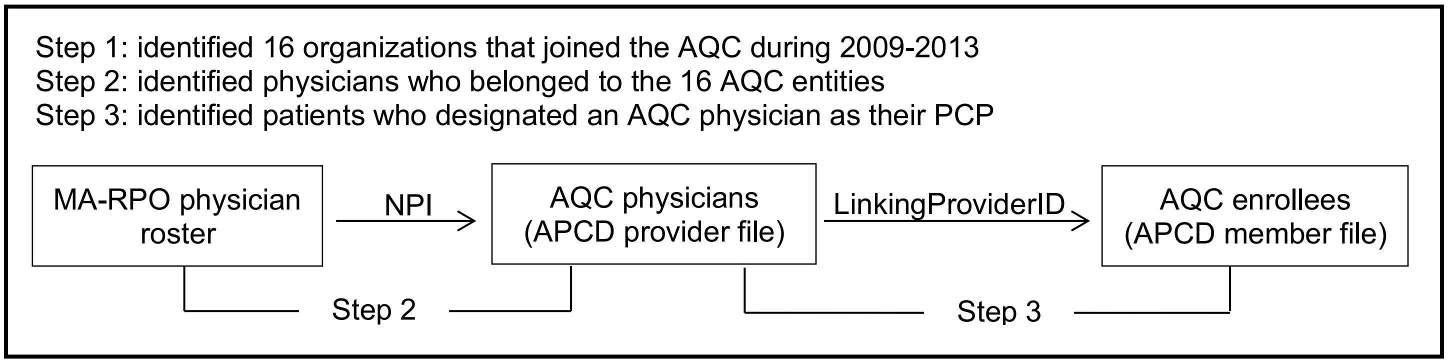


Figure A3: Identification of study sample

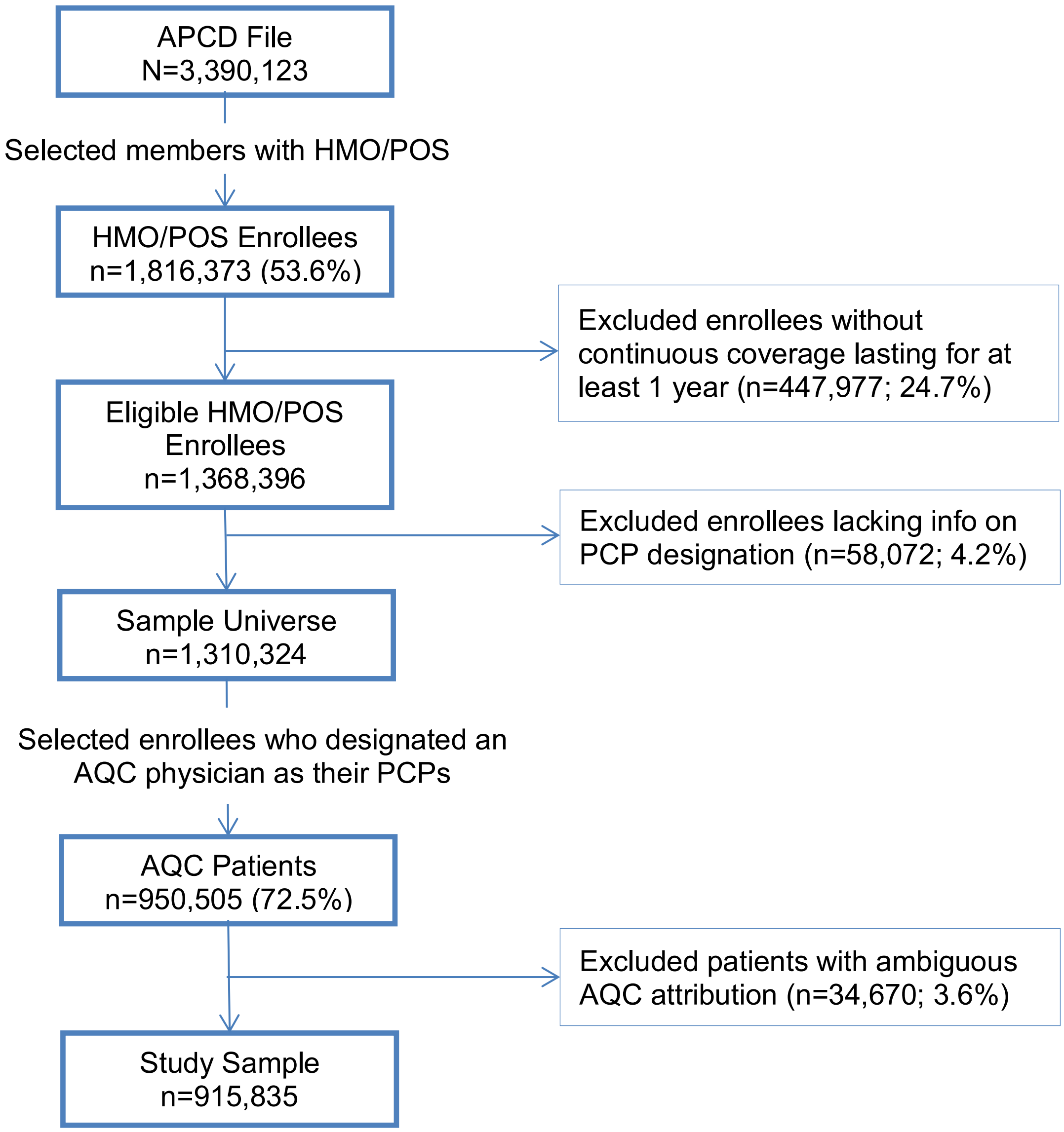
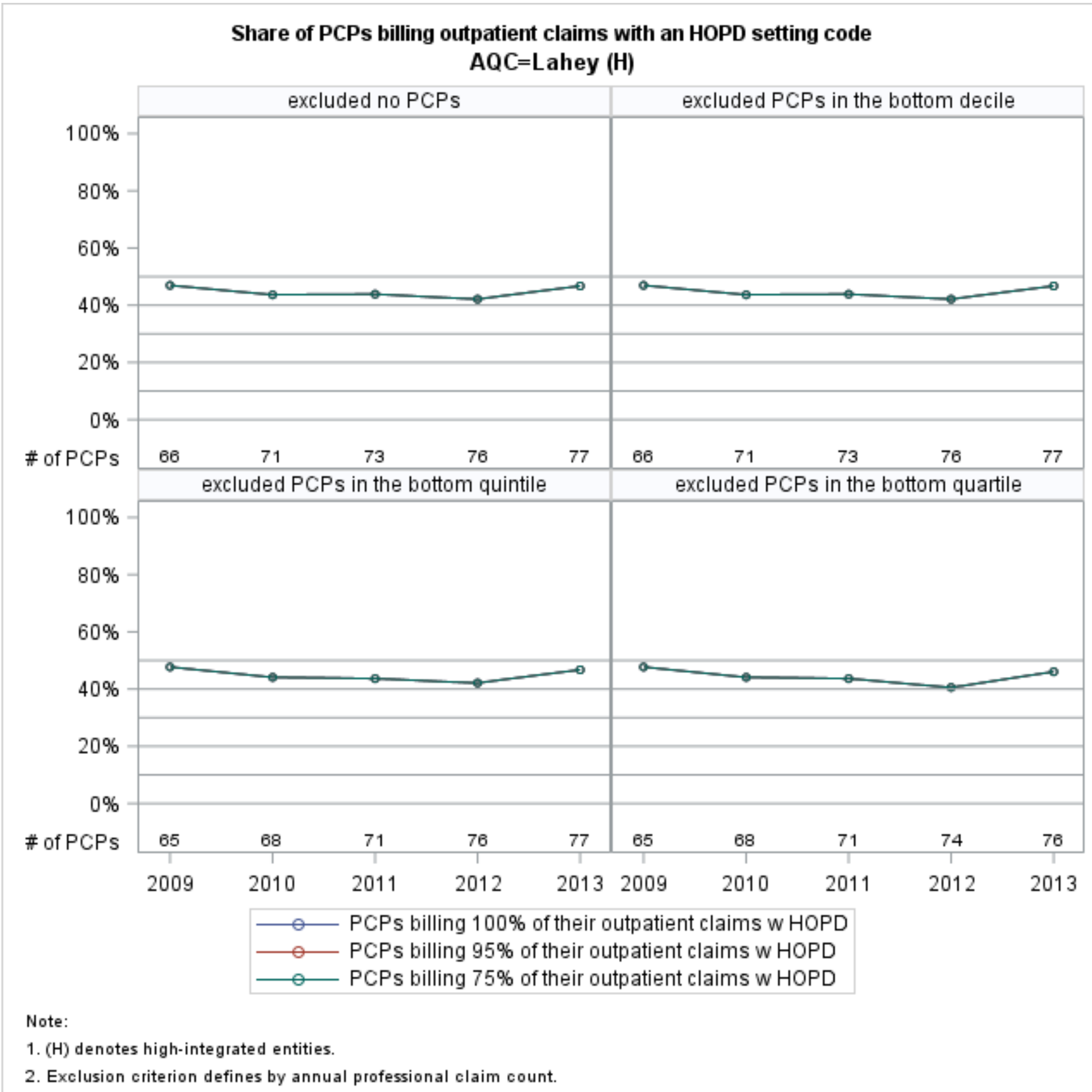


