

“Good-Enough” Risk Adjustment Models for Physician Payment and Performance Assessment

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June 20, 2015

Abstract:

The Affordable Care Act has moved diagnosis-based risk adjustment models to center stage, in part by embracing risk adjustment for health insurance exchanges, but less overtly in its promotion of payment innovations, and increased attention to performance measurement. Almost all system reform innovations, including Affordable Care Organizations (ACOs), Patient Centered Medical Homes (PCMH), and Pay-for-Performance, assume “good enough” risk adjustment models are available for use for payment and performance assessment, but the specifics for creating and evaluating these models, which present formidable challenges, are rarely fleshed out.

A series of published articles (Ash and Ellis, 2012; Ellis and Ash, 2012; Vats et al. 2013) has described and evaluated “good enough” – imperfect but useful and implementable – risk adjustment models for the Primary Care Activity Level (PCAL) models for primary care payment and performance assessment. These primary care payment models described in these papers were developed in collaboration with researchers at Verisk Health, and use the DxCG-HCC classification system to organize diagnostic information. The PCAL payment model is its fifth year of use by one health plan to pay primary care practitioners (PCPs), and was recently recalibrated in preparation for its use by the Massachusetts Medicaid (MassHealth) program in 2015. This paper augments our earlier work by summarizing a variety of alternative formulations underlying that work that we may foster further efforts developing “good enough” risk adjustment models.

We start with a rationale for estimating “good enough” bundled payment models for primary care providers. The 2006-2007 MarketScan Commercial Claims and Encounter data are used to select a sample, estimate payment models, assign patients to unique primary care practitioners (PCPs). An innovation is the creation of representative “pseudo-PCP” panels of patients for each PCP, that includes assigning the 29% of patients who did not see any PCP during a two year period to a PCP practicing in the same county, and combining small panels into broader sets of patients in the same county to more closely mimic typical PCP patient loads of at least 800 patients.

A sensitivity analysis is conducted of nine alternative bundles of services - narrowly to broadly defined-potential useful for primary care payment, and evaluated for their predictiveness, implied financial risk to PCPs, and payment stability over time. Three alternative weighted sums of top-coded services were developed to approximate the burdens facing PCPs for managing well the primary care needs of their patients. For the sample of 436 midsized practices with 500 to 5000 assigned patients, the preferred PCAL model used 653 parameters in a sample of 17.4 million, achieving an R^2 of 67% in average spending at the individual level. The same model explains 72% of the per capita variation for large assigned NEWPCP level, and 82% at the Pseudo-PCP level. Nine performance measures explain meaningful variation when models are customized for the dependent variables.

Diagnosis based risk adjustment models can substantially improve predictions relative to age-sex models, and with careful crafting concurrent models can explain over 50 percent of the practice-level variation, which we believe is sufficient for ensuring the relatively stable payments and performance assessment for measures needed for PCP practices with 500-5000 patients.

1. Introduction

It is increasingly recognized that in order to control costs and improve quality in the US dramatic changes are needed in how primary care medicine is practiced, and many argue that primary care practice reform and changes in payment systems will be the cornerstone of these changes. The Patient Centered Medical Home (PCMH)¹ is the leading example of how practice reform and bundled, comprehensive payment may promote personalized, coordinated care that is cost-effective, efficient, and evidence-based. As advocated in Goroll et al (2007)², carefully constructed, risk adjusted payments will be at the center of payment reform that changes incentives. This paper develops, calibrates and evaluates alternative risk adjustment models that could potentially be used in support of the PCMH or other bundled payment systems for primary care.

As discussed in Goroll (2008) and by others, fee-for-service payment systems reward volume and procedures and underpay for evaluation and management services; in so doing, they are widely viewed as insufficient to incentivize effective primary care. A growing number of researchers and policymakers (Goroll, et al., 2007; Guterman et al, 2009; McCarthy et al, 2009; McGuire 2010, plus others) have argued for a fundamental change in the payment system away from FFS, toward more bundled payments. Fundamental change in primary care payment is also featured prominently in the 2010 Health Care Reform Act.³

¹ Patient Centered Primary Care Collaborative. Joint Principles of the Patient Centered Medical Home. February 2007: <http://www.pcpcc.net/node/14>.

² Goroll AH. The future of primary care: reforming physician payment. N Engl J Med. [2008 Dec 18;359\(25\):2636-9](https://doi.org/10.1056/NEJMoa0809112).

³ The ACA created a new Center for Medicare and Medicaid Innovations and instructs it to select models to test that include “(i) Promoting broad payment and practice reform in primary care, including patient-centered medical home models for high-need applicable individuals, medical homes that address women’s unique health care needs, and models that transition primary care practices away from fee-for-service based reimbursement and toward comprehensive payment or salary-based payment. “(ii) Contracting directly with groups of providers of services and suppliers to promote innovative care delivery models, such as through risk-based comprehensive payment or salary-based payment.

Payment reforms that utilize bundled payments and rewards for desired outcomes are critical for changing incentives. We focus here on per patient per year risk-adjusted base payments models for primary care physicians that could be used in support of a PCMH as envisioned by Goroll (2007), in which a per person per month payment would largely replace rather than simply augment the existing levels of FFS. We leave it for other papers to examine reforms for specialty care, how to create bonus systems in support of comprehensive payment, or other practice reforms that may be required beyond payment reform not because we think they are any less important but because merely developing concepts for a comprehensive base payment model is sufficiently ambitious.

