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Can We Quantify the Benefits of IT-Enabled Chronic Disease Management?

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Abstract

The treatment of chronic diseases consumes 86% of U.S. healthcare costs, and yet the U.S. lags in patient outcomes for chronic diseases compared with other industrialized nations that spend far less per capita on healthcare. Initiatives intended to stem the rapid increase in healthcare costs, such as the 2009 Affordable Care Act (ACA), have not resulted in meaningful improvements to population-level health outcomes or to reductions in per capita costs. We build on prior healthcare research to develop an A-B-C framework, which suggests that chronic diseases with the highest potential for disease state management are those with high (A)voidable costs, available (B)iomarkers to monitor the patient's status, and a strong (C)linical understanding to manage the disease. We apply the framework using data on diabetic patients from the U.S. state of Vermont Blueprint for Health (VBH) initiative, which included a significant implementation of information technology (IT) and data analytics.

Keywords

Healthcare, cost, chronic, disease, diabetes, quality, value.

Introduction

Healthcare costs in the United States consume 17% of gross domestic product (GDP) and rank highest among countries in the Organization for Economic Cooperation and Development (data.oecd.org). The treatment of chronic diseases consumes 86% of U.S. healthcare costs (cdc.gov), and yet the U.S. lags in patient outcomes for chronic diseases compared with other industrialized nations that spend far less per capita on healthcare (Papanicolas, Woskie and Kha 2018). To stem the rapid increase in healthcare costs, the U.S. is embarking on multiple national initiatives including the 2009 Affordable Care Act (ACA). While the ACA's broad objectives are consistent with the Institute for Healthcare Improvement's Triple Aim "Better care for individuals, better health for populations, and lower per capita costs" (ihi.org), these broad objectives do not provide much implementation guidance for parties 'on the ground' to meet the objectives. As a result, 'on the ground' parties such as federal and state governments, insurers (payers), and hospitals (providers), have promoted various 'value-based healthcare' initiatives. However, a full decade after passage of the ACA, these initiatives have not yet resulted in meaningful improvements to population-level health outcomes or to reductions in per capita costs.

With respect to chronic disease, there are three primary reasons why disparate 'value-based healthcare' initiatives have not improved health outcomes or reduced costs. First, the costs of screening and prevention can be very high when applied to all patients. For example, mammograms to screen for breast cancer increase overall healthcare costs while providing only a small improvement in health outcomes (Schousboe, Kelikowske, Loh and Cummings 2011). Second, many chronic disease conditions are not well-understood by prevailing medical science, and efforts to prevent or manage the condition are often futile. For example, regular screenings for Alzheimer's disease have had virtually no effect on patient

outcomes, resulting in higher costs even as provider attempts to forestall disease progression have not been successful (Folch, Petrov, Ettcheto, Abad and Sanchez-Lopez 2016). Third, some disease conditions manifest as long periods of time with no worsening of symptoms followed by the 'sudden' onset of more severe symptoms. Many of these disease conditions have few reliable tests to measure a patient's current status to justify preventive interventions. For example, chronic obstructive pulmonary disease (COPD) can be diagnosed, but treatment is typically palliative where providers react to advancing symptoms rather than being able to halt or reverse disease progression.

In this context, value-based health initiatives are challenging for providers because they are typically structured to reward providers who meet or exceed quality standards while reducing the total cost of care (Rosenthal, Cutler and Feder 2011). To achieve higher quality, providers focus on activities they can control such as improving the patient experience, avoiding infections and readmissions, and eliminating medication errors. Cost containment efforts focus on sources of waste and inefficiency that are under the provider's control. However, these 'direct cost' savings programs are typically structured such that the impact on reimbursable clinical activities is minimal and rarely results in consistent savings (McWilliams, Hatfield, Chernew, Landon and Schwartz 2016). For example, direct cost savings programs might focus on eliminating waste from inefficient processes that use high-cost resources such as ambulatory services, operating room suites, excess inventory, and unnecessary tests and procedures. As a result, there are some one-time savings in the short-term, but those savings do not recur over time.