Figure A4: Change in physician-hospital integration during 2009 and 2013

A) Example of high-integrated entity



B) Example of low-integrated entity

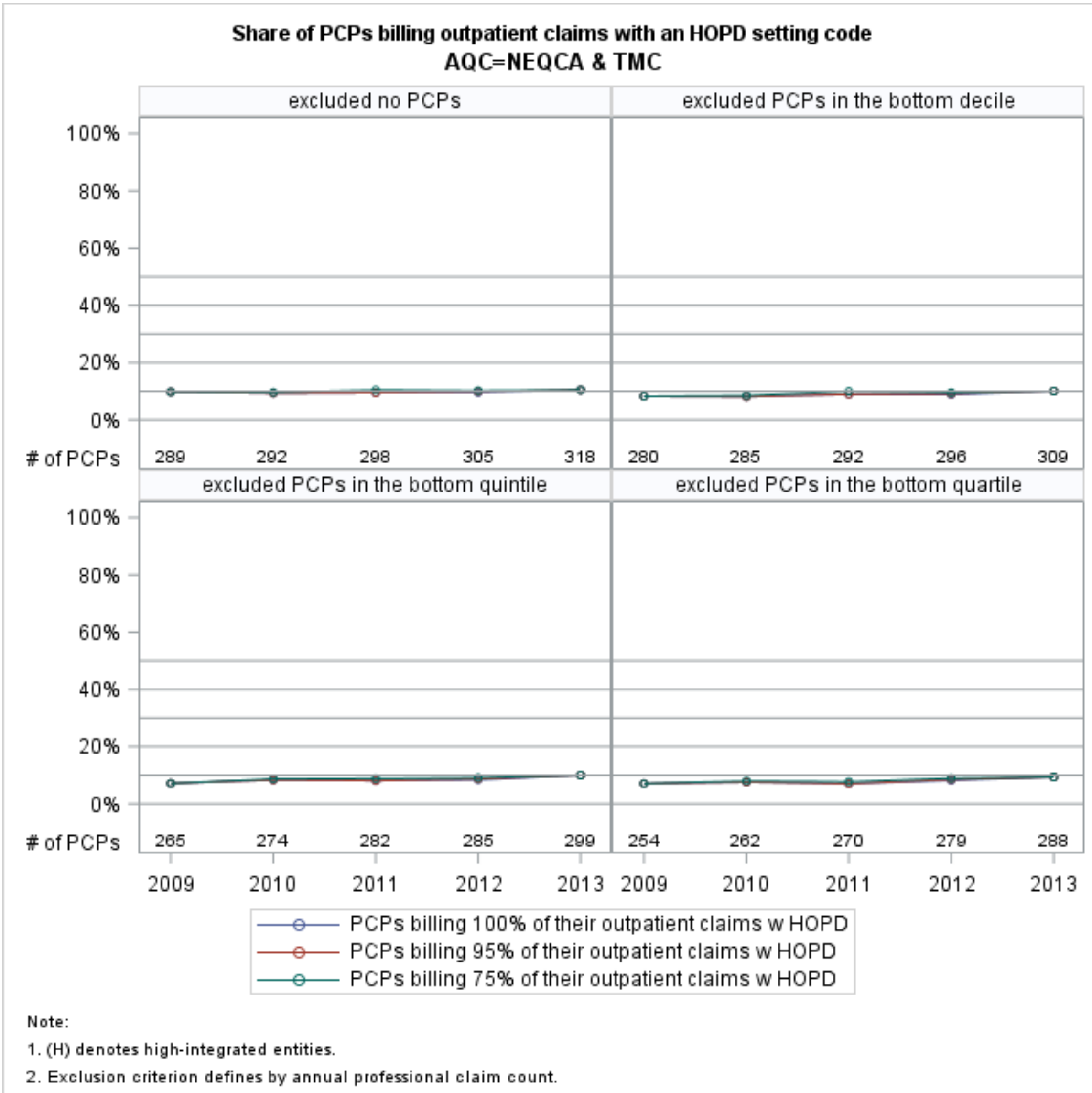


Table A2: Organization profile of the 16 AQC entities

AQC entity (short name)	# of enrollees	Medicare ACO[b]	For-profit status	# of acute-care hospitals	# of DSH	# of nursing facility[c]	# of FQHC/RHC	# of hospital beds[d]	# of hospital beds[d] per 1,000 enrollees
Mt Auburn	30,569	0	1	1	0	0	0	220	7.2
Hampden[a]	8,325	0	.	.	.	.	.	.	.
NEQA & TMC	108,311	0	0	1	0	1	0	293	2.7
Signature	13,872	0	0	1	1	0	0	245	17.7
Lowell	23,808	1	0	1	0	1	1	366	15.4
Atrius	104,866	1	0	0	0	0	0	0	0.0
South Shore	14,072	0	0	1	0	0	0	406	28.9
Steward	146,425	0	1	8	5	0	0	1,358	9.3
Northeast	24,110	0	0	1	0	2	0	404	16.8
BID	108,694	1	1	0	0	0	0	0	0.0
Partners	243,594	1	0	7	2	4	1	2,738	11.2
Cooley Dickinson	18,445	0	0	1	0	0	0	94	5.1
Children's	16,261	0	0	1	0	0	0	371	22.8
BMC	22,986	0	0	1	1	0	0	478	20.8
Lahey	32,212	1	0	1	0	0	0	570	17.7
Umass	84,994	0	0	4	4	0	1	921	10.8

Table A2: Organization profile of the 16 AQC entities — (Cont'd)

AQC entity (short name)	Type of physician group	# of medical groups[e]	# of physicians[f]	Share of PCPs (%)	Share of salaried physicians[c] (%)	Share of salaried PCPs[g] (%)
Mt Auburn	IPA	56	499	20.0	39.9	47.0
Hampden	IPA	.	.	.	.	.
NEQA & TMC	IPA	392	1,801	21.3	51	37.3
Signature	IDS	30	279	15.8	53.8	100.0
Lowell	PHO	93	353	27.2	19.5	22.9
Atrius	MSG	22	859	37.5	80.1	100.0
South Shore	PHO	87	400	13.0	25.3	0.0
Steward	IDS	486	2,525	19.0	32	38.5
Northeast	PHO	72	309	19.4	16.5	31.7
BID	MSG	251	2,353	19.3	0	0.0
Partners	IDS	453	6,462	14.1	72	54.8
Cooley Dickinson	PHO	53	261	32.6	36	27.1
Children's	IDS	83	1,344	22.8	80	13.0
BMC	IDS	27	1,091	28.2	90.4	92.5
Lahey	IDS	3	670	12.5	91.5	100.0
Umass	IDS	90	1,438	23.8	73	59.6

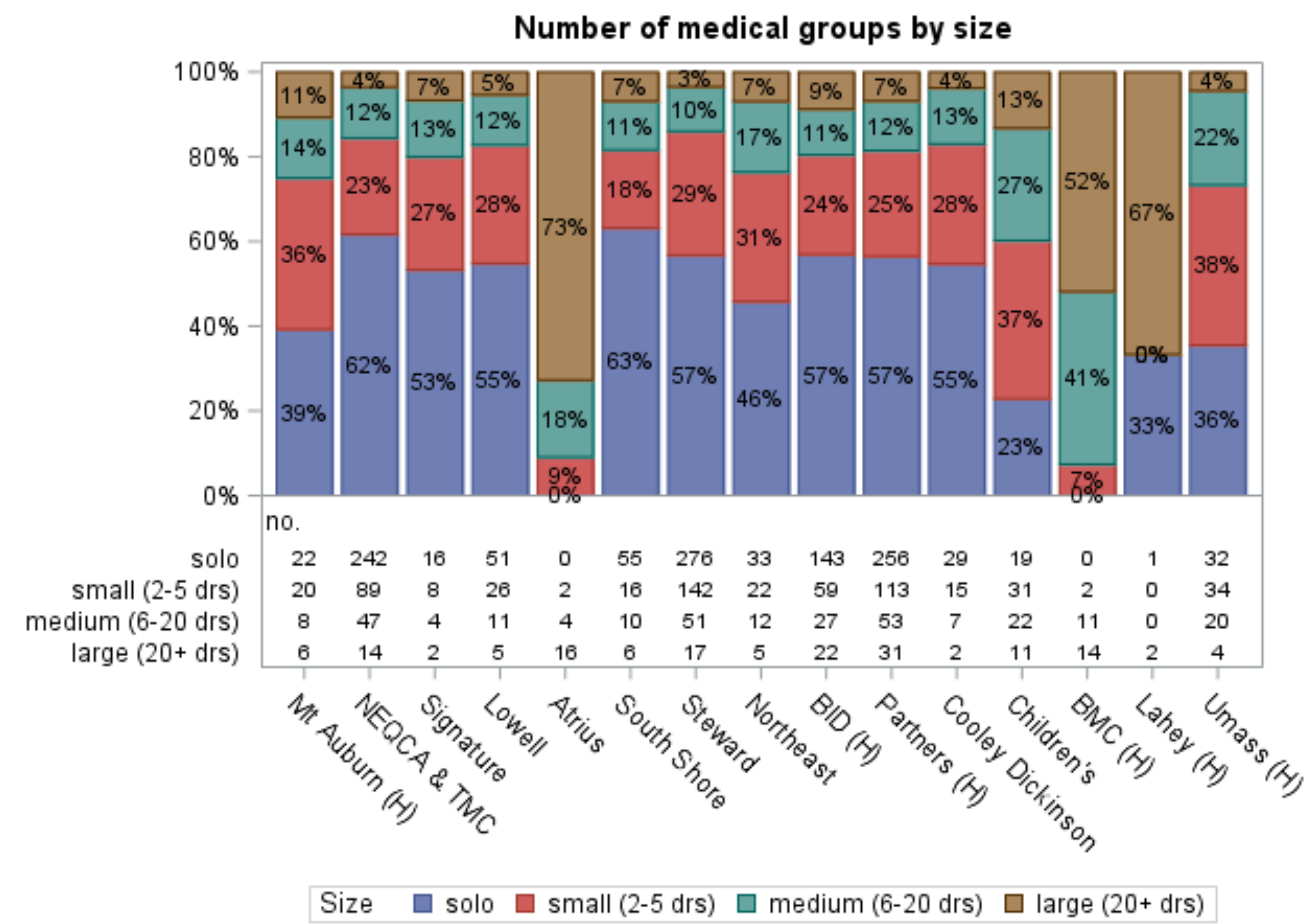
Abbreviations: ACO, Accountable Care Organization; DSH, Disproportionate Share Hospital; FQHC, Federal Qualified Health Center; RHC, Rural Health Clinic; IPA, Independent Practice Association; MSG, Multiple Specialty Groups; IDS, Integrated Delivery System; PHO, Physician Hospital Oranization.

Notes:

[a] Hampden County Physician Associates shut down in late 2014 and, therefore, did not submit data to the MA-RPO program in 2015.
[b] Organizations also participated in the Medicare ACO programs (Medicare Pioneer or Share Saving Program) during 2009-2013.
[c] Nursing home or skilled nurse facility.
[d] Total acute hospital beds reported in CHIA hospital profiles (FY 2013).
[e] Number of medical groups (unique NPIs) affiliated with each AQC entity.
[f] Number of physicians (unique NPIs) associated to each AQC entity.
[g] Physicians could be directly employed by the AQC or via its subsidiary cooperate affiliates, which could be a hospital or physician group.

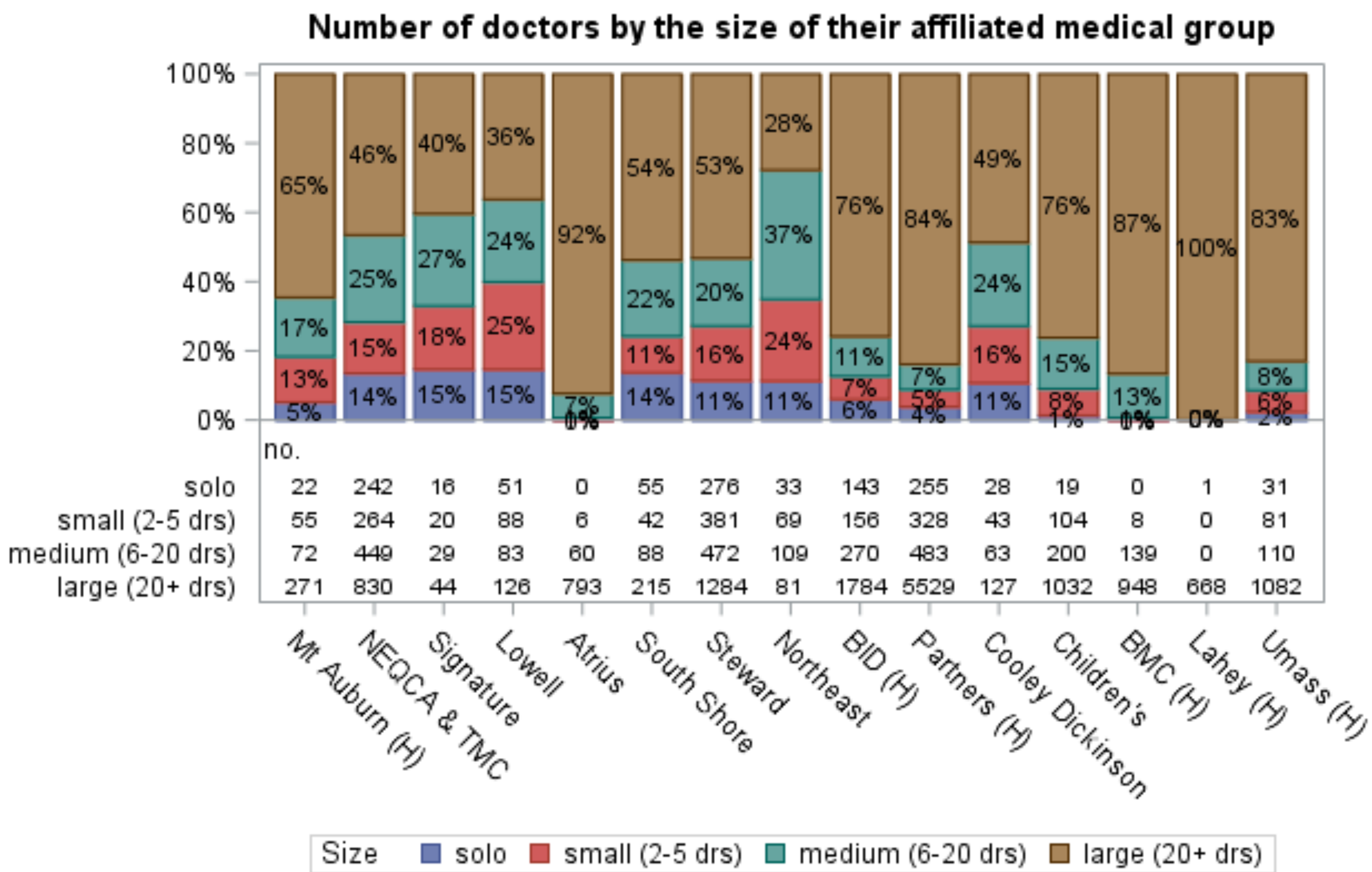
Figure A5: Physician networks according to medical group size

A) Share of medical groups



Note: (H) denotes high-integrated entities.