There is growing evidence that the PCMH can control costs and improve quality. Experience with Medical Homes in Louisiana is one prominent example. Another is the widely-reported (e.g.,) June 2009 "White Paper" from Group Health Cooperative (GHC) medical center found their pilot PCMH site demonstration to be cost-neutral within 12 months, despite increased expenses for primary care.⁴ Their PCMH pilot reduced urgent care and hospital use, improved indicators of quality of care, reduced face-to-face visits while increasing e-mail and telephone contacts, and, notably improved both the patient and clinician experience. Based on these findings, GHC plans rapid deployment of its PCMH model to all its clinics. Vats et al (2013) document meaningful savings at a provider network that adopted a PCMH model in 2009. The success of the VA in controlling costs from its innovations is also relevant (XXX cites and updates needed). Rosenthal (2010) provides evidence of cost savings and quality improvements from Geisinger health plan use of payment reform. There have been several recent reviews of PCMH demonstrations with mixed results (cites XXX).

The remainder of this paper is organized as follows. In the next section we discuss the conceptual framework and model to be used. The subsequent section briefly describes the data being

⁴ <http://www.scienceblog.com/cms/group-health-cooperative-shows-investing-more-primary-care-pays-itself-22376.html>

used and our sample selection criteria. The breadth of services, the information used, and the modeling framework are all considered. The fourth section presents the results from empirical estimates of a feasible base payment model, and contrasts the models in terms of its predictive power and robustness at the individual level. The fifth section discusses our approach to assigning patients uniquely to primary care practitioners (PCPs) and evaluates the predictive model at the PCP level. While patients can only be imperfectly assigned, some mechanism is needed in the interim to evaluate primary care payment models until such time as large samples are available on which to both calibrate models and evaluate their implications for real panels of patients assigned to actual physicians.

The next section presents a sensitivity analysis by comparing the estimated PCAL model to two alternative specifications. Three models are evaluated for their predictiveness, the financial risk imposed on PCPs, and the payment stability at the PCP (rather than the individual). The final section of the paper discusses some of the limitations of the model, implementation issues, and needs for further research.

2. Conceptual framework

Motivation

It is conceptually clear that fee-for-service (FFS) payments that reward volume and intensive interventions while underpaying for primary care evaluation, management and preventive services do not encourage or support the coordinated care that could prevent or delay disease progression and reduce "downstream" needs for intensive services.^{5,6} In contrast, an appropriately resourced and organized primary care team, operating as a patient-centered medical home (PCMH), should be able to

⁵ Goroll, Allan H., Berenson, Robert A., Schoenbaum, Stephen C., and Gardner, Laurence B. "Fundamental Reform of Payment for Adult Primary Care: Comprehensive Payment for Comprehensive Care." *J Gen Intern Med.* 2007 March; 22(3): 410–415.

⁶ Goodson, John D. "Unintended Consequences of Resource-Based Relative Value Scale Reimbursements." *JAMA*, November 21, 2007. 298 (19): 2308-2310.

deliver good value for society, reducing other health care spending by encouraging more prudent patterns of use and improving population health. Payment reform is essential for practice reform.⁷

The PCMH model, like most proposed reforms of health care delivery in the US, relies for its success upon being able to calculate, *for specific panels of patients*, what resources are needed for their care and what outcomes to expect under good care. Such calculations, at the individual level, are commonly called risk adjustment. Risk adjustment can compensate providers for the difficulty of managing the sickest and most challenging patients (and avoid overcompensating for healthy ones); it is also needed to make assessments of provider "outcomes" (quality measures) reflect the difficulty of achieving those outcomes *with their patients*.

The Patient Centered Medical Home (PCMH)⁸ is used broadly to refer to a practice model that delivers personalized, coordinated, comprehensive, evidence-based care to a defined population (panel) of patients. In a PCMH, a mixed clinical team assisted by health information technology collaborates in managing care for a patient panel. Implementing the PCMH and achieving its comprehensive care goals requires a net investment in, and restructuring of, medical practice.⁹ A clear overview of the many challenges to creating a PCMH is provided in an unpublished summary from the Society of General Internal Medicine (SGIM) based on meetings in October 7, 2008.¹⁰

The Risk-Based Comprehensive Payment system envisioned by Allan Goroll and the MA CPR relies on bundled payment, which replaces FFS's volume-based incentives with payments that support comprehensive, patient-centered primary care. The comprehensive payment will include 1) a risk-

⁷ Guterman, S., K. Davis, C. Schoen, and K. Stremikis, Reforming Provider Payment: Essential Building Block for Health Reform, The Commonwealth Fund, March 2009

⁸ Patient Centered Primary Care Collaborative. Joint Principles of the Patient Centered Medical Home. February 2007: <http://www.pcpcc.net/node/14>.

⁹ Ibid.

¹⁰ Society of General Internal Medicine (SGIM) "Emerging Themes: Developing a Policy Relevant Research Agenda for the PCMH." (Working paper, circa November, 2008.)

adjusted “base” payment to the practice that ensures adequate financial resources to meet the needs of the practice’s patients, and 2) a potentially substantial (up to 25%) supplemental bonus for achieving desired outcomes in quality, patient experience, and cost-effectiveness. This system differs from many pay for performance approaches by tying these bonus rewards to measurable outcomes *that are compared to risk-adjusted expected outcomes* rather than specifying one-size-fits-all performance targets. (For example, this approach would not count each patient with diabetes as a success if and only if the HbA1c is below 7). Using risk-adjusted expected outcomes rather than clinically determined performance targets also has the important value of enabling us to calculate measures immediately rather than wait for clinical or policy guidelines to become established.