In contrast, 'indirect cost' savings programs are activities such as prevention, routine screening, care coordination, and the integration of healthcare providers, practices and systems. Indirect savings initiatives are much more effective mechanisms to improve population health and reduce healthcare costs, especially costs related to chronic disease (Leung, Rubenstein, Yoon, Post, Jaske, Wells and Trivedi 2019). Unfortunately, healthcare providers are reluctant to implement indirect cost savings initiatives. Due to the design of reimbursement contracts, providers bear the expenses associated with cost savings initiatives, but are not compensated or reimbursed for undertaking these activities. Indirect cost savings programs require providers to invest time and money upfront on delivery process reconfiguration, information and communication technologies, and recruitment and training of staff patient care teams. However, the benefits associated with these upfront investments may (or may not) accrue until years later. Since the cost savings do not materialize during the defined time frame of contractual arrangements with payers, the provider's efforts to improve population health do not result in tangible benefits or bonuses for the provider.

This presents a conundrum. The long-term goal of value-based healthcare is to achieve lower healthcare costs by avoiding chronic disease if possible or effectively managing chronic disease when it does appear. However, the structure of value-based healthcare arrangements creates a disincentive for providers to work towards that goal. Even worse, if providers were successful in their collective efforts to reduce chronic disease, this success would reduce their future revenue streams. So, providers would not receive any near-term benefits from their upfront investments, and they would also diminish their longer-term revenue.

We argue that moving past this roadblock requires progress on two fronts: a) making a formal distinction between population health management and traditional healthcare services, and b) developing a framework to support the efficient allocation of population health investments to conditions with high potential for prevention and disease management.

Population Health vs. Healthcare

Healthcare providers are sometimes described as 'sick care' providers because they focus on treating patients who are already diagnosed with a disease (Menino and Johnson 2012). This critique may be unfair, because healthcare providers are doing what they were asked to do and what they are paid to do. Society does ask healthcare providers to eliminate waste and clinical mistakes, but mainly aspires to advanced medical science and high-quality healthcare services. For example, a review of the National Institute of Health's shows 80% of the $39.2 billion allocated to research grants was to support discovery of new disease-specific interventions while only 20% was allocated to prevention research.

Managing the health of a population in general, and addressing the public menace of chronic disease in particular, are fundamentally different challenges than the treatment of diagnosed disease complications. Managing chronic disease requires far more outreach, education, screening, community support programs, and addressing of societal barriers to healthcare, including a lack of access to food, housing, transportation and finances. Ironically, many of the initiatives and programs to prevent or reverse chronic disease require very little provider involvement. Instead, chronic disease management requires different skill sets, capabilities, community partners, and performance metrics than the delivery of traditional healthcare services (Huard 2018). Many value-based health initiatives expect providers to develop effective programs using only slack resources left over after being reimbursed for the delivery of traditional healthcare services. In reality, chronic disease management programs to improve population health will require substantial new investments. However, investments in population health and chronic disease management represent another healthcare-related expense, adding more cost to an already costly system. As a result, providers and payers will need a framework to guide their investment decisions.

A Framework to Allocate Public Health Investments

This paper develops and tests a framework to help payers and providers develop shared priorities and actions that will support progress towards value-based health objectives. Our framework articulates a methodology through which payers and providers can jointly identify opportunities through mutually-agreed evidence that would help payers and providers to improve population-level healthcare outcomes and reduce costs.

We begin by identifying three factors that drive the ability of providers to create value, and we label these factors as A-B-C. First, there must be a high level of (A)voidable costs that can be eliminated or reduced if the disease is properly managed and does not progress to advanced stages. Second, there must be one or more (B)iomarkers that are relatively easy to monitor and accurately identify the patient's current clinical status. Biomarkers are substances that appear in blood or other bodily fluids and tissues that provide chemical indicators which signal the presence and severity of disease. The availability of biomarkers enables practitioners to assess the risk, presence, and likely outcome of the disease, and develop treatment plans accordingly. Third, there must be a high (C)linical understanding of procedures and treatment protocols to alleviate disease progression. By identifying the conditions under which value-based healthcare can have the greatest impact, we provide a template for payers and providers to implement initiatives based on these conditions. By comparing the financial return with the underlying investment, payers and providers are better able to prioritize various initiatives to manage chronic disease.