B) Share of physicians



no.	Mt Auburn (H)	NEQCA & TMC	Signature	Lowell	Atrius	South Shore	Steward	Northeast	BID (H)	Partners (H)	Cooley Dickinson	Children's	BMC (H)	Lahey (H)	Umass (H)
solo	22	242	16	51	0	55	276	33	143	255	28	19	0	1	31
small (2-5 drs)	55	264	20	88	6	42	381	69	156	328	43	104	8	0	81
medium (6-20 drs)	72	449	29	83	60	88	472	109	270	483	63	200	139	0	110
large (20+ drs)	271	830	44	126	793	215	1284	81	1784	5529	127	1032	948	668	1082

Note: (H) denotes high-integrated entities.
* a physician may affiliate with multiple medical groups.
** on average, info on affiliated medical group was available for 97.5% of physicians. However, 15.8%, 69.2%, and 11.5% of Mt Auburn, Signature, and UMass physicians lack such info.

Table A3: AQC physicians determined by the MA-RPO Physician Roster and identified in APCD

AQC entity (short name)	Physicians listed in the MA-RPO Physician Roster (n=18,603 unique NPIs)[c]			Physicians identified in APCD (n=16,141 unique NPIs)[c]			
	# of physicians	# of PCPs	Share of PCPs (%)	# of physicians	Identified rate (%)	# of PCPs	Share of PCPs (%)
Mt Auburn	499	113	22.6	468	93.8	106	22.6
Hampden[a]	-	-	-	96	-	-	-
NEQA & TMC	1,801	465	25.8	1,526	84.7	425	27.9
Signature	279	45	16.1	233	83.5	38	16.3
Lowell	353	97	27.5	321	90.9	92	28.7
Atrius	859	322	37.5	818	95.2	317	38.8
South Shore	400	53	13.3	372	93.0	53	14.2
Steward	2,525	579	22.9	2,174	86.1	528	24.3
Northeast	309	60	19.4	287	92.9	58	20.2
BID	2,353	533	22.7	1,962	83.4	482	24.6
Partners	6,462	1,103	17.1	5,561	86.1	1,056	19.0
Cooley Dickinson	261	86	33.0	237	90.8	81	34.2
Children's	1,344	346	25.7	1,216	90.5	335	27.5
BMC	1,091	379	34.7	894	81.9	312	34.9
Lahey	670	108	16.1	578	86.3	104	18.0
Umass	1,438	381	26.5	1,283	89.2	357	27.8
Total[b]	18,603	4,592	24.7	16,053	86.3	4,270	26.6

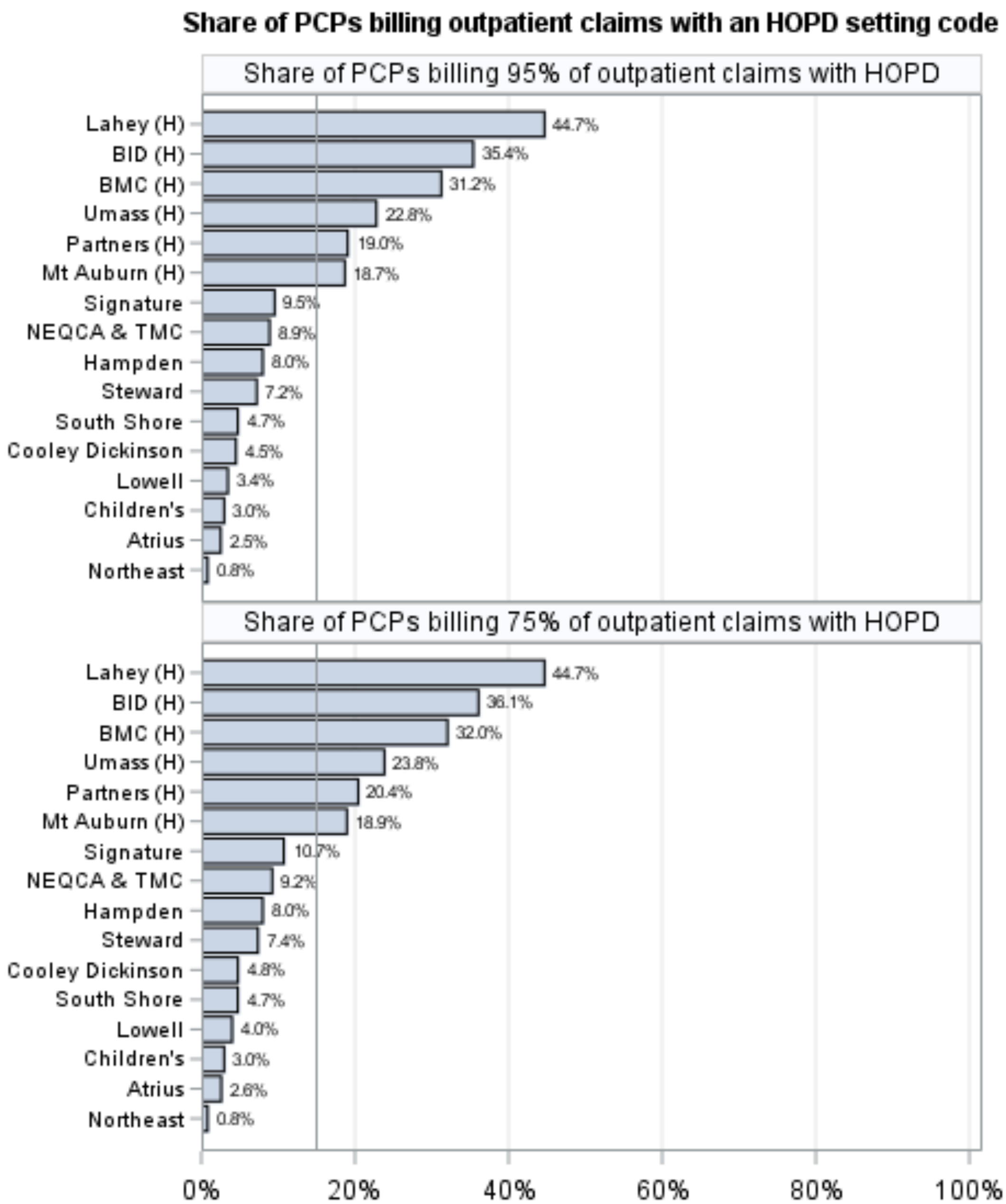
Notes:

[a] Hampden County Physician Associates shut down in late 2014 and, therefore, did not submit data to the MA-RPO program in 2015. Its affiliated physicians were determined by the affiliation element in the APCD provider file. I identified 96 physicians whose affiliated organization suggesting Hampden County Physician Associates (NPI: 17576719).

[b] The total statistic indicates numbers of unique NPI affiliated with the 15 AQC entities, excluding Hampden County Physician Associates.

[C] The number is less than the summation of physicians affiliated with each organization because around 10% of physicians affiliated with multiple AQC organizations

Figure A6: Level of physician-hospital integration (sensitivity analyses)



Note:

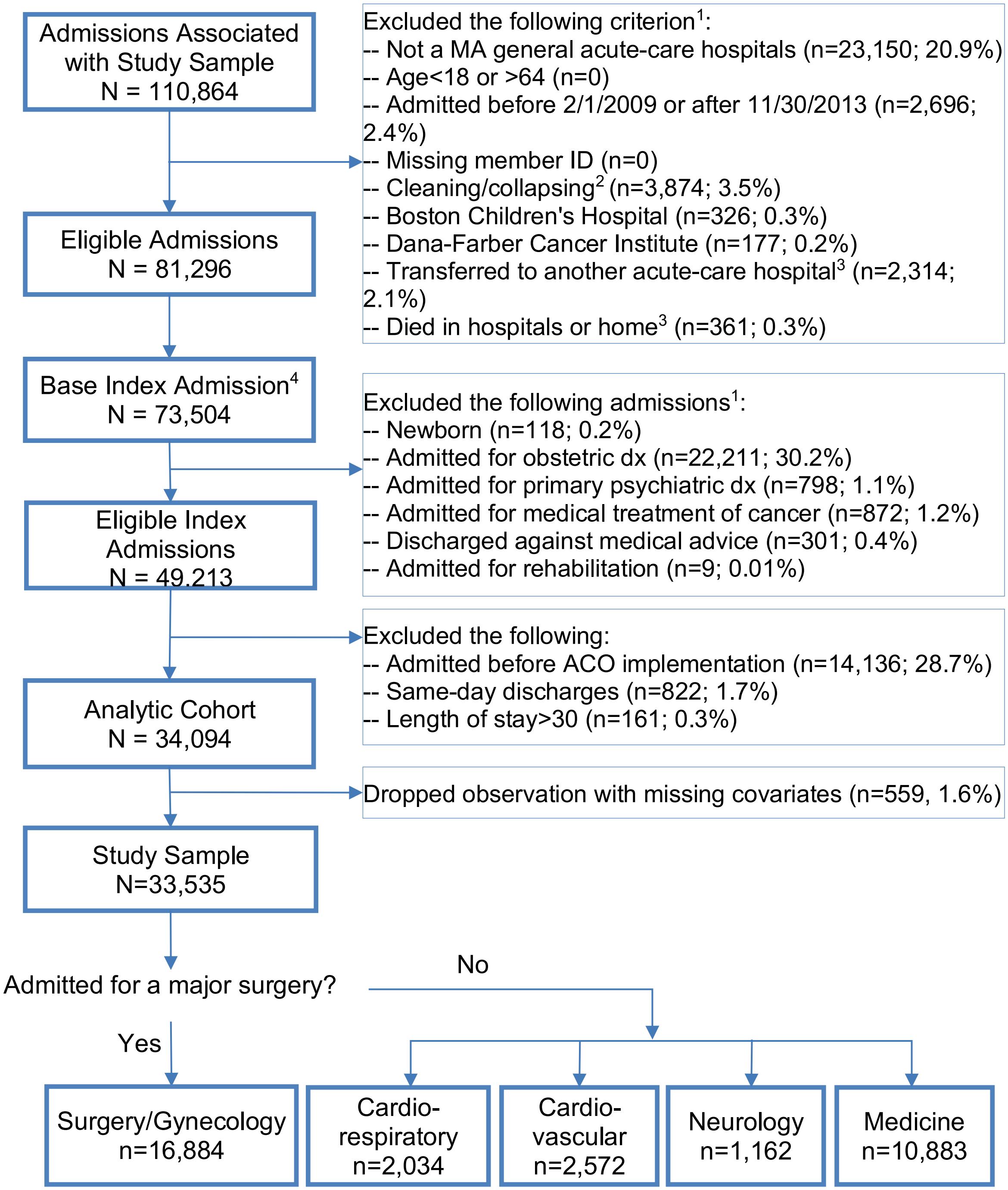
1. (H) denotes high-integrated entities.

2. 5-year average.