In this paper we focus on the calculation of the base payment amount, which primary care practices would receive largely in place of their current FFS payments. For concreteness, it is useful to think of this payment as reflecting about 75 percent of total practice compensation, with the remainder being in the form of bonus (incentive) payments that reward specific performance achievements. There is nothing inherent in the results presented that requires this proportional allocation, however, and the models developed could be used for other allocations as well.

Any diagnosis-based classification could be used to generate risk-adjusted base payments and bonus measures. We use the DxCG/HCC system, refined from the model we originally developed for the Medicare program; it has been repeatedly validated as robust and predictive, and the first two authors of this paper are key developers of the classification system. Diseases and health conditions (ICD codes) are organized using DxCG’s Hierarchical Condition Category (HCC) classifications, Version 7.0, which distinguishes 394 distinct condition categories that are arranged hierarchically according to their severity and expected costs. Published and unpublished work by Verisk Health (formerly DxCG), have documented estimated risk adjustment models for PCMH base payments using very large insurance

claims datasets. These models are based on the age, sex, and disease profile of each patient in a primary care doctor's panel. While the factors used to predict resource needs and expected outcomes should eventually be expanded, we have found these HCC models to be highly predictive. While future models may ultimately rely on a richer set of data from electronic health records, at this point, only insurance claims and encounter data contain comprehensive data on very large samples that are highly comparable across provider groups. This paper focuses only on claims and encounter based predictive models.

Fundamental challenges for bundled payment for primary care

In developing bundled payment models for primary care, a series of challenges must be addressed. The four challenges that we address in this paper are defined in the following Table 1.

Table 1 Fundamental questions to answer in calibrating and evaluating bundled payment for primary care

- 1. Definition of a PCP:** Who is to be considered a primary care practitioner (PCP) eligible for bundled payment?
- 2. Patient-PCP assignment problem:** How are patients assigned to PCPs given that under the existing, fragmented US health care delivery system patients often see multiple PCPs or no PCPs during a one-year period?
- 3. Primary care core services:** What services will no longer be allowed to be billed for on a FFS basis?
- 4. Primary Care Activity Level:** What weighted sum of existing services best approximates the level of resources needed in order to appropriately treat a given patient?
- 5. Primary care services not from the assigned PCP:** How will bundled payments be adjusted when a patient receives primary care from a provider is not the assigned PCP.

The primary focus here is on the fourth item, identifying the a useful set of resources that captures the resource PCP needs of diverse patients. We do not make any original contributions here on

the other topics other than having to address them in developing and evaluating our alternative PCAL models. For the definition of who is considered a PCP, we limit our analysis to include only physicians in four specialties: family practice, internal medicine, gerontology, and pediatrics. For the patient-PCP assignment problem, discussed extensively below, we match patients to PCPs using an empirical algorithm, rather than requiring patients or physicians to enroll or self-identify their assignments. This broadens the applicability of our models even while introducing some imprecision in the patient-PCP assignment, which we discuss below. The identification of primary care core services is discussed below, as are alternatives for paying for services procured from other than the assigned PCP.

Our distinction between primary care core services and Primary Care Activity Level (PCAL) is more novel and deserves greater discussion. Since it is commonly understood that if a PCP starts to receive a bundled base payment, the PCP will no longer be permitted to also continue to bill for certain primary care core services, it might seem as if the sum of these existing core services could serve as the outcome measure or dependent variable to be predicted. This would be wrong on several counts. First, the existing system of payment is already paying too little for preventive care and for evaluation and management services – information provision and diagnosis – which are at the heart of high quality primary care. To use the existing payments will simply build in this underpayment. Second, existing primary care cores services– which are likely underprovided – are often divided up among too many different providers, and often provided in inefficient duplicative ways by specialists and PCPs or by multiple PCPs. An improved system would do a better job at channeling most or all primary care services to one identifiable PCP for each patient and avoiding duplication. Finally, it is widely believed (and increasingly supported by empirical evidence) that higher quality primary care could reduce the use of some times of specialty care, hospitalizations, emergency departments, and certain outpatient prescriptions. But achieving these savings will presumably require more effort by PCPs, and this effort will tend to be concentrated on patients with the types of conditions that currently use above average

rates of these services. The existing level of spending on primary care core services is not a desirable metric to use for calculating appropriate levels of base payments for PCPs.

As elaborated in Ash and Ellis (2012) instead of modeling only the existing distorted current level of core services, a different metric is needed, which we call the Primary Care Activity Level (PCAL).¹¹ Conceptually, we wish to identify, for each person, the dollars that a practice can expect to need to provide comprehensive primary care for that person. Each predicted (or expected) value of PCAL is calculated as a function of demographic and medical risk factor data; the predictions for all individuals in a practice are added together to calculate the practice's base payment. We do not know PCAL – we need to find a plausible measure of (or proxy for) it; in this case, using a large (claims) database. Specifically, we compute the variable PCAL as the sum of costs allowed for all traditional primary care activities plus some fraction of the costs associated with other medical activities, such as hospitalizations and ER visits. Our premise is that *the kinds of patients* who are likely to have these costly medical outcomes *should* be getting more attention from their PCPs – either because better attention from the PCMH could help avert the utilization or simply because good care for such people is complex. Note that a person's RRS will be higher *not because he is hospitalized*, but on the basis of his medical profile – *because he has the conditions associated with people who do get hospitalized*. Adding "slivers" of costs from different services to PCAL is a way of compensating for the fact that the primary care services in today's claims databases are distorted for the three reasons discussed above. We describe the logic for how we calculated PCAL empirical in the following section after first discussion data.