Creating Value from Improved Management of Chronic Diseases

In the context of chronic disease, the inefficiencies described above are exacerbated by the fact that the 'category' of chronic disease actually represents a range of conditions that are very different in causes, treatments, and the ability of medical science to screen, diagnose, and monitor progression. For example, the medical community has a much better clinical understanding (C in the A-B-C framework of this paper) of the screening, diagnosis and treatment of diabetes than Alzheimer's disease. For diabetes, providers have access to low-cost, easily-administered tests including to screen for the condition and monitor the emergence, progression, and impact on health, with high avoidable costs (A in the A-B-C framework) if the condition is properly monitored. In contrast, Alzheimer's disease is a complex neurological condition that is often only identified after serious symptoms manifest. Further, once diagnosed, there are few treatment options available to mitigate the progression of Alzheimer's disease. In contrast to diabetes, providers have very limited ability to screen, detect, and monitor the progression of Alzheimer's disease or the effectiveness of treatment efforts beyond tracking obvious changes in symptoms.

Providers typically rely on biomarkers to monitor for the presence and progression of a disease. In the case of diabetes, biomarkers (B in the A-B-C framework) such as blood glucose levels, percentage of glycosylated hemoglobin (HbA1C), and urine glucose levels give providers the ability to closely monitor the presence and severity of the condition. In contrast, Alzheimer's disease is not well-understood and there are no biomarker tests currently available to help providers obtain a similar level of insight. The

ability for providers to alter the progression of a disease and accurately measure that progression are important considerations for value-based health initiatives, because a substantial investment requires an a priori expectation that disease progression will slow and costs will be avoided.

The ability to fairly compensate providers for the value they create is important because while improving chronic disease management can result in lower healthcare costs, it also requires changes to processes and/or human resources that can be costly to develop and maintain over time. One of the greatest challenges in healthcare is that most payment systems compensate providers only for tests and procedures they perform to treat healthcare ailments, with very little payment to prevent/screen for disease or to mitigate disease progression. This challenge is exacerbated by the fact that many patients with chronic disease face social barriers such as inadequate financial resources, unreliable transportation, and uncertainty over access to employer-sponsored health insurance that make it difficult to comply with the plan of care (Rosner 2006).

Helping patients obtain the resources they need to fully engage in the plan of care is often overlooked because the associated costs are not considered 'traditional' healthcare services and are not reimbursed by payers. The Vermont Blueprint for Health, described in more detail in the next section, includes initiatives that are specifically designed to fill this gap. For example, Vermont implemented an initiative to monitor diabetes patients with a HbA1C level over 8.0 who did not visit a medical home for three months, and this monitoring and follow-up helped to reduce the number of patients with uncontrolled diabetes and no visits for three months by 45% during 2015 (Vermont Blueprint for Health 2015).

IT-Enabled Vermont Blueprint for Health

The Vermont Blueprint for Health (VBH) is a state-led program designed to transform healthcare delivery. The VBH foundation is the local network of project managers, practice facilitators, and community health team leaders who work with patient-centered medical homes (PCMH), community health teams (CHT), and local health and human services leaders. This local network allows for rapid response to Vermont's health priorities through statewide implementation of new initiatives. BH programs and practitioners are continuously informed by comprehensive evaluations of healthcare quality and outcomes at the practice, community and state levels, and by information sharing across multiple providers and payers.

Supporting these information flows and integrating the information flows into care delivery workflows required two major efforts. The first effort was a significant investment in IT infrastructure and migration of practices from basic EMRs, which were not able to share data with or receive data from other organizations, to a new integrated platform. The second effort was the creation of incentives to encourage information sharing and direct provider efforts toward population health management and wellness efforts, rather than reactive treatment of diseases and their symptoms.

Incentives were structured at three levels. At the first level, all certified PCMHs received $2.50 per-member, per-month (PMPM) to offset costs associated with more proactive care. The second level was incentives for information sharing. Once a practice was certified as a PCMH, it could receive an additional $0.50 PMPM to report quality measures through the Vermont Health Information Exchange (VHIE) network, which typically required changes related to systems connectivity and data semantics. The VBH supported the information systems changes, but practices could still incur some costs. Once the changes were made, the practice was able to share and receive patient information with all payers and providers that were part of the VHIE network, as well as total cost of care data from the Vermont All-Payer Claims Database (APCD).