3. excluded PCPs in the bottom decile by annual professional claim count.

APPENDIX B: SUPPLEMENTAL MATERIALS FOR CHAPTER 3

Figure B1: Sample selection

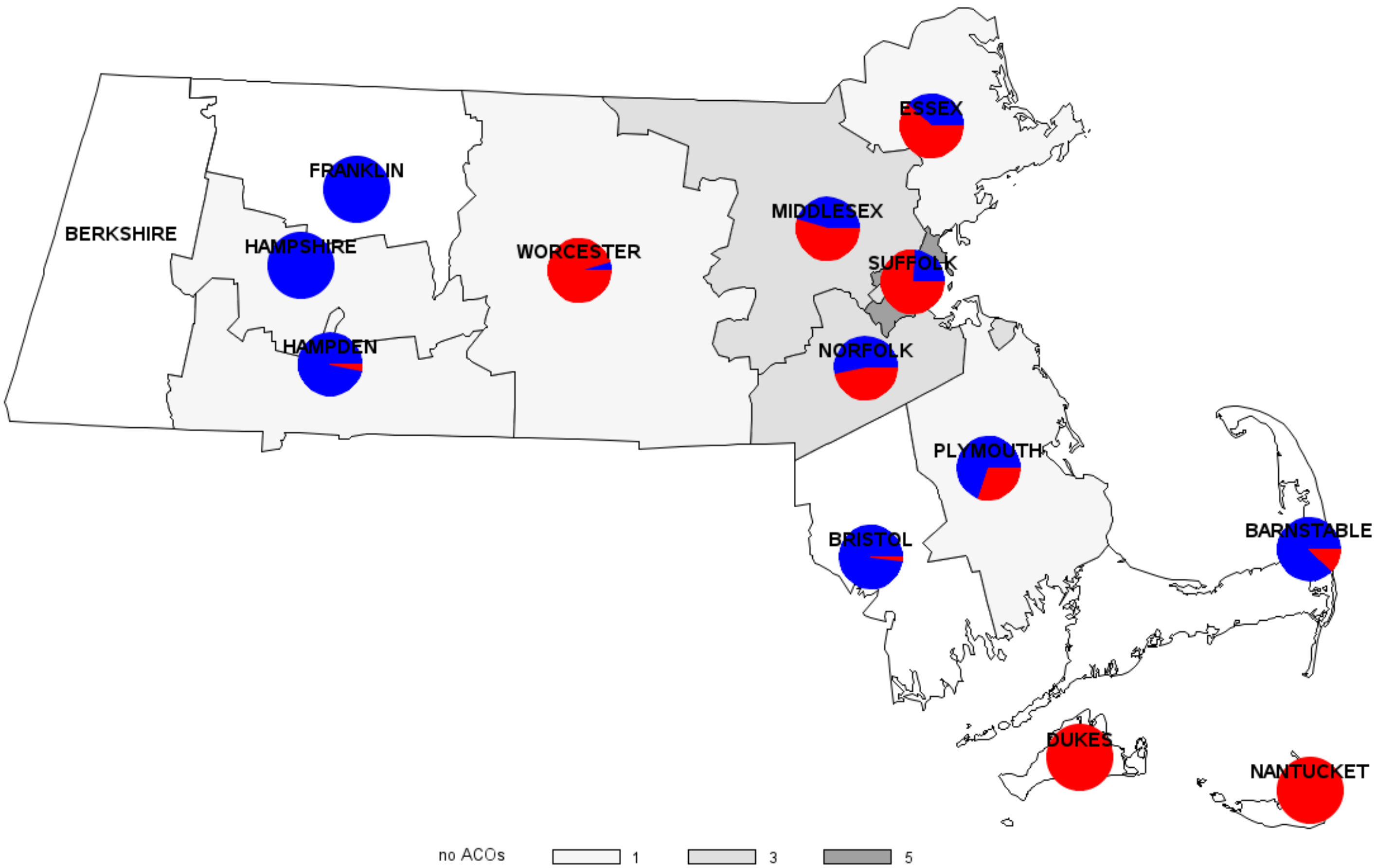


Notes:

1. Exclusions are not mutually exclusive.

2. Removeing duplicate records, collapsing overlapping stays, dropping stays > 1 year & newborn admissions.
3. The exclusions for transfer and death were implemented after making the exclusions avobe them.
4. 1) admisstions occurred 30 days post the enrollment start date & 30 days prior to the enrollment end date, and 2) 30 days after the discharge date of previous hospitalization.

Figure B2: Composition of PCPs by ACO affiliation in each county



Notes:

1. Both primary and seondary practice sites were counted.
2. The blue/red portion represents the approximate share of PCPs affiliated with a low-/high-integrated ACO.
3. Ligh grey, grey, and dark grey shading indicate there are 1, 3, and 5 ACOs operating in the corresponding county respectively.

Table B1: Quality measures[1,2]

Domain	Year	Clinical Area	Measure Name	Description
HEDIS	2012	Wonen's Health	Breast Cancer Screening	% of women aged 50-74 who had a mammogram to screen for breast cancer
			Cervical Cancer Screening	% of women aged 21-64 who were screened for cervical cancer[3]
			Chlamydia Screening in Women Ages 21 to 24	% of women aged 21-24 who are identified as sexually active and had at least one test for chlamydia
		Diabetes Care	HbA1c Testing	% of patients aged 18-75 with type-1 or type-2 diabetes who had HbA1c testing
			LDL-C Screening	% of patients aged 18-75 with type-1 or type-2 diabetes who had LDL-C screening
			Medical Attention for Nephropathy	% of patients aged 18-75 with type-1 or type-2 diabetes who had medical attention for nephropathy
		Diagnostic and Preventive Care	Colorectal Cancer Screening	% of patients aged 50-75 who had appropriate screening for colorectal cancer
			Use of Imaging Studies for Low Back Pain	% of patients aged 18-50 who did not get imaging tests within 28 days after being diagnosed with lower back pain[4]
		Medication Management	Annual Monitoring for Patients on Persistent Medications – Total Rate	% of patients aged 18+ who received at least 180 treatment days of ambulatory medication therapy for a select therapeutic agent and at least one therapeutic monitoring event for the therapeutic agent
			Annual Monitoring for Patients on Persistent Medications – ACE Inhibitors or ARBs	% of patients aged 18+ who received at least 180 treatment days of ambulatory medication therapy for ACE inhibitors or ARBs and at least one therapeutic monitoring event for it
			Antidepressant Medication Management – Effective Continuation Phase Treatment	% of patients aged 18+ with a diagnosis of major depression and were treated with antidepressant medication, and who remained on an antidepressant medication treatment for at least 180 days

		Controlling High Blood Pressure	Cholesterol Management for Patients with Cardiovascular Conditions – LDL-C Screening	% of patients aged 18-75 who were discharged alive for AMI, CABG or PCI in the year prior to the measurement year, or who had a diagnosis of IVD during the measurement year and the year prior to the measurement year, who had LDL-C screening during the measurement year
		Asthma Medication Use	Use of Appropriate Medications for People with Asthma	% of patients aged 12-50 who were identified as having persistent asthma and who were appropriately prescribed medication
PES[5]	2013	Patient Experience	Communication	% of survery respondents who were sarisified with their patient-providers' communication
			Coordination of Care	% of survery respondents who were sarisified with their providers' coordination of their care
			Knowledge of Patient	% of survery respondents who were sarisified with how well doctors know them
			Office Staff	% of survery respondents who were sarisified with their interactions with office staff
			Organizational Access	% of survery respondents who were sarisified with their ability to get timely appointments, care, and information
			Willingness to Recommend	% of survery respondents who reported YES, they would definitely recommend their doctor to family and friends

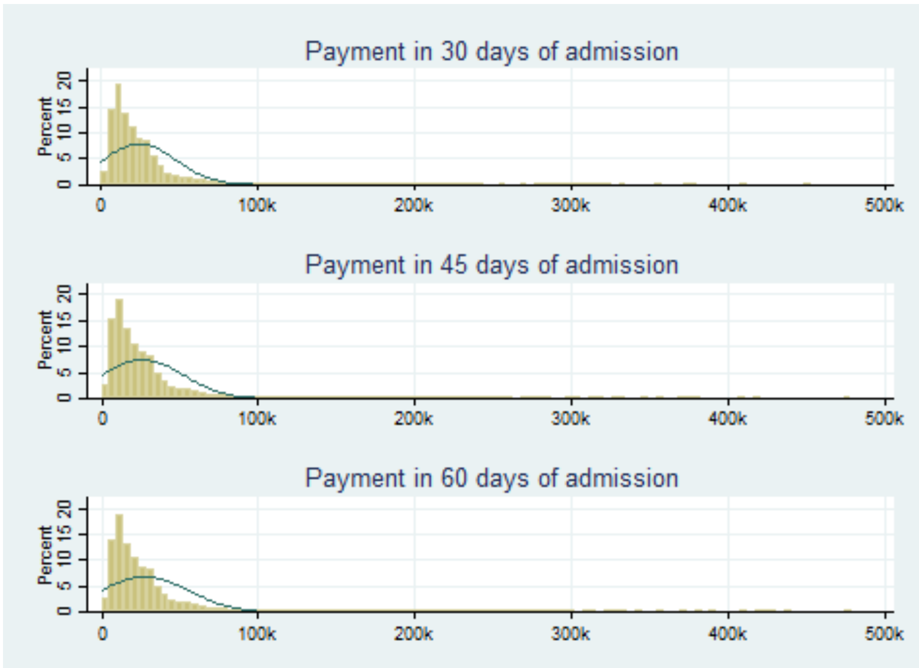
Abbreviation: HbA1c, hemoglobin A1c; LDL-C, low-density lipoprotein cholesterol; ACE inhibitors, angiotensin-converting enzyme inhibitors; ARBs, angiotensin II receptor blockers; AMI, acute myocardial infarction; CABG, coronary artery bypass graft; PCI, percutaneous coronary interventions; IVD, ischemic vascular disease.

Notes:

1. Quality measures were based on commercially insured patients from the five largest health plans in MA, collectively representing approximately 70% of the commercial population.
2. Each score is rated on a scale from 0 to 100 (0 is worst; 100 is best). Measure scores of individual respondents are case-mix adjusted before aggregating to medical group or parent provider group level by Massachusetts Health Quality Partners.
3. Using either of the following criteria: (1) women aged 21-64 who had cervical cytology performed every 3 years, or (2) women aged 30-64 who had cervical cytology/human papilloma virus co-testing performed every 5 years.
4. Imaging tests include X-rays, MRIs, and CT-scans. A higher score means that more patients did not get imaging tests during this time, which is good
5. Based on Clinician and Group Consumer Assessment of Healthcare Providers and Systems (CG-CAHPS) survery.