¹¹ In early drafts of our research we called this concept the Primary Care Burden (PCB), but this has a decided emphasis on the physician view of patients, who do not like to think of themselves as burdens. Since it is intended to be used to compensate PCPs for a level of their activity, PCAL was selected as a more appropriate moniker.

3. Data and Methods

Sample Selection

The ideal sample to use for this paper would be a very large sample of individuals, with complete cost, diagnoses, procedure, pharmaceutical use, demographic, socioeconomic, survey, and provider information, all combined with rich, accurate and uniformly coded electronic health record information. Unfortunately we are not aware of any dataset that exists satisfying all of these properties. Largely because it is readily available, very large, carefully cleaned and well understood by us and many other researchers, for our analysis we use instead a much more limited set of information: insurance claims information from commercially-insured Truven Analytics (formerly Thompson-Reuters) Marketscan Claims and Encounter Data. The full sample of Marketscan commercial data for 2007 contains usable, complete inpatient, outpatient, prescription drug, and basic plan level information on over 17 million people. The data excludes those with Medicare or Medicaid coverage and those without insurance. Most enrollees have relatively generous insurance coverage. Starting from the universe of all covered lives, we selected a basic estimation sample of 1,668,486 people with the following properties.

- Insured for at least six months in 2007.
- Non missing age and gender
- In a plan type which was an HMO, FFS, PPO, POS, or POS with capitation plan (which excludes Consumer Directed Health Care plans and Exclusive Provider Organizations (EPOs))
- In a health plan (or employer) with 1000 or more enrolled individuals and where at least 50 percent of the unique individuals who saw a provider had information about the provider county, provider ID, and provider specialty.
- Has a valid enrollee county of residence

Services to use for calculating base payments

Most discussions of bundled or capitated payment for primary care services do not specify what primary care services are to be included in the bundle (GHC white paper, XXXX, Guterman et al, 2009;

SGIM, XXXX, McGuire, 2010). Remarkably little analysis has been done on this topic. As discussed above, two related decisions are needed for this assignment.

1. What specific services will no longer be permissible for the PCPs to bill the health plan separately? We call these **Primary Care Core Services**.
2. What weighted sum of all services best reflects the expected burden imposed on PCPs for a given patient? We previously identified this sum as the **Primary Care Activity Level or PCAL**.

To identify the list of primary care core services, we asked a panel of physicians to review several thousand individual CPT4 and ICD-9 procedure codes, initially organized by the CMS's Berenson-Eggers Type of Service (BETOS) classification system. Altogether, 377 procedure codes were identified as core services. An additional 79 procedure codes were identified as mixed services, for which some but not necessarily all of the services would be considered primary care. For these, we gave them a weight of .5 and only counted half of their cost as spending on primary care core services. We call these semi-core services.

There is no general definition or conceptual framework for physicians or anyone about what constitutes the PCAL. For this paper we consider three possible PCAL definitions, which evolved over time. The conceptual differences between these three definitions are summarized in Table 2. The first PCAL definition was a preliminary one which used only clusters of procedures commonly performed by PCPs without regard to place of service or provider specialty. It closely approximates the initial concept of core services, except that it includes a substantial set of services provided by non-PCPs. It requires only that each claim has a procedure code. Primarily because it was available earlier than the next two, this first PCAL definition is the one currently in use by the three practices examined in Vats et al (2013) which implemented a PCMH in 2009. Note that this definition does not include the cost of any services such as hospitalizations, emergency departments, or pharmaceuticals.

Table 2 Three definitions of PCAL examined

PCAL Definition	Name	Use subset of procedure codes	Use place of service information	Require identifying PCPs	Include fraction of spending on non physician services
1	Preliminary	X			
2	Refined	X	X	X	X
3	Pragmatic	X	X		X

Our second definition uses a smaller set of primary care core services, but a broader set of non-primary care services to define PCAL: it captures the additional burden or effort that a physician will have to take for preventing, preparing for, and following up on other services such as hospitalizations, emergency departments and pharmaceuticals. For this second definition, we looked at who actually provided the core services, and attached different weights to them according to whether it was a PCP or some other provider. We call this the “detailed PCAL” definition. As noted in Table 2, this detailed method uses procedure codes, place of service, provider specialty, and non professional claims (pharmacy, and inpatient facility claims, for instance). One significant drawback of this second definition, however, is that it presupposes that physician IDs and provider specialties are present on the claim or encounter record, and can be assigned accurately to specialty types that identify them as PCPs (since different proportions of spending are used for PCPs than non-PCPs).¹² This “Detailed PCAL” definition would be problematic to implement in settings where an individual patient does not always visit a

¹² In the Thomson-Reuters Marketscan commercial claims and encounter data for 2007 that we are using for this analysis, provider ID, specialty and county was present on more than half of the claims for a given plan in only ten percent of the records and was the major factor in reducing our sample size from 17 million to the 1.7 million people used for estimation. Moreover, we observe that in some HMO and POS plans, claims often are coded with provider specialty “clinic” without always specifying a more precise PCP specialty, which is problematic to this measure.

physician during a primary care visit, which is common in many HMOs and particularly in multispecialty clinics. Estimating the Detailed PCAL model required that we drop 90 percent of our Marketscan data that did not reliably allow PCPs to be identified (although this was the same sample that contained provider and enrollee counties which we also wanted).