The third level of incentives was the ability to use CHTs and care coordinators at no cost. Care coordinators coordinate activities among the patient, PCMH, and any needed outside support services. CHTs were in the field, checking on high-risk patients and notifying the care coordinator and/or PCMH of any concerns regarding the patient's status. All of those activities were recorded in the EMR, which enabled physicians to spend more time with the patient and less time entering data, which improved quality and enhanced productivity. These support services were funded by payers, as Vermont law required each payer to contribute $350,000 to fund five full-time positions per 20,000 covered members.

Diabetes care is one example of an initiative supported by the VBH. Type 2 diabetes is a widespread chronic condition associated with 20% of healthcare costs in the U.S. (Simcoe, Catillon and Gertler 2019).

There is a strong clinical understanding (C in A-B-C framework), and in most cases treatment is straightforward. Moreover, there are routine blood tests that can determine with high certainty whether the current treatment is effectively managing the disease. The most frequently-used test measures the biomarker (B in A-B-C framework) concentration of HbA1C in the blood. Concentrations higher than 6.5% provide strong evidence that the condition is not being well managed, and that the treatment therapy should be changed. PCMHs seek to identify the condition as early as possible and provide aggressive treatment to minimize or halt disease progression and the resulting comorbid conditions.

Simultaneously, CHTs and local health services agencies actively engage in education efforts, such as workshops that help individuals understand the lifestyle changes to improve their health status and the importance of adherence to the plan of care. CHTs monitor the patient condition, and work with patients to ensure that they have the ability to refill prescriptions and keep medical appointments that may require transportation assistance.

Previous research has demonstrated that IT-enabled initiatives such as VBH lead to improved healthcare indicators and lower costs (Thompson, Whitaker, Kohli and Jones 2019), where population-level improvements were associated with increasing use of IT and data analytics to promote information sharing, patient engagement, and provider collaboration. In this paper, we quantify the cost savings and financial returns associated with diabetes care. Consistent with the A-B-C framework in this paper, diabetes is a chronic condition for which long-term costs are high but potentially (A)voidable, (B)iomarkers are available to accurately assess treatment effectiveness, and there is a high (C)linical understanding of treatment protocols.

Data Sources and Sample Selection

We now describe the sources and sample selection methodology for our data that we analyze to demonstrate our A-B-C framework. Our data sources are the Vermont All Payer Claims Database (APCD) and the Vermont Health Information Exchange (VHIE), which together contain medical claims plus the utilization of health and pharmacy services, clinical outcomes, and mandatory quality reporting measures for every Vermont resident that is uninsured, covered by commercial insurance, or covered by Medicaid for the years 2010 – 2015. At the time of this study, the data sources did not include information for Vermont residents covered by Medicare or Medicare Advantage. Total cost of care and utilization of health services are based on actual medical claims data gathered and formatted by the Vermont Department of Public Health.

The data were normalized to control for payer mix effects using the methodology deployed in past research (Finison, Mohlman, Jones, Pinette, Jorgenson, Kinner, Tremblay and Gottlieb 2017). Controlling for payer mix effects eliminates specific industry practices that could bias results. For example, providers negotiate reimbursement rates with each payer separately. A payer covering a relatively small proportion of individuals in a given geographic location will have less negotiating power and therefore pay higher per patient amounts to providers than a payer with a larger market share. Failure to account for the pricing mechanism could lead to erroneous conclusions where providers seemingly reduce total cost of care, when the reduction was actually due to payer mix factors. Cost of care measures are adjusted for the medical inflation rate calculated for the state of Vermont using data from the APCD.

We add three filters to the data to address the research objectives of this paper. First, we focus only on patients and practices located in the four largest Health Service Areas (HSAs) in Vermont – the Burlington HSA, Barre HSA, Rutland HSA, and White River Junction HSA. We focus on the four largest HSAs in Vermont, so that our data more closely represents (as far as possible) other medium and large HSAs in the U.S. The Burlington HSA is by far the largest. Our sample from that HSA includes 193,000 unique members serviced by 165 named VBH practices and a pool of non-VBH practices that are not named. The sample from the other three HSAs includes 180,000 unique members, of which 40% are in Barre, 33% are in Rutland, and 27% are in White River. The members in these three HSAs are serviced by 312 named VBH practices and a pool of non-VBH practices. Noting that the combined population of the three non-Burlington HSAs in our analysis is similar to the Burlington HSA, we perform our tests separately for Burlington, separately for the three other HSAs, and then for all four HSAs together.