Figure B3: Distribution of payment outcomes

A) Raw scale



B) Log scale

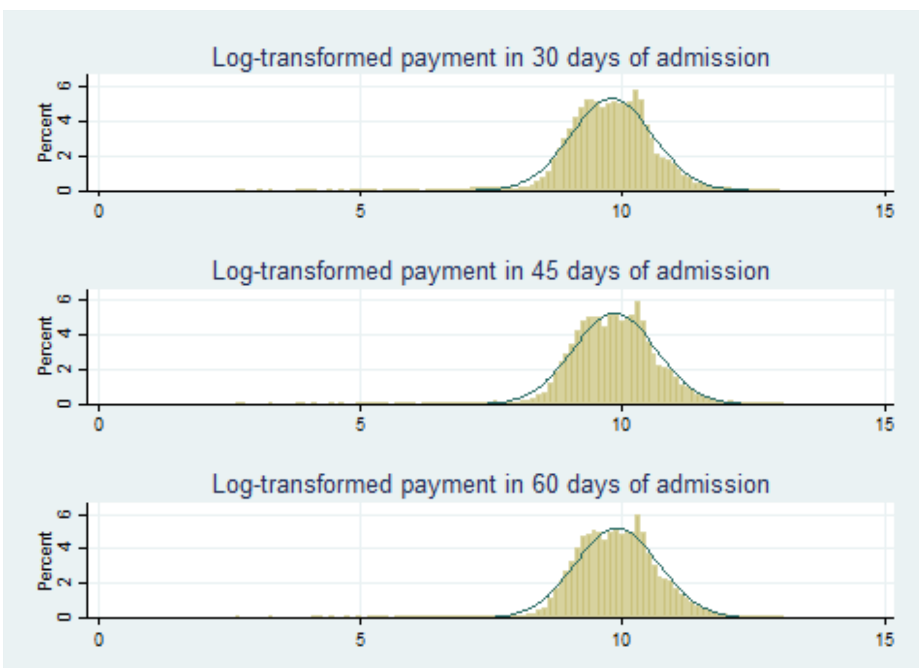


Table B2: Changes in outcomes associated with physician-hospital integration using 2SLS regression

Explanatory variables[1]	Spending in 30 days	Spending in 45 days	Spending in 60 days	Length of Stay	30-day Readmission
High integration	-6911***	-6841***	-6307**	-1.03***	0.017
Demographic characteristics					
Age at admission (ref=18-39)					
40-49	507	356	383	0.08	0.002
50-59	531	632	751*	0.22***	0.003
60-64	819*	750	706	0.33***	0
Female	-564*	-618*	-541	-0.01	0
Health risk score[2]	400***	517***	626***	0.05***	0.003***
Comorbidities[3]					
No. of comorbid conditions (ref=none)					
1	1893***	1721***	1391*	0.34***	-0.005
2	3784***	3316***	2690**	0.64***	-0.008
3+	4950***	4303**	3185	0.94***	-0.015
Congestive heart failure	3561**	3572**	3972**	0.54***	0.007
Valvar disease	1425	2142	3343**	0.31*	0.017
Pulmonary circulation disease	5458**	5835**	7693***	1.30***	0.003
Peripheral vascular disease	4664***	4927***	5488***	0.26	0.005
Paralysis	-2431	-452	-373	0.21	-0.043**
Other neurological disorders	953	1068	1221	0.30*	-0.006
Chronic pulmonary disease	-1483**	-966	-926	-0.14	0.008
Diabetes w/o chronic complications	-2375***	-2272***	-2102***	-0.42***	0.009

Diabetes w/ chronic complications	-1773	-1524	-1077	0.28	0.009
Hypothyroidism	-1274**	-1038	-745	-0.36***	0.005
Renal failure	-6761***	-6752***	-7621***	-1.06***	-0.02
Liver disease	-1284	-490	-664	-0.23*	0.026**
Peptic ulcer Disease x bleeding	-4241	-5959	-5371	-1.01*	0.034
Acquired immune deficiency syndrome	-1824	-3612	-2559	-0.23	-0.033
Lymphoma	-5492***	-5605**	-4011	-1.30***	-0.040*
Metastatic cancer	-5631***	-5075***	-3806**	-0.99***	-0.006
Solid tumor w/out metastasis	-4078**	-3376*	-2280	-1.47***	-0.007
Rheumatoid arthritis/collagen vas	-2496**	-2341*	-1480	-0.37**	0.006
Coagulopathy	8067***	8800***	8977***	0.90***	0.016
Obesity	77	288	481	0.05	-0.005
Weight loss	4949**	5709**	6299**	1.94***	0.022
Fluid and electrolyte disorders	3236***	3337***	3717***	0.82***	0.004
Chronic blood loss anemia	-115	498	872	0.56*	0.01
Deficiency Anemias	-1489**	-1436*	-1004	0.15	0.004
Alcohol abuse	-1557	-1809*	-1250	-0.04	0.004
Drug abuse	905	811	918	-0.05	0.018
Psychoses	-2126**	-1717*	-1125	0.11	0.044***
Depression	-2156***	-1705**	-1362*	-0.24**	0.016**
Hypertension	-1956***	-1754***	-1426*	-0.30***	0.004
ACO quality measure[4]	-706**	-674**	-704**	-0.12***	0.005
Area socioeconomic characteristics					
Income (ref=low)					
Medium	-682*	-656	-640	-0.15**	0.002
High	-263	-41	47	0.03	0.004

Poverty (ref=low)					
Medium	-158	-51	-13	0.14***	0
High	296	572	661	0.23***	0.005
PCP shortage	-1336***	-1282**	-1264**	-0.16**	-0.005
Year (ref=2009)					
2010	214	120	276	-	-
2011	2050***	1948***	2030***	-	-
2012	4792***	4733***	4578***	-	-
2013	6063***	6036***	5941***	-	-

* p<0.05, ** p<0.01, *** p<0.001

Abbreviation: 2SLS, two-stage least squares.

Notes:

1. Hospital fixed effects and diagnotic category fixed effects were included but not shown.
2. Based on HHS-HCC risk score.
3. Based on Elixhauser Comorbidity Index.
4. Based in selected HEDIS measures and patient-reported experiences.

APPENDIX C

Figure C1: Sample selection

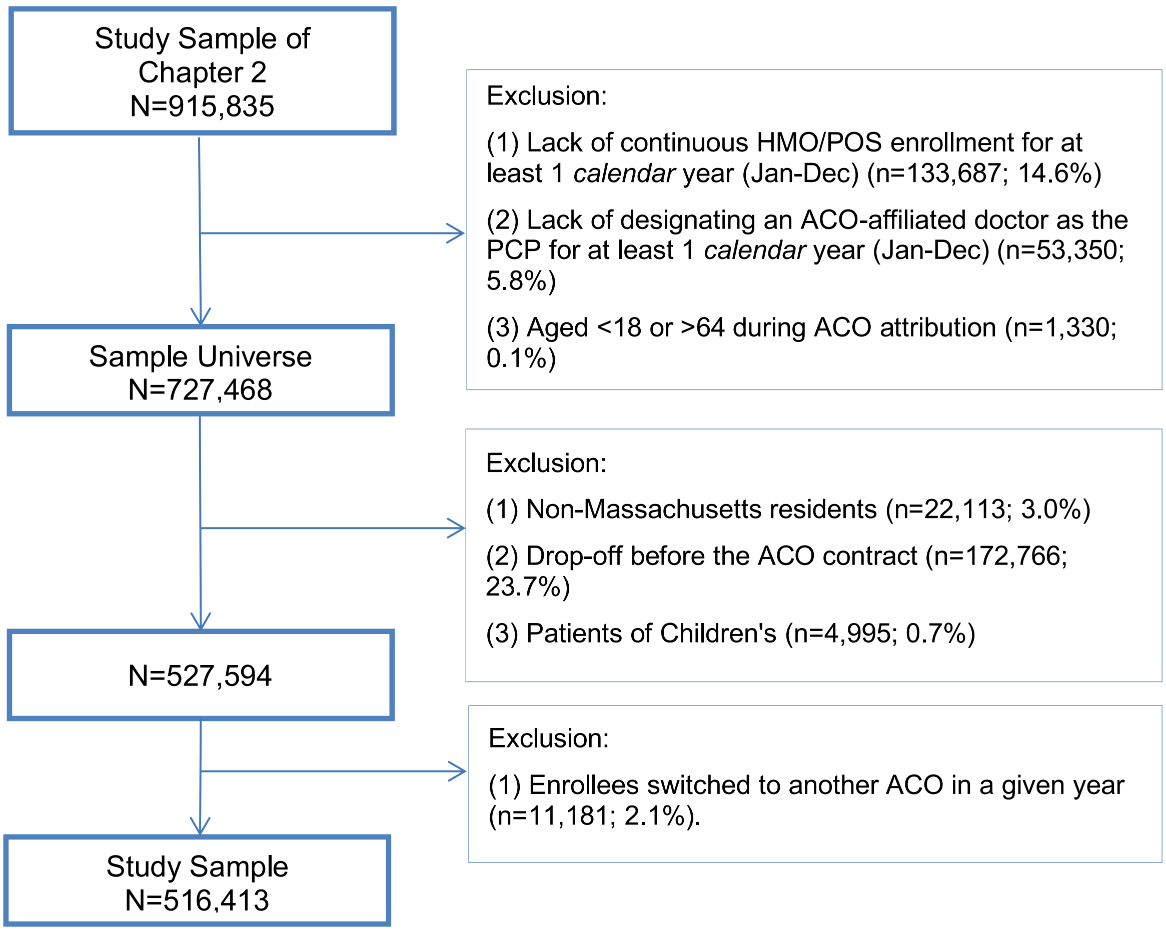
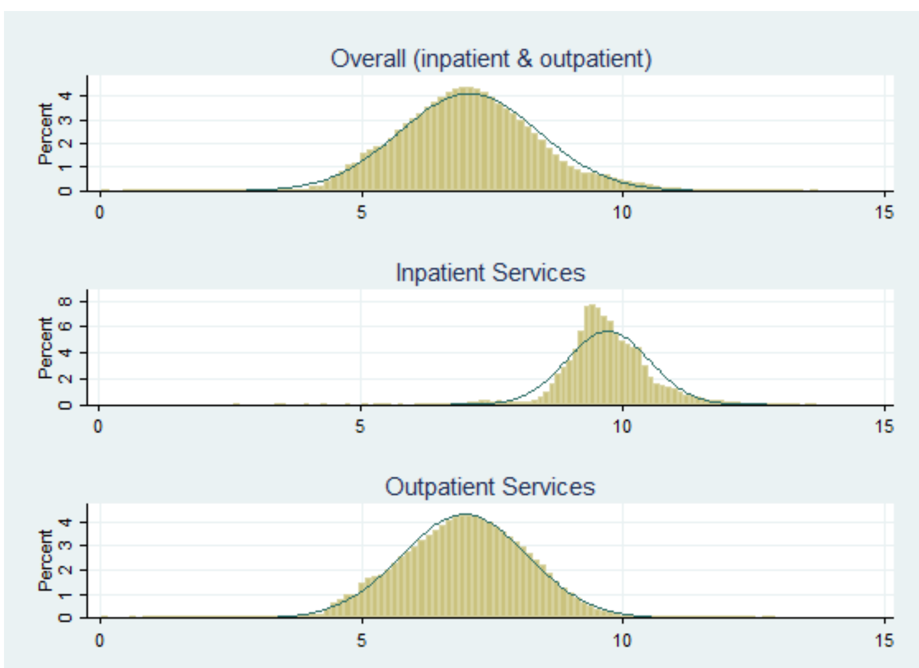


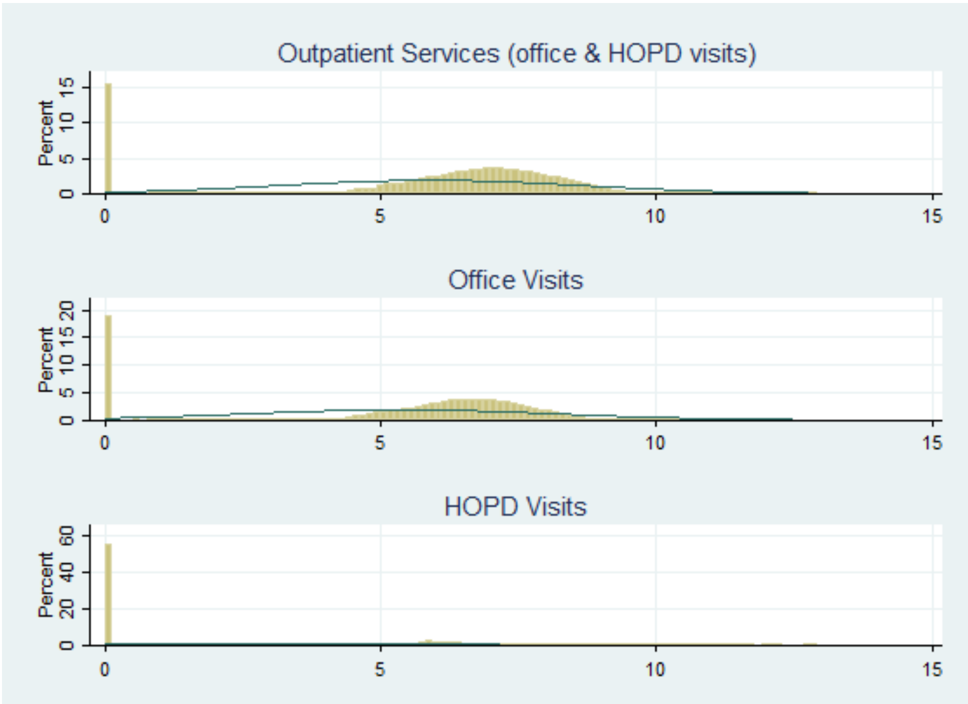
Figure C2: Distribution of spending outcomes