Given the over simplicity of the “preliminary PCAL” definition, and the demanding data requirements of the “Detailed PCAL” definition 1 (requiring accurate provider IDs and specialty assignments) we selected as our preferred one a third definition, which we call the “pragmatic PCAL” definition. For the pragmatic PCAL measure we imposed the restriction that the only information that could be used are procedure codes and place of service, and not provider specialty information. Second, we wanted our measure to be stable over time, and highly predicted by acute and chronic condition prevalence, much the way primary care services are, so we favored services that are more predictable in our definition (See Ellis and McGuire, 2007, and Ellis, Jiang and Kuo, 2010 for discussion of the predictability of different services). Finally we wanted our PCAL measure to approximate the relative effort that doctors report that different activities take. It was unclear, for instance, whether time spent prescribing drugs, time spent with inpatient care preparation, follow-up and prevention, or time spent making specialists referrals take up more time for the average PCP providing high quality PCHM care.

Therefore we conducted a survey of a small sample of primary care doctors in well managed group practices about their time allocation to different types of activities. We then selected weights on different types of services such that the proportion of the PCAL that is influenced by each broad types of service corresponds to the reported time allocation

Table 3 Service Costs components of pragmatic PCAL

- 50% PCP core services by anyone
- 5% specialty and lab service spending
- 5% emergency department visit spending
- 5% hospital spending
- 10% prescription drug spending
- 25% fixed age-sex based fixed component
- 100% total of the above

*Payments to be based on *expected* PCAL

from the survey. The specific weights used and the list of procedure codes and interactions with place of service is proprietary information owned by Verisk Health. Table 3 provides a summary of how the Pragmatic PCAL definition was generated. Further discussion of the pragmatic PCAL is in Ash et al (2012).

Our three alternative PCAL measures of primary care resource need differ not only in the information used and breadth of services they include, but also in their sample means. It might seem that the generosity of payments to PCPs would vary greatly according to which measure we use. This will not be true, however if we always use each model to create relative risk scores with a mean of 1. The RRSs from any of these models can then be multiplied by the appropriate dollar weight to generate predictions that have the right average payment. We are interested in how PCAL models can be used to calculate relative payments, not absolute payments.

Table 4: Summary statistics for alternative spending measures

	Individual Patient Analysis (N=1,668,486)			% of Total Expenditures
	Mean	Std. Dev		
Professional and Outpatient Services				
1. PC Core Services by Assigned PCP	\$ 150	\$ 291		3.5%
2. PC Core Services by PCPs	\$ 207	\$ 343		4.9%
3. All PC Core Services	\$ 416	\$ 608		9.8%
4. All Services by Assigned PCP	\$ 235	\$ 1,391		5.5%
5. All Services by PCPs	\$ 308	\$ 1,435		7.2%
6. All Services	\$ 1,266	\$ 4,336		29.8%
PCAL				
7. PCAL _Def 1	\$ 450	\$ 765		10.6%
8. PCAL _Def 2	\$ 297	\$ 714		7.0%
9. PCAL _Def 3	\$ 546	\$ 1,376		12.9%
Others				
10. Drug Expenditures	\$ 832	\$ 2,654		19.6%
11. All Expenditures (I+O+D)	\$ 4,247	\$ 23,152		100.0%

In addition to the three PCAL models estimated, we also explored the means and predictability

of six alternative summaries of professional and outpatient services. Sample means and standard deviations are shown in Table 4. The MarketScan data suggests that only 3.5 percent of all spending is on what we define to be core services provided by the assigned PCP, and that about a third more core services are provided by other PCPs. Altogether, services by PCPs (providers in four specialties) account for 7.2 percent of total health spending in 2007 in our sample.

4. Results from a pragmatic PCAL model

Summary statistics from our sample using the pragmatic PCAL definition are shown in Table 5.

Table 5: Regression results predicting Primary Care Activity Level (PCAL) using pragmatic model

	Age-Sex model	Hierarchical Condition Category (HCC) model
Sample size	1,668,486	1,668,486
Mean annualized PCAL spending (\$)	546	546
Standard Deviation	1376	1376
Coefficient of Variation (*100)	251.7	251.7
Parameters	34	427
R-Square (individual level)	0.048	0.511
Adjusted R-Square (individual level)	0.048	0.511
K-fold Validated R-Square (K=100)	0.048	0.506
Standard Error	1063	762
Mean Absolute Deviation	479	267
Grouped R-Square using NEW PCP	0.952	0.975
Grouped R-Square using Pseudo PCP	0.920	0.949

Notes: Each regression used weighted least squares of the annualized spending on PCAL (Definition 3) as defined in the main text. The HCC model used 394 HCC dummy variables for conditions plus 34 age-sex dummies, while the age-sex model used only the 34 age-sex dummies. The conventional and adjusted R-Squares are calculated within sample at the individual patient level. The K-fold validated R-Square is an outside of sample measure at the individual level. The NEWPCP and Pseudo PCP R'square measures sum up patient actuals and predicted PCALS before calculating the R-Squares using the respective clusters of patients.

The two columns correspond to two separate regressions predicting the annualized spending on PCAL. The first column is for a model with only 34 age and gender dummy variables, while the second column includes these 34 dummies plus an additional 384 HCC dummies and selected interactions.¹³ Each regression was run separately using weighted least squares with the fraction of the year eligible as

¹³ Ash et al (2000) is the best source for discussion of why the nonlinear relationship between age, gender and health spending mean that age-gender dummies are superior to using powers of age as explanatory variables.

the weight. The sample mean is \$546, and its coefficient of variation at 252 is less than that of total spending in the same group.