Second, we restrict the sample to individuals aged 18 and older, because we want to generate results that are applicable to the U.S. adult population. This filter reduces the Burlington sample to 161,000 members

and the non-Burlington sample to 152,000 members. Third, we restrict the samples to the 61,000 Burlington and 54,000 non-Burlington members who have data for all six years 2010 – 2015 inclusive. This third filter ensures that our analysis is not affected by later entrants to the pool, individuals who moved in or out of the four HSAs during the study timeframe, or individuals who have missing data for other reasons.

The data includes two demographic characteristics – age and gender. An important covariate in the data is the baseline comorbidity index defined by the Aggregated Clinical Risk Grouping (ACRG) score. The ACRG score is an annual measure of the overall health of each individual ranging from 1 (good health) to 9 (poor health). Based on the ACRG scores, we partition individuals into four categories (healthy, minor chronic disease, moderate chronic disease, end-stage). Individuals with ACRG scores of 1 or 2 are considered healthy. These individuals have no medical conditions upon examination or present with a transient, treatable condition such as a sinus infection or the flu. Individuals with ACRG scores of 3 or 4 have minor chronic disease. These individuals are newly diagnosed or have minimally-advanced chronic disease. Individuals with ACRG scores of 5 or 6 have moderate chronic disease. These individuals have some progression in their disease state. Individuals with ACRG scores from 7 to 9 are end-stage with multiple severe chronic, metastatic, or catastrophically-debilitating conditions. Examples would include a diabetic patient that experiences a severe stroke or below-the-knee amputation, or a patient suffering from metastatic cancer or conditions that require extensive medical treatment and support, such as quadriplegia or end-stage Alzheimer's disease. While individuals in the end-stage category may live for many years, it is highly unlikely that efforts to treat the condition will result in lower cost of care over time.

The distribution of members by ACRG score in 2010 across VBH and non-VBH practices for the Burlington and other HSAs show two important facts. First, non-VBH individuals are much more likely to have missing ACRG scores, consistent with the background above that non-VBH practices do not monitor their patients as closely as VBH practices. Second, VBH individuals generally have higher ACRG scores. This indicates that there is no evidence that practices with healthier patients chose to enroll in VBH, which suggests that this confounding factor is not present in our data.

Identifying Diabetic Patients in VBH and non-VBH Practices

The data includes an indicator whether an individual has been designated as diabetic in each year. Individuals are designated as diabetic if they simultaneously meet two conditions. First, their claims data contain any of the relevant ICD-9 (International Classification of Diseases, 9th Revision) diagnostic codes. ICD-9 codes are used for both disease classification and medical billing purposes. These codes are initial diagnostic codes, and on their own do not suggest higher or lower levels of patient acuity or future cost. As the condition progresses and complications arise, providers submit claims based on the codes specific to the additional treatments, procedures, and tests that are needed to address the condition.

The second condition to be designated diabetic in our analysis is that the individual has an ACRG score between 3 and 6 (minor chronic disease or moderate chronic disease, as described above). We drop healthy individuals with ACRG scores of 1 and 2, because these individuals are considered free of any chronic diseases based on medical claims data. We also drop end-stage individuals with ACRG scores of 7 to 9, because these individuals are at a very advanced stage of multiple chronic conditions and may not improve significantly from any value-based health initiatives.

In our analysis, we select only individuals designated as diabetics in 2010, and we measure their outcomes in the remaining five years. As a robustness test, we focus on individuals designated as diabetic in either of the first two years of the sample period (2010 or 2011) and track their experience over the remaining four years, and we achieve similar results. VBH individuals are slightly older and sicker than non-VBH individuals, which indicates a lack of evidence that VBH practices select patients with better health and suggests that this confounding factor does not exist in our data.

There are two variables in the data that measure the efforts of an attending physician to proactively reduce the progression of diabetes in a patient over time. The first variable is an indicator whether an individual received a comprehensive diabetes mellitus (DM) test. We use this variable as a measure of preventive care. The second variable is an indicator whether an individual has a normal level of HbA1C. As mentioned above, a normal level of HbA1C (less than 6.5%) for a diabetic patient provides a clear indicator that the condition is being well managed. Conversely, elevated HbA1C (equal to or greater than

6.5%) is a strong signal for the attending physician to change the current therapy. If elevated HbA1C levels are not reduced in a timely manner, the patient's condition will almost certainly worsen over time.