A) Log-transformed annual per-enrollee overall spending

B) Log-transformed annual per-enrollee overall spending, excluding zeros



C) Log-transformed annual per-enrollee outpatient spending



D) Log-transformed annual per-enrollee outpatient spending, excluding zeros

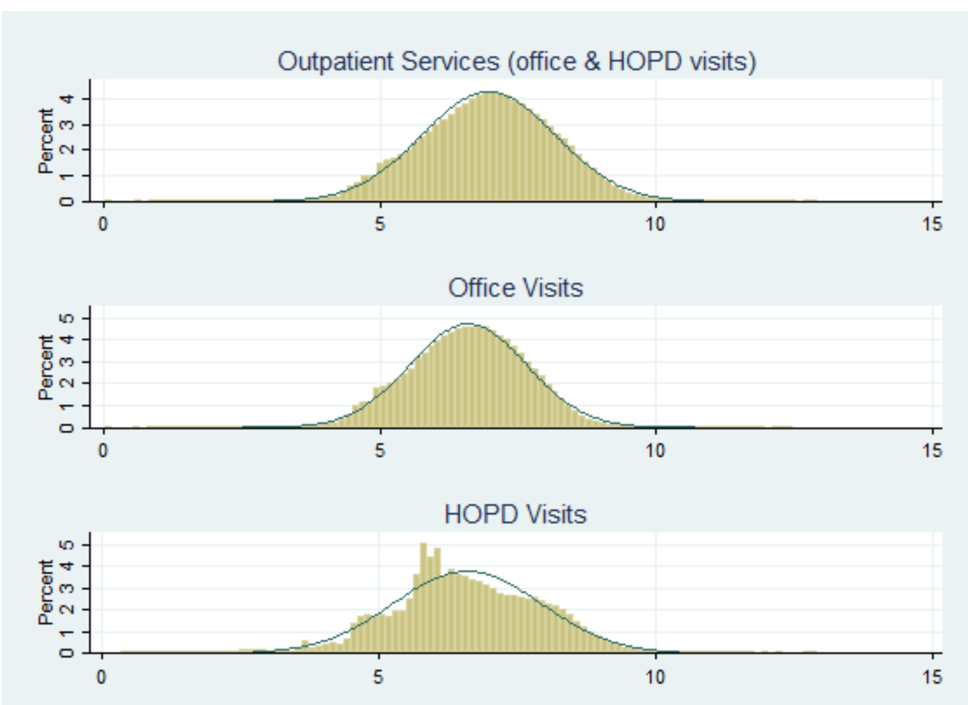
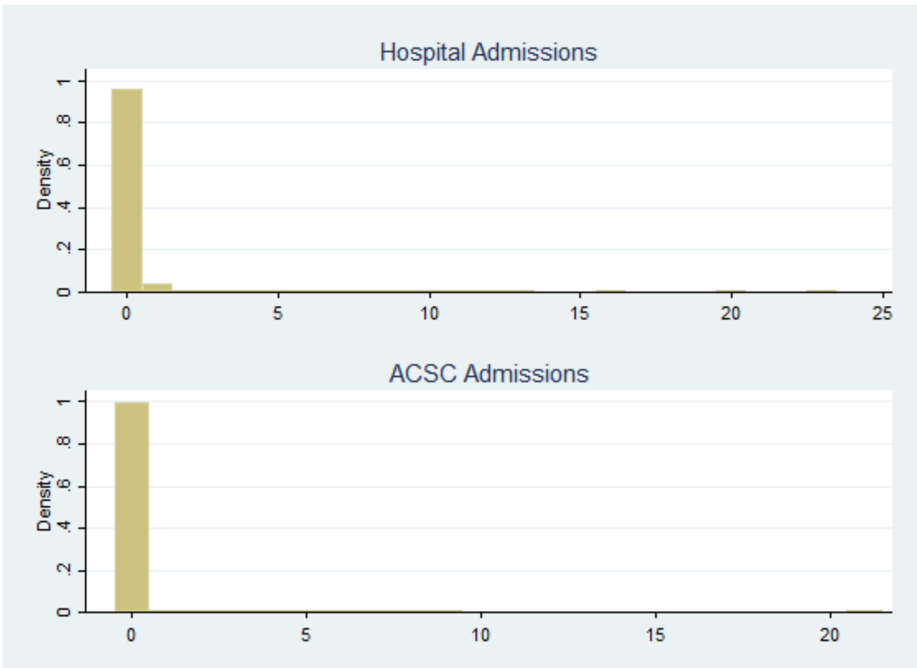


Figure C3: Distribution of utilization outcomes

A) Inpatient services (annual counts of hospitalizations per enrollee)



B) Outpatient services (annual counts of outpatient visits per enrollee)

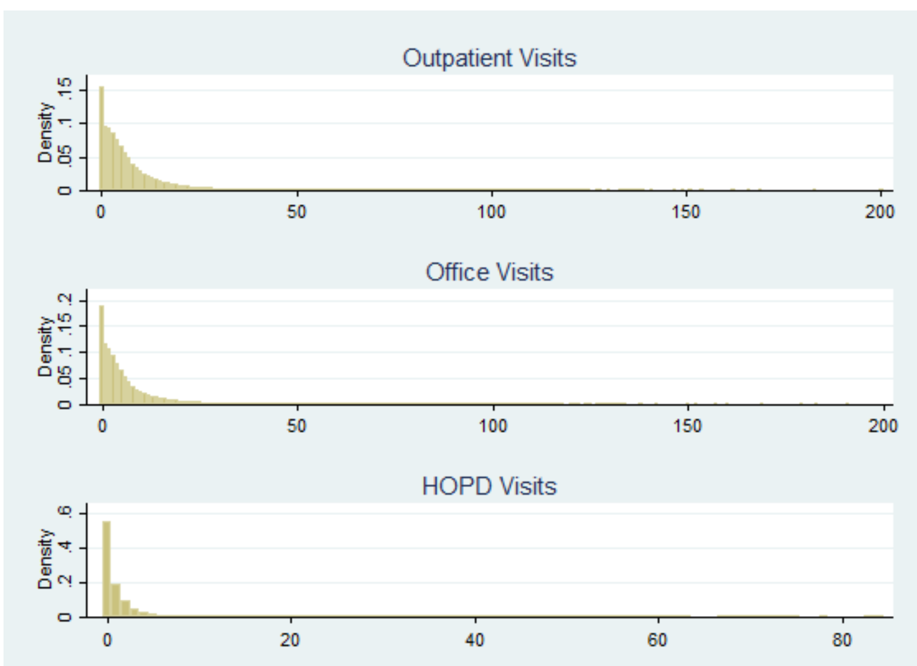


Table C1: Sensistive analyses 1: effects of integration on healthcare expenditure based on models estimating odds of non-zero spending and level of spending

a) Overall expenditures by service type

	LATE[1]	p > |z|	95% Confident Interval	
Logit model estimating spending>0				
Overall	-15.1%	0.027	-26.5%	-1.8%
Inpatient care	-13.7%	0.043	-25.1%	-0.5%
Outpatient care	-15.0%	0.028	-26.4%	-1.7%
GLM model estimating level of spending				
Overall	8.7%	0.036	0.5%	17.5%
Inpatient care	3.8%	0.494	-6.7%	15.5%
Outpatient care	11.2%	0.016	2.0%	21.3%

Abbreviations: LATE, Local Average Treatment Effect.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].

b) Outpatient expenditures by care setting

	LATE[1]	p > |z|	95% Confident Interval	
Logit model estimating spending>0				
Office	-49.8%	0.000	-62.4%	-32.9%
HOPD	95.3%	0.013	15.3%	230.6%
GLM model estimating level of spending				
Office	-8.8%	0.371	-25.5%	11.6%
HOPD	13.8%	0.024	1.7%	27.5%

Abbreviations: LATE, Local Average Treatment Effect; HOPD, Hospital Outpatient Department.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].

Table C2: Sensistive analyses 2: effects of integration on healthcare utilization based on models with alternative functional forms

a) Utilization by service type

	LATE[1]	p > |z|	95% Confident Interval	
	Negative binomial models			
Hospitalizations	-13.0%	0.011	-21.8%	-3.2%
ACSC hospitalizations	7.5%	0.452	-11.0%	30.0%
Outpatient visits	-6.8%	0.014	-11.9%	-1.4%
	Zero-inflated Poisson models			
Hospitalizations	-12.9%	0.014	-22.1%	-2.7%
ACSC hospitalizations	14.6%	0.339	-13.3%	51.5%
Outpatient visits	-4.5%	0.077	-9.2%	0.5%
	Zero-inflated negative binomial models			
Hospitalizations	-13.4%	0.007	-22.1%	-3.9%
ACSC hospitalizations	6.0%	0.594	-14.3%	31.1%
Outpatient visits	-6.1%	0.021	-11.0%	-1.0%

Abbreviations: LATE, Local Average Treatment Effect; ACSC, ambulatory care-sensitive condition.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].

b) Outpatient utilization by care setting

	LATE[1]	p > |z|	95% Confident Interval	
	Negative binomial models			
Office	-17.7%	0.000	-25.8%	-8.6%
HOPD	70.1%	0.005	17.2%	146.7%
	Zero-inflated Poisson models			
Office	-9.4%	0.034	-17.3%	-0.8%
HOPD	38.7%	0.013	7.3%	79.4%
	Zero-inflated negative binomial models			
Office[2]	-	-	-	-
HOPD	62.7%	0.007	14.3%	131.5%

Abbreviations: LATE, Local Average Treatment Effect; HOPD, Hospital Outpatient Department.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].
2. Model did not converge.

Table C3: Sensistive analyses 3: effects of integration on healthcare spending and utilization based on analyses using top-coded outcomes

a) Effects of integration on spending and utilization, overall and by service type

Outcomes	LATE[1]	p > |z|	95% Confident Interval	
Expenditure				
Overall	6.5%	<0.001	2.9%	10.2%
Inpatient	-13.5%	0.107	-27.6%	3.2%
Outpatient	8.2%	<0.001	5.1%	11.4%
Utilization				
Hospitalization	-20.4%	0.010	-32.9%	-5.4%
ACSC hospitalization	3.7%	0.810	-23.1%	39.9%
Outpatient visits	-6.0%	<0.001	-7.8%	-4.2%

Abbreviations: LATE, Local Average Treatment Effect; ACSC, ambulatory care-sensitive condition.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].

b) Effects of integration on outpatient spending and utilization by care setting

Outcomes	LATE[1]	p > |z|	95% Confident Interval	
Expenditure				
Office	-19.6%	<0.001	-21.3%	-17.8%
HOPD	54.5%	<0.001	47.7%	61.6%
Utilization				
Office	-16.7%	<0.001	-18.4%	-15.0%
HOPD	59.7%	<0.001	54.6%	65.1%

Abbreviations: LATE, Local Average Treatment Effect; HOPD, Hospital Outpatient Department.
Notes:
1. LATE is equal to [exponentiated β1 in Equation (3) - 1].