The R-Square, standard error, and mean absolute deviation are three popular measures of goodness of fit. All three measures show that the HCC regression has substantially more predictive power than the simple age-sex specification. With a conventional and adjusted R^2 of 51.1 percent, PCAL is modestly more predictable than total spending on health care.

Even with 1.7 million observations, overfitting can be a problem in risk adjustment models if both the dependent variable and the independent variables are highly skewed. Therefore we recalculated the R^2 using k-fold validation with $k=100$. The K-fold validated R^2 gives an outside of sample measure of goodness of fit that is superior to using a single split sample technique. With only a .5 percentage point reduction in the R^2 , overfitting is not a problem with this model.

Figure 1 shows that the actual and predicted means of PCAL by percentiles of individuals track quite well for low and high PCAL relative risk scores. This figure uses 1.7 million people in the development sample, and hence is a within sample demonstration of goodness of fit.

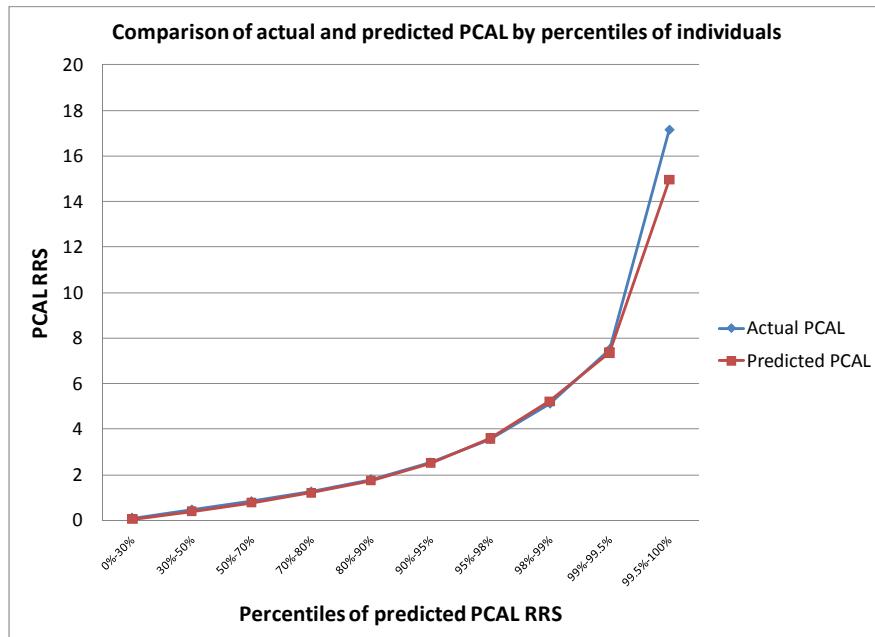


Figure 1 Comparison of actual and predicted pragmatic PCAL by percentiles of individuals

Medical Vignettes on PCAL

Physicians, policymakers, and many others often find clinical vignettes revealing. We created over 30 actual and synthetic patients with diverse patterns of illness, and asked a group of five physicians to consider the likely PCAL needs of each patient. Table 6 lists five hypothetical patients and the HCCs that they might each have. Also shown are the relative risk scores using the conventional DxCG commercial concurrent full spending model, and the pragmatic PCAL. The vignettes illustrate that in some cases the ordering of most expensive and most serious cases are non-monotonic by total costs. Some conditions such as HIV AIDS is relatively expensive in terms of overall spending, but somewhat less extreme in terms of its primary care needed. Diabetes and some other chronic conditions require relatively more PCP effort than other high cost chronic conditions.

Table 6 Five hypothetical women – whose PCAL is highest?

All female, age 53

	DxCG Full Spending RRS	PCAL RRS
Person 1: Healthy	0.62	0.17
Person 2: Type 2 diabetic	2.40	1.92
Person 3: Type 1 diabetic w serious problems	5.15	3.30
Person 4: Long-term HIV patient	6.42	2.93
Person 5: CHF patient w no AMI	4.36	2.30

Assigning a primary care practitioner (PCP) to each patient

A fully implemented PCMH would have each patient (consumer) assigned uniquely to one primary care practitioner (PCP) who would help promote the consumer's health and coordinate the care received from all of the different healthcare providers. Since the PCMH model is not widely adopted,

and since many consumers do not initially have a designated PCP, we need to have a framework for calculating base payments for the PCMH using claims information that do not already presuppose patients having chosen a PCP. Also, to evaluate how well a payment model will do with this payment system, we need to know how patients will be assigned to a PCP. For this paper, we combine information about actual patient use of PCPs with an algorithm that assigns all patients in a sample to a PCP. For this paper, we only considered doctors to be potential PCPs if they were in the following four primary care specialties: general practice, internal medicine, pediatrics and geriatrics. Recall that in the previous step we only attempted to assign patients to PCPs in a sample in which provider IDs, specialty codes, and county information was largely present.

The patient-PCP assignment algorithm we used to assign was as follows from the full sample.

1. Divide the subsample of people who made at least one visit to a physician in a primary care specialty (i.e., a PCP) in 2007 into two parts: those visiting exactly one PCP (who are thereby uniquely assigned to one PCP) and those seeing multiple PCPs during 2007.
2. For the patients seeing more than one PCP during 2007, assign that patient to the PCP who accumulated the largest total payments (plan payments plus copayments).¹⁴ In the event of a tie in spending, assign the patient to the PCP most recently seen.
3. For those not seeing a PCP during 2007: examine their claims for the prior year (2006) and repeat steps 1 and 2 using 2006 data.
4. For those not seeing any PCP during 2006 or 2007, assign patients to PCPs from the same county as the enrollee's county of residence, giving priority to children (age<=18) being assigned primarily to pediatricians and those over age 65 assigned primarily to geriatricians.