Descriptive Statistics

The proportion of patients that attend VBH practices steadily increases during the timeframe of this study. For example, in 2010 52%(6,870 out of 13,110) of patients attend VBH practices, and in 2015 66% (8,689 out of 13,110) patients attend VBH practices. The explanation for this steady increase is that more practices in Vermont joined VBH during the timeframe of this study. In terms of gender, about 55% of the patients in our study are female, across years and across VBH and non-VBH practices. In terms of age, the average age of patients in our study is in the low 50s, with a standard deviation in the low 10s, during the entire timeframe of our study and including VBH and non-VBH practices. The comparability in gender and age across VBH and non-VBH practices adds confidence in our ability to generate comparisons between the VBH and non-VBH patients in our study.

Measurement of Value Creation for Diabetes Patients

First, we examine whether VBH practices are more effective than non-VBH practices in keeping the (B)iomarker HbA1C of diabetic patients within normal levels. Second, we examine the manner in which the improvement of blood sugar management for VBH practices will reduce (A)voidable healthcare costs. We use a two-stage modelling framework to perform our analysis. The first stage examines the effect of VBH on the probability of achieving normal HbA1C levels, and the second stage measures the effect of the VBH-induced improvement in normal HbA1C occurrence on annual healthcare costs.

We estimate two such frameworks: 1) a standard instrumental-variable, two-stage least squares (2SLS) model and 2) a treatment-regression model. Both frameworks require the same two assumptions for valid inference. The first assumption is that the assignment of patients to VBH practices must be independent of the potential outcomes for each patient. In other words, VBH practices should not be able to 'cherry-pick' healthier patients or patients that are more disciplined and likely to comply with their treatment plants. We have no reason to believe that this assumption is violated in our setting. If anything, patients attending VBH practices in 2010 were slightly sicker than patients attending non-VBH practices in 2010. The second assumption is that the effect of VBH practice assignment on healthcare costs must occur only through its effect on managing HbA1C levels, conditional on control variables. To make this assumption more reasonable, we include the patient's ACRG score to control for additional time-varying effects of VBH assignment or other factors on the overall health of the patients. We also add control variables for patient age, gender, payer code and year fixed effects.

There is significant migration of patients across practices during the timeframe of our data, and in some cases patients switch from VBH to non-VBH practice or vice versa. For the timeframe of our study, 82% (3,088 out of 3,788) of Burlington patients and 82% (2,541 out of 3,082) of Non-Burlington patients who originally attended VBH practices in 2010 are still attending such practices in 2015. In contrast, only 44% of Burlington and 55% of Non-Burlington patients originally attending non-VBH practices in 2010 still attend non-VBH practices in 2015. This disparity is largely driven by the gradual increase in practices that joined VBH during the timeframe of our study.

Our empirical analysis will provide unbiased estimates of the effect of VBH on diabetic patients, under the assumption that the migration of practices to VBH is not related to the potential outcomes of these patients. We believe that this assumption is reasonable based on the similarity of patients attending each type of practice in 2010.

Diabetes Testing and Management of HbA1C

We estimate models that vary along three dimensions. First, we estimate both linear probability (OLS) and probit models. Second, we define diabetic patients based on their classification in 2010 and in the 2010-2011 period. Third, we estimate each model for patients in Burlington, patients in the other three HSAs, and patients in all four areas combined. The combination of all three dimensions generates 12 separate models that all include the same control variables – patient age, gender, year and payer code fixed effects, and ACRG score.

Regardless of model, the effect of VBH practice on the comprehensive testing is positive, large and statistically significant, and the effect of VBH practice on the successful management of patient HbA1c is positive, large and statistically significant. If we take the linear probability results for patients diagnosed with diabetes in 2010, the probability of a patient in Burlington receiving comprehensive testing increases by about 8%, and the probability of a non-Burlington patient receiving comprehensive testing increases by 16% (about 10% across all four HSAs), relative to the probability of comprehensive testing for patients attending non-VBH practices. The probability of a patient in Burlington diagnosed with diabetes in 2010 having normal levels of HbA1C increases by about 10%, and the probability of a non-Burlington patient having normal level of HbA1C increases by about 13% (about 10% across all four HSAs), relative to the probability of this outcome for patients attending non-VBH practices. This analysis confirms that the presence of a (B)iomarker that can be easily monitored identifies a clinical condition that is amenable to disease state management.