BIBLIOGRAPHY

1. Alternative Quality Contract. Available from: https://www.bluecrossma.com/visitor/about-us/affordability-quality/aqc.html.

2. Agency for Healthcare Research and Quality. Elixhauser Comorbidity Software, Version 3.7. Available from: https://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp.

3. Massachusetts All Payer Claims Database (Release 3.0), Center for Health Information and Analysis, Editor. 2009-2013.

4. American Community Survey (5-year Estimates), U.S Census Bureau, Editor. 2009-2013.

5. Area Health Resources Files (County Level Data), Health Resources and Services Administration, Editor. 2010.

6. Centers for Medicare and Medicaid Services. Berenson-Eggers Type of Services. 2013; Available from: https://www.cms.gov/Medicare/Coding/HCPCSReleaseCodeSets/BETOS.html.

7. Bureau of Labor Statistics, U.S. Department of Labor. 2013; Available from: https://data.bls.gov/pdq/SurveyOutputServlet.

8. 958 CMR 6.00: REGISTRATION OF PROVIDER ORGANIZATIONS. 2014.

9. Registration of Provider Organizations, Massachusetts Health Policy Commission, Editor. 2015.

10. New hospitals and health care providers join successful, cutting-edge federal initiative that cuts costs and puts patients at the center of their care, U.S. Department of Health and Human Services, Editor. 2016.

11. 2016 Report on the Performance of the Massachusetts Health Care System Center for Health Information and Analysis, Editor. 2016.

12. Accountable Care Organizations (Updated), in *Health Affairs Health Policy Brief*. August 13, 2010.

13. Afendulis, C.C., et al., The impact of global budgets on pharmaceutical spending and utilization: early experience from the alternative quality contract. *Inquiry*, 2014. 51.

14. Agency for Healthcare Research and Quality. Prevention Quality Indicators Technical Specifications - Version 6.0, October 2016. 2016 [cited 2014 5/1]; Available from: http://www.qualityindicators.ahrq.gov/Modules/PQI_TechSpec.aspx.

15. Al-Amin, M., Hospital characteristics and 30-day all-cause readmission rates. *Journal of Hospital Medicine*, 2016. 11(10): p. 682-687.

16. Alexander, J.A. and M.A. Morrisey, Hospital-physician integration and hospital costs. *Inquiry*, 1988. 25(3): p. 388-401.

17. Ambardekar, A.V., et al., Quality of care and in-hospital outcomes in patients with coronary heart disease in rural and urban hospitals (from Get With the Guidelines-Coronary Artery Disease Program). *American Journal of Cardiology*, 2010. 105(2): p. 139-143.

18. Anderson, D.G. and D.E. Morris, Characteristics of successful 'super ACOs'. *Healthcare Financial Management*, 2015. 69(6): p. 98-100.

19. Baicker, K. and H. Levy, Coordination versus competition in health care reform. *New England Journal of Medicine*, 2013. 369(9): p. 789-791.

20. Baker, L.C., M.K. Bundorf, and D.P. Kessler, Vertical integration: hospital ownership of physician practices is associated with higher prices and spending. *Health Affairs*, 2014. 33(5): p. 756-763.

21. Baker, L.C., et al., Physician practice competition and prices paid by private insurers for office visits. *JAMA: The Journal of the American Medical Association*, 2014. 312(16): p. 1653-1662.

22. Baker, L.C., et al., Hospital Ownership of Physicians: Hospital Versus Physician Perspectives. *Medical Care Research and Review*, 2016.

23. Baker, L.C., M.K. Bundorf, and D.P. Kessler, The effect of hospital/physician integration on hospital choice. *Journal of Health Economics*, 2016. 50: p. 1-8.

24. Barry, C.L., et al., The Early Impact Of The 'Alternative Quality Contract' On Mental Health Service Use And Spending In Massachusetts. *Health Affairs*, 2015. 34(12): p. 2077-2085.

25. Berenson, R.A., T. Bodenheimer, and H.H. Pham, Specialty-service lines: salvos in the new medical arms race. *Health Affairs*, 2006. 25(5): p. w337-343.

26. Berwick, D.M., T.W. Nolan, and J. Whittington, The triple aim: care, health, and cost. *Health Affairs*, 2008. 27(3): p. 759-769.

27. Burgess, J.F., Innovation and efficiency in health care: does anyone really know what they mean? *Health Systems*, 2012. 1(1): p. 7-12.

28. Burns, L.R. and R.W. Muller, Hospital-physician collaboration: landscape of economic integration and impact on clinical integration. *Milbank Quarterly*, 2008. 86(3): p. 375-434.

29. Burns, L.R., J.C. Goldsmith, and A. Sen, Horizontal and vertical integration of physicians: a tale of two tails. *Advances in Health Care Management*, 2013. 15: p. 39-117.

30. Buu, A., et al., Statistical models for longitudinal zero-inflated count data with applications to the substance abuse field. *Statistics in Medicine*, 2012. 31(29): p. 4074-4086.

31. Carlin, C.S., B. Dowd, and R. Feldman, Changes in Quality of Health Care Delivery after Vertical Integration. *Health Services Research*, 2015. 50(4): p. 1043-1068.

32. Carlin, C.S., R. Feldman, and B. Dowd, The Impact of Hospital Acquisition of Physician Practices on Referral Patterns. *Health Economics*, 2016. 25(4): p. 439-454.

33. Cawley, J. and C. Meyerhoefer, The medical care costs of obesity: an instrumental variables approach. *Journal of Health Economics*, 2012. 31(1): p. 219-230.

34. Chernew, M.E., et al., Private-payer innovation in Massachusetts: the 'alternative quality contract'. *Health Affairs*, 2011. 30(1): p. 51-61.

35. Chien, A.T., et al., Two-year impact of the alternative quality contract on pediatric health care quality and spending. *Pediatrics*, 2014. 133(1): p. 96-104.

36. Chien, A.T., et al., How Accountable Care Organizations Responded to Pediatric Incentives in the Alternative Quality Contract. *Academic Pediatrics*, 2016. 16(2): p. 200-207.

37. Chukmaitov, A., et al., Delivery system characteristics and their association with quality and costs of care: implications for accountable care organizations. *Health Care Management Review*, 2015. 40(2): p. 92-103.

38. Ciliberto, F. and D. Dranove, The effect of physician-hospital affiliations on hospital prices in California. *Journal of Health Economics*, 2006. 25(1): p. 29-38.

39. Colla, C.H., et al., Hospitals Participating In ACOs Tend To Be Large And Urban, Allowing Access To Capital And Data. *Health Affairs*, 2016. 35(3): p. 431-439.

40. Commission, M.P.A., Report to the Congress: Medicare and the Healthcare Delivery System. June 2013, Medicare Payment Advisory Commission.

41. Cuellar, A.E. and P.J. Gertler, Strategic integration of hospitals and physicians. *Journal of Health Economics*, 2006. 25(1): p. 1-28.

42. Cutler, D.M. and F. Scott Morton, Hospitals, market share, and consolidation. *JAMA: The Journal of the American Medical Association*, 2013. 310(18): p. 1964-1970.

43. DeSantis, S.M., et al., Analyzing Propensity Matched Zero-Inflated Count Outcomes in Observational Studies. *Journal of Applied Statistics*, 2014. 41(1).

44. Devers, K.J., L.R. Brewster, and L.P. Casalino, Changes in hospital competitive strategy: a new medical arms race? *Health Services Research*, 2003. 38(1 Pt 2): p. 447-469.

45. Diez Roux, A.V., Invited commentary: places, people, and health. *American Journal of Epidemiology*, 2002. 155(6): p. 516-519.

46. Donabedian, A., Evaluating the quality of medical care. 1966. *Milbank Quarterly*, 2005. 83(4): p. 691-729.

47. Epstein, A.M., et al., Analysis of early accountable care organizations defines patient, structural, cost, and quality-of-care characteristics. *Health Affairs*, 2014. 33(1): p. 95-102.

48. Finkelstein, E.A., et al., Annual medical spending attributable to obesity: payer-and service-specific estimates. *Health Affairs*, 2009. 28(5): p. w822-831.

49. Fisher, E.S., et al., Creating accountable care organizations: the extended hospital medical staff. *Health Affairs*, 2007. 26: p. w44-57.

50. Fisher, E.S., S.M. Shortell, and L.A. Savitz, Implementation Science: A Potential Catalyst for Delivery System Reform. *JAMA: The Journal of the American Medical Association*, 2016. 315(4): p. 339-340.

51. Frakt, A., The Downside of Merging Doctors and Hospitals, in *TheUpshot*. 2016, The New York Times.

52. Frakt, A.B. and R. Mayes, Beyond capitation: how new payment experiments seek to find the 'sweet spot' in amount of risk providers and payers bear. *Health Affairs*, 2012. 31(9): p. 1951-1958.

53. Frakt, A.B., Determining Value and Price in Health Care. *JAMA: The Journal of the American Medical Association* , 2016. 316(10): p. 1033-1034.

54. Garabedian, L.F., et al., Potential bias of instrumental variable analyses for observational comparative effectiveness research. *Annals of Internal Medicine*, 2014. 161(2): p. 131-138.

55. Grider, J.S., et al., Economic impact of converting an interventional pain medicine physician office-based practice into a provider-based ambulatory pain practice. *Pain Physician*, 2014. 17(3): p. E253-261.

56. Harris, L.J., et al., Characteristics of Hospital and Emergency Care Super-utilizers with Multiple Chronic Conditions. *Journal of Emergency Medicine*, 2016. 50(4): p. e203-214.

57. Healthcare Cost and Utilization Project (HCUP). HCUP Elixhauser Comorbidity Software (Version 3.7). June 2017; Available from: www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp.

58. Healthcare Cost and Utilization Project (HCUP). HCUP CCS (2015). March 2017; Available from: www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp.

59. Henke, R.M., et al., Impact of Health System Affiliation on Hospital Resource Use Intensity and Quality of Care. *Health Services Research*, 2016.

60. Hesselink, G., et al., Improving patient handovers from hospital to primary care: a systematic review. *Annals of Internal Medicine*, 2012. 157(6): p. 417-428.

61. Higgins, A., et al., Early lessons from accountable care models in the private sector: partnerships between health plans and providers. *Health Affairs*, 2011. 30(9): p. 1718-1727.

62. Hruby, M., S.Z. Pantilat, and B. Lo, How do patients view the role of the primary care physician in inpatient care? *Disease-a-Month*, 2002. 48(4): p. 230-238.

63. Huber, P.J. *The behavior of maximum likelihood estimates under nonstandard conditions*. in *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability, Volume 1: Statistics*. 1967. Berkeley, Calif.: University of California Press.

64. Huskamp, H.A., et al., Effects of Global Payment and Accountable Care on Tobacco Cessation Service Use: An Observational Study. *Journal of General Internal Medicine*, 2016.

65. Hwang, W., et al., Effects of integrated delivery system on cost and quality. *American Journal of Managed Care*, 2013. 19(5): p. e175-184.

66. Kautter, J., et al., The HHS-HCC risk adjustment model for individual and small group markets under the Affordable Care Act. *Medicare & Medicaid Research Review*, 2014. 4(3).

67. Kleiman, M.A., Provider integration: PO (physician organization) versus PHO (physician hospital organization). *Healthcare Financial Management*, 1995. 49(6): p. 22, 24.

68. Kocher, R. and N.R. Sahni, Physicians versus hospitals as leaders of accountable care organizations. *The New England Journal of Medicine*, 2010. 363(27): p. 2579-2582.

69. Kocher, R. and N.R. Sahni, Hospitals' race to employ physicians--the logic behind a money-losing proposition. *New England Journal of Medicine*, 2011. 364(19): p. 1790-1793.