We call the patient panels created after conducting steps 1 to 3 the Actual PCP panels, since each patient is assigned to an actual PCP that they visited. The actual PCP panels are unrepresentative of the total sample because those with zero or little health care spending are not assigned to a PCP. The fourth step, which is an innovation, is intended to ensure that every consumer is assigned to some PCP. After merging on these individuals who did not see any PCP in either 2006 or 2007, we call these the

¹⁴ We also examined classifying people to PCPs based on having the largest number of visits and days of treatment in 2007, however the assignment was nearly identical. Since ultimately the PCP will be responsible for the costs of many types of services, we slightly prefer dollar sums to visit counts but either can be defended. Vats et al (2013), following Song et al (2012) examines alternative, more refined assignment algorithms, applied in an actual PCMH setting.

NEWPCP panels. Table 7 shows the proportion of patients assigned to PCPs at each step of this algorithm. Unfortunately since we only observe patients from a selection of insurance plans, the average panel size in both the ACTUALPCP and NEWPCP panels are relatively small ranging from 1 to 50,000 patients per PCP practice with a mean NEWPCP size of 31.4 patients. Recall that a practice can have more than one PCP. MarketScan data may allow some Provider IDs to be a tax billing number, in which case very large clinics or multispecialty practices may appear as a single NEWPCP. For some of our analysis, we analyze what we call midsized NEWPCPs that have at least 50 but no more than 1500 patients.

Fortunately, our

**Table 7 Assignment of patients to PCPs
N= 1,668,486**

	Percent of Patients
Saw exactly one PCP during 2007	42.4%
Saw multiple PCPs in 2007	12.6%
Saw at least one PCP in 2006 but none in 2007	15.7%
Did not see any identifiable PCP	29.3%

sample is large enough, and geographically concentrated enough that we still have 4817 midsized NEWPCP panels to analyze. A histogram showing

the distribution of these midsized NEWPCP panels by number of patients enrolled is shown in Figure 2. This distribution may be typical of the distribution that might be observable by a single insurer or large employer concentrated in a limited geographic area. The relatively small sizes highlight the challenges of implementing a PCMH in a multiple payer setting, as well as the problem of making quality inferences

based on such small panel sizes.

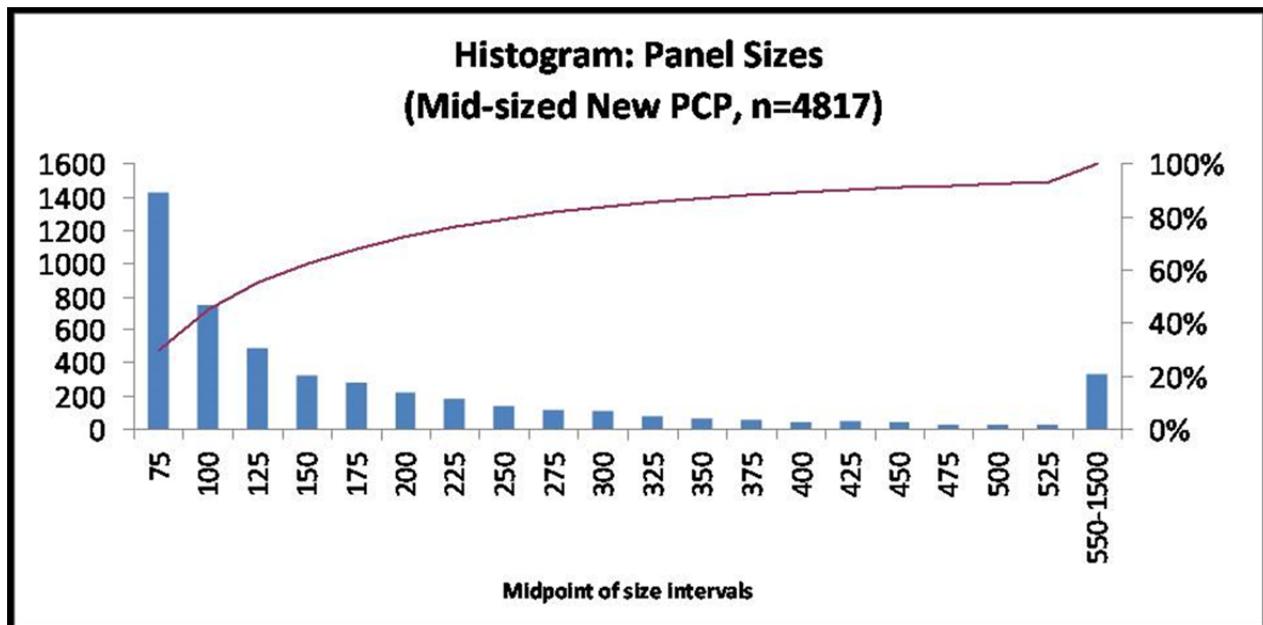


Figure 2: Histogram of PCP panel sizes after assigning patients with no visits.

Creation of realistically sized panels of patients: PSEUDO PCP panels

For some purposes it is useful to be able to assess how well our models will perform if we were to observe all of the patients treated by a PCP. Since we do not have claims for Medicare, Medicaid, or uninsured patients, we have no hope of creating panels of patients with diverse insurance coverage. Because risk and precision are affected by sample sizes, it remains interesting to consider panel sizes that approximate a full size PCP practices. Therefore, we create pseudo PCP panels by consolidating patients across NEWPCPs within the same county or state, using patients as assigned to NEWPCPs as generated by steps 1-4 described in the previous section. We generate pseudo PCP panels by undertaking the following steps.