Annual Costs

After establishing the beneficial effects of VBH practice on patient HbA1C levels, we proceed with our second analysis that examines the effect of VBH on total annual healthcare expenses through its effect on the successful management of HbA1C levels. Similar to the models discussed above, we run 12 model variations grouped along three dimensions: 1) two types of two-stage models -- IV vs. treatment regression; 2) 2010 vs. 2010-2011 diabetic designation; and 3) Burlington, non-Burlington, or all HSAs.

Average annual cost savings through improved HbA1C management for a patient in Burlington diagnosed with diabetes in 2010 are about $15,600 per year, and the average annual cost savings for a non-Burlington patient diagnosed with diabetes in 2010 is about $15,000 per year. The average annual savings is about $18,000 per year across all four HSAs, which we note is greater than the annual savings in the Burlington and non-Burlington sub-samples. This result is possible because the coefficients on all control variables are not restricted to be the same in the three cases, and because the IV estimator is nonlinear. These estimates suggest that the upfront costs of VBH and the ongoing incentives paid to VBH practices were extremely effective in reducing the overall healthcare costs associated with diabetic patients in Burlington, the other three HSAs, and all four HSAs combined. There is a large return on these investments in terms of long-term cost savings. This analysis confirms that the presence of high (A)voidable costs for a clinical condition, together with (B)iomarkers and a strong (C)linical understanding creates the conditions under which disease state management can produce a meaningful increase in healthcare outcomes alongside a significant reduction in healthcare costs.

Discussion

This paper introduces a framework to evaluate the disease state management potential for a chronic disease. Our A-B-C- framework suggests that chronic diseases with the highest potential for disease state management are those with high (A)voidable costs, available (B)iomarkers to monitor the patient's status, and a strong (C)linical understanding to manage the disease. We apply the framework using data on diabetic patients from the U.S. state of Vermont Blueprint for Health (VBH) initiative, which included a significant implementation of IT and data analytics.

We develop three important insights based on our empirical analysis. Our first insight can help to address the phenomenon that the U.S. healthcare system currently expends far greater resources to treat existing healthcare conditions than it does to prevent those conditions from occurring in the first place. The U.S. federal government spent $588 billion on Medicare during 2016, and only $724 million for research and related activities (R&RA) on the biological sciences during 2016. And most of the research on biological sciences is for basic research "activity aimed at acquiring new knowledge or understanding without specific immediate commercial application or use," with very little spending to implement treatments that are already known to prevent or stem the advance of chronic diseases that affect a large portion of the U.S. population. We anticipate that this phenomenon occurs because it is easier to measure healthcare costs that are incurred than it is to objectively quantify costs that are avoided, and there is greater political pressure to fix things that are broken than there is to prevent things from breaking in the first place. Our framework and empirical analysis make significant progress on this phenomenon by demonstrating a rigorous and reasonable methodology to quantify avoidable healthcare costs. An advantage of our methodology is that the healthcare procedures to stem the progression of some chronic diseases have been known for 50 years. Our analysis demonstrates a high payoff per dollar of investment, which would

be much greater than the return to existing R&D spending and treatment of complications associated with disease progression.

To illustrate the substantial return on investment in preventative care and support services, consider a large primary care practice with 10 physicians. If we assume that each physician manages 2,000 patients, the practice is responsible for 20,000 individuals. VBH payments are based on the number of individuals attributed to a practice, regardless of whether they are sick. In this example, total payments attributable to the practice would be:

1. $350,000 per year paid by insurance companies to fund community support services,
2. $2.50 per member per month ($30 per member per year) paid to providers for achieving PCMH certification, and
3. $0.50 per member per month ($6 per member per year) paid to providers for meeting technology and reporting standards.