70. Kocher, R. and N.R. Sahni, Hospitals' race to employ physicians--the logic behind a money-losing proposition. *The New England Journal of Medicine*, 2011. 364(19): p. 1790-1793.

71. Konetzka, R.T., E.A. Stuart, and R.M. Werner, The effect of integration of hospitals and post-acute care providers on Medicare payment and patient outcomes. *Journal of Health Economics*, 2018.

72. Le Cook, B., et al., Comparing methods of racial and ethnic disparities measurement across different settings of mental health care*. Health Services Research*, 2010. 45(3): p. 825-847.

73. Leibenluft, R.F., ACOs and the enforcement of fraud, abuse, and antitrust laws*. New England Journal of Medicine*, 2011. 364(2): p. 99-101.

74. Lewis, V.A., et al., Accountable Care Organizations in the United States: market and demographic factors associated with formation*. Health Services Research*, 2013. 48(6 Pt 1): p. 1840-1858.

75. Lewis, V.A., et al., Accountable Care Organizations in the United States: market and demographic factors associated with formation*. Health Services Research*, 2013. 48(6 Pt 1): p. 1840-1858.

76. Macinko, J., B. Starfield, and L. Shi, Quantifying the health benefits of primary care physician supply in the United States*. International Journal of Health Services*, 2007. 37(1): p. 111-126.

77. Madison, K., Hospital-physician affiliations and patient treatments, expenditures, and outcomes*. Health Services Research*, 2004. 39(2): p. 257-278.

78. Marmor, T. and J. Oberlander, From HMOs to ACOs: The Quest for the Holy Grail in U.S. Health Policy*. Journal of General Internal Medicine*, 2012. 27: p. 1215-1218.

79. Maybury, R.S., D.C. Chang, and J.A. Freischlag, Rural hospitals face a higher burden of ruptured abdominal aortic aneurysm and are more likely to transfer patients for emergent repair*. Journal of the American College of Surgeons*, 2011. 212(6): p. 1061-1067.

80. McGlynn, E., P. Shekelle, S. Chen, G. Goldman, J. Romley, P. S. Hussey,H. de Vries, M. Wang, M. Timmer, J. Carter, C. Tringale, and R. Shanman, Health Care Efficiency Measures: Identification, Categorization, and Evaluation. 2008, AHRQ.

81. McKellar, M.R., et al., Geographic Variation in Health Care Spending, Utilization, and Quality Among the Privately Insured. 2012, Harvard Medical School Department of Health Care Policy.

82. McWilliams, J.M., et al., Delivery system integration and health care spending and quality for Medicare beneficiaries*. JAMA Internal Medicine*, 2013. 173(15): p. 1447-1456.

83. McWilliams, J.M., et al., Performance differences in year 1 of pioneer accountable care organizations. *New England Journal of Medicine*, 2015. 372(20): p. 1927-1936.

84. McWilliams, J.M., et al., Early Performance of Accountable Care Organizations in Medicare. *New England Journal of Medicine*, 2016. 374: p. 2357-2366.

85. Mechanic, R.E., et al., Medical group responses to global payment: early lessons from the 'Alternative Quality Contract' in Massachusetts. *Health Affairs*, 2011. 30(9): p. 1734-1742.

86. Menec, V.H., et al., Does the relationship between neighborhood socioeconomic status and health outcomes persist into very old age? A population-based study. *Journal of Aging and Health*, 2010. 22(1): p. 27-47.

87. Muhlestein, D., Growth And Dispersion Of Accountable Care Organizations In 2015, in *Health Affairs Blog*. 2015.

88. Muhlestein, D. and M. McClellan, Accountable Care Organizations In 2016: Private And Public-Sector Growth And Dispersion, in *Health Affairs Blog*. 2016, Health Affairs.

89. Muhlestein, D.B. and N.J. Smith, Physician Consolidation: Rapid Movement From Small To Large Group Practices, 2013-15. *Health Affairs*, 2016. 35(9): p. 1638-1642.

90. Neprash, H.T., et al., Association of Financial Integration Between Physicians and Hospitals With Commercial Health Care Prices. *JAMA Internal Medicine*, 2015. 175(12): p. 1932-1939.

91. Neprash, H.T., et al., Measuring Prices in Health Care Markets Using Commercial Claims Data. *Health Services Research*, 2015. 50(6): p. 2037-2047.

92. Neprash, H.T., M.E. Chernew, and J.M. McWilliams, Little Evidence Exists To Support The Expectation That Providers Would Consolidate To Enter New Payment Models. *Health Affairs*, 2017. 36(2): p. 346-354.

93. O'Malley, A.S., A.M. Bond, and R.A. Berenson, Rising hospital employment of physicians: better quality, higher costs? *Issue brief*, 2011(136): p. 1-4.

94. Office of the Attorney General of Massachusetts, Examination of Health Care Cost Trends and Cost Drivers. June 2011. https://www.massdigitalhealth.org/sites/mehi/files/documents/Health%20Care%20Costs%20Trends%20and%20Cost%20Drivers%202011.pdf

95. Ortiz, J., et al., Primary Care Clinics and Accountable Care Organizations. *Health Services Research and Managerial Epidemiology*, 2015. 2.

96. Palmer, S. and D.J. Torgerson, Economic notes: definitions of efficiency. *BMJ: British Medical Journal*, 1999. 318(7191): p. 1136.

97. Pesko, M.F., et al., Spending per Medicare Beneficiary Is Higher in Hospital-Owned Small- and Medium-Sized Physician Practices. *Health Services Research*, 2017.

98. Pickett, K.E. and M. Pearl, Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. *Journal of Epidemiology and Community Health*, 2001. 55(2): p. 111-122.

99. Pourhoseingholi, A., et al., Statistical count models for prognosis the risk factors of hepatitis C. *Gastroenterology and Hepatology from Bed to Bench*, 2013. 6(1): p. 41-47.

100. Prasad, S., et al., Rural Hospital Employment of Physicians and Use of Cesareans and Nonindicated Labor Induction. *Journal of Rural Health*, 2018. 34 Suppl 1: p. s13-s20.

101. Reinhardt, U.E., Competition's Shortcomings in Curtailing Health Care Costs, in *Economix*. 2010.

102. Reschovsky JD, W.C., Location, Location, Location: Hospital Outpatient Prices Much Higher than Community Settings for Identical Services. 2014, Mathematica Policy Research.

103. Rittenhouse, D.R., et al., Improving chronic illness care: findings from a national study of care management processes in large physician practices. *Medical Care Research and Review*, 2010. 67(3): p. 301-320.

104. Robinson, J.C., Hospital market concentration, pricing, and profitability in orthopedic surgery and interventional cardiology. *American Journal of Managed Care*, 2011. 17(6 Spec No.): p. e241-248.

105. Robinson, J.C. and K. Miller, Total expenditures per patient in hospital-owned and physician-owned physician organizations in California. *JAMA:*

The Journal of the American Medical Association, 2014. 312(16): p. 1663-1669.

106. Scheffler, R.M., S.M. Shortell, and G.R. Wilensky, Accountable care organizations and antitrust: Restructuring the health care market. *JAMA: The Journal of the American Medical Association*, 2012. 307(14): p. 1493-1494.

107. Schneider, J.E., et al., The effect of physician and health plan market concentration on prices in commercial health insurance markets. *International Journal of Health Care Finance and Economics*, 2008. 8(1): p. 13-26.

108. Scott, K.W., et al., Changes in Hospital-Physician Affiliations in U.S. Hospitals and Their Effect on Quality of Care. *Annals of Internal Medicine*, 2017. 166(1): p. 1-8.

109. Seidman, J. and N. Ganesan, Payment Reform on the Ground: Lessons from the Blue Cross Blue Shield of Massachusetts Alternative Quality Contract. 2015, Avalere Health LLC.

110. Sharp, A.L., et al., The effect of bundled payment on emergency department use: alternative quality contract effects after year one. *Academic Emergency Medicine,* 2013. 20(9): p. 961-964.

111. Shortell, S.M. and L.P. Casalino, Health care reform requires accountable care systems. *JAMA: The Journal of the American Medical Association*, 2008. 300(1): p. 95-97.

112. Shortell, S.M., L.P. Casalino, and E.S. Fisher, How the center for Medicare and Medicaid innovation should test accountable care organizations. *Health Affairs*, 2010. 29(7): p. 1293-1298.

113. Shortell, S.M., et al., Physician practice participation in accountable care organizations: the emergence of the unicorn. *Health Services Research*, 2014. 49(5): p. 1519-1536.

114. Shortell, S.M., et al., A taxonomy of accountable care organizations for policy and practice. *Health Services Research*, 2014. 49(6): p. 1883-1899.

115. Shortell, S.M., et al., Accountable Care Organizations: The National Landscape. *Journal of Health Politics, Policy and Law*, 2015. 40(4): p. 647-668.

116. Shortell, S.M., Applying Organization Theory to Understanding the Adoption and Implementation of Accountable Care Organizations: Commentary. *Medical Care Research and Review*, 2016. 73(6): p. 694-702.

117. Singleton, T. and P. Miller, The Physician Employment Trend: What You Need to Know. *Family Practice Management*, 2015. 22(4): p. 11-15.

118. Song, Z., et al., Health care spending and quality in year 1 of the alternative quality contract. *The New England Journal of Medicine*, 2011. 365(10): p. 909-918.

119. Song, Z., et al., The 'Alternative Quality Contract,' based on a global budget, lowered medical spending and improved quality. *Health Affairs*, 2012. 31(8): p. 1885-1894.

120. Song, Z., et al., Global Budgets and Technology-Intensive Medical Services. *Healthcare (Amsterdam, Netherlands)*, 2013. 1(1-2): p. 15-21.

121. Song, Z., et al., Changes in health care spending and quality 4 years into global payment. *New England Journal of Medicine*, 2014. 371(18): p. 1704-1714.

122. Song, Z. and D.A. Chokshi, The role of private payers in payment reform. *JAMA: The Journal of the American Medical Association*, 2015. 313(1): p. 25-26.

123. Staiger, D. and J.H. Stock, Instrumental Variables Regression with Weak Instruments. *Econometrica*, 1997. 65(3): p. 557-586.

124. Stamp, K.D., M.A. Machado, and N.A. Allen, Transitional care programs improve outcomes for heart failure patients: an integrative review. *Journal of Cardiovascular Nursing*, 2014. 29(2): p. 140-154.

125. Terza, J.V., A. Basu, and P.J. Rathouz, Two-stage residual inclusion estimation: addressing endogeneity in health econometric modeling. *Journal of Health Economics*, 2008. 27(3): p. 531-543.

126. Terza, J.V., Two-Stage Residual Inclusion Estimation in Health Services Research and Health Economics. *Health Services Research*, 2018. 53(3): p. 1890-1899.

127. The Center for Consumer Information & Insurance Oversight. 2014 Benefit Year Risk Adjustment HHS-Developed Risk Adjustment Model Algorithm

Software. June 2, 2014; Available from: https://www.cms.gov/CCIIO/Resources/Regulations-and-Guidance/.

128. van Walraven, C., et al., The association between continuity of care and outcomes: a systematic and critical review. *Journal of Evaluation in Clinical Practice*, 2010. 16(5): p. 947-956.

129. Wheeler, J.R., T.M. Wickizer, and S.M. Shortell, Hospital-physician vertical integration. *Hospital and Health Services Administration*, 1986. 31(2): p. 67-80.

130. White, H., A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, 1980. 48(4): p. 817-838.

131. Workforce, B.o.H. 2010.

132. Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE), 2016 All-Cause Hospital-Wide Measure Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Readmission Measure – Version 5.0. March 2016.

133. Yeager, V.A., Y. Zhang, and M.L. Diana, Analyzing Determinants of Hospitals' Accountable Care Organizations Participation: A Resource Dependency Theory Perspective. *Medical Care Research and Review*, 2015. 72(6): p. 687-706.

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