Total costs attributed to the 20,000 patients of this hypothetical practice are $350,000 + ($30 × 20,000) + ($6 × 20,000) = $1,070,000. Our analysis above shows savings of about $18,000 per diabetic patient per year. According to the American Diabetes Association, approximately 9.4% of the U.S. population was diabetic in 2015 (http://www.diabetes.org/diabetes-basics/statistics/). If we assume that the proportion of diabetics is the same for the hypothetical practice in this example, the practice would have 20,000 × 0.094 = 1,880 diabetic patients. Savings of $18,000 per patient would result in total savings of $33,840,000, or a return of $31.63 per dollar invested in wellness and prevention. This impressive return likely understates the value because only one chronic condition is included in the analysis. Nevertheless, it is important to note that the management of a single chronic condition can more than offset the implementation cost of the entire VBH initiative.

Our analysis helps quantify the benefits of a cultural change within the healthcare industry that would prioritize the 'exploitation' of known treatments to a large portion of the population over the 'exploration' of expensive treatments that may apply to only a small segment of the population (March, 1991). While programs such as VBH require complementary investments in IT infrastructure and community health teams, the methodologies for IT infrastructure and community health teams are already known and would yield higher benefits at lower risk than speculative investments in R&D (Thompson, Whitaker, Kohli and Jones, 2019). The real underlying challenges to creating healthcare value are information management, care coordination, and addressing community and societal factors that prevent patients from adhering to the plan of care. Physicians already know what needs to be done – the challenge has been related to lack of insight and surveillance, lack of community partners, and the inability to communicate and coordinate with those partners.

A second insight is that our empirical analysis is based on data from a program that made large upfront infrastructure investments to obtain that data. Presently, coordinated data integration and aggregation across multiple payers and providers are relatively uncommon. While progress in being made, the data integration tends to focus on either the payer or provider side of the healthcare industry. For example, HealtheLink aggregates data across numerous disparate providers in Western New York state to support care coordination and reduce unnecessary tests and procedures. However, the information exchange does not include cost data which is in the possession of payers. The irony is that payers would like providers to improve quality (which providers are aggressively trying to do) and lower costs, but will not share data needed to evaluate economic opportunities and results. While providers could, in theory, share their own financial data, current incentive mechanisms and industry norms discourage the practice. For example, individual providers do not have the incentive to make large upfront investments in healthcare infrastructure, because a reduction in transition to higher ACRG scores will actually reduce the number of high-intervention procedures that are the greatest source of revenue for providers. Some individual providers may even experience a negative return on investment. At the same time, individual insurance companies do not have an incentive to make large investments in healthcare infrastructure, because 1 in 5 U.S. citizens change their insurance company each year. If a payer were to invest a substantial amount in healthcare infrastructure, one of their competitors may be the firm that benefits from the investment. Interestingly, this lack of incentive for individual insurance companies occurs despite that fact that payers would collectively be one of the largest beneficiaries of lower healthcare costs.

Our third insight is the importance of creating frameworks and mechanisms to utilize the integrated provider and payer data to estimate the value created by effective disease prevention and management. For example, our framework shows that a naïve estimate of the value created by the VBH would be on the order of $500 - $700 annually per individual relative to a pool of patients served by traditional PCPs. A slightly more sophisticated analysis comparing only patients with diagnosed chronic disease suggests the VBH practices achieve annual cost reductions of approximately $1,200 to $1,500 per patient while analysis of diabetic patients only, suggests annual cost reductions of $1,200 to $2,100 per patient. However, our analysis of the impact of effectively managing the prognostic biomarker HbA1c shows savings of approximately $18,000 per year. This is not surprising given the cumulative, multi-organ effects of uncontrolled diabetes. However, it highlights the need to measure where and how value is created when treating different conditions as the corresponding importance of supporting effective programs, redesigning ineffective programs to more closely mirror best practices, and investing in medical research to develop more accurate screening, diagnostic, and prognostic biomarkers for the most common health conditions. Using frameworks such as the one developed in this study can reduce costs by improving outcomes, thereby freeing economic resources to support research and treatment of less well-understood diseases.

To conclude, this paper develops and tests a framework for identifying opportunities to create value in healthcare by improving the management and subsequent outcomes of chronic conditions. Utilizing our framework, we identify diabetes as a chronic disease with high potential for effective disease management and cost reduction. Our results show that by integrating provider data, payer data, and medical research to identify conditions with high (A)voidable costs, where reliable prognostic (B)iomarkers are available, and where there is a high (C)linical understanding of disease etiology and management, payers and providers can effectively identify and manage some of the most costly chronic conditions.

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