1. Sort all patients assigned to NEWPCPs by their PCP's state and county, so that PCPs in the same or nearby counties are adjacent.
2. Starting with the first NEWPCP, accumulate the count of patients assigned to a PSEUDO PCP. If the count for a PSEUDO PCP exceeds 800 then that group of patients is a complete panel. If the number of patients assigned is less than 800 then continue to add the patients for the next NEWPCP listed to that particular panel.

3. If a PSEUDOPCP had less than 800 members, we allowed merging of NEWPCPs from the next state. Remaining NEWPCPs at the end of the process were added to the final PSEUDOPCP.

This algorithm consolidates diverse NEWPCP's into PSEUDO PCPs. These PSEUDO PCPs do not cross state boundaries, although they may cross county lines; patients assigned to a particular PCP are always grouped together into the same PSEUDOPCP panel. In all we generated 1380 such PSEUDO PCP panels with an average of 1086 patients per panel. Note that because we are combining patients across diverse PCPs, the PSEUDOPCP panels are more homogeneous than actual panels are likely to be. However they do still maintain the geographic variation that is well-established at the state and county levels. Table 8 shows the alternative PCP panels created with the MarketScan data. Further details are provided in appendix tables A1 and A2.

Table 8 Alternative PCP panels created using 2006-2007 data

	Number of PCP doctors	Average numbers of patients assigned	Total patients assigned	Mean total health spending per patient
Actual PCPs, their actual patients	53,192	20.6	1,058,906	\$4,893
NEWPCPs: PCPs with all patients assigned, including those with no PCP visits	53,192	31.4	1,668,486	\$4,144
Mid-sized NEWPCPs: PCPs with all patients assigned, but seeing more than 50 patients and less than 1500	5,219	234	1,018,665	\$4,139
Large NEWPCPs: PCPs with all patients assigned, but only PCPs seeing more than 500 patients and less than 5000	436	1048	456,781	\$4,324
Pseudo PCPs: after assigning patients and merging NEWPCPs	1,380	1086	1,668,486	\$4,144

5. PCP Level Results

Empirical measures of each of the eleven measures of primary care resources from Table 4 were generated using our MarketScan commercial claims sample of 1,668,486 individuals assigned to NEWPCPs and PSEUDO PCP. Using standard DxCG methods¹⁵, for each dependent variable predictions were made at the individual level using 394 HCCs from Version 3.0 of the software and selected interactions. Because of our large sample size, the overfitting problem is small, and we report here only within-sample measures, not out-of-sample, validated measures. These individual level predictions are then aggregated up to the level of NEWPCPs and PSEUDO PCPs, both of which include patients with zero spending during our two year period. When using a model to assess a practice, we sum actual and predicted PCAL outcomes over all patients in a panel to create observed (O) and expected (E) values at the practice level.

First we measured these models' predictive ability in the new data. The accuracy of a model for predicting a continuous outcome, such as cost, is most commonly measured by R^2 , which is the proportion of the total variability in the outcome that a model "explains." When a model perfectly predicts each outcome for each person, its (individual) R^2 is 100%. For our purposes, however, we are more interested in accurate predictions at the PCP level. It turns out that two measures of PCP level fit can be used. If total spending measures are used, then size effects dominate the measures of goodness of fit. See Figure 3-6 for sample plots for large NEWPCPs. They show that the pragmatic PCAL model

¹⁵ We organized ICD-9-CM diagnostic information using Verisk Health's Sightline DxCG's disease classification system Version 3.0, which was updated in 2010 to contain 394 HCCs. The DxCG model is an enhanced version of the CMS-HCC model used for Medicare Advantage capitation payments which uses 80 CMS-HCCs. Results shown here are from concurrent regressions using 394 HCCs plus 32 age and sex dummies plus interactions of sets of HCCs.

does about as well as models of total spending, achieving a grouped R-square of .723 for large NEWPCPs.

Figure 3

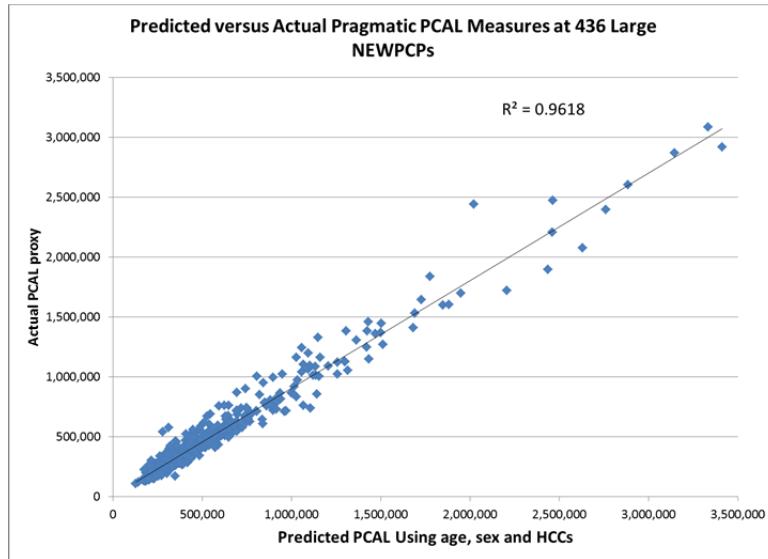


Figure 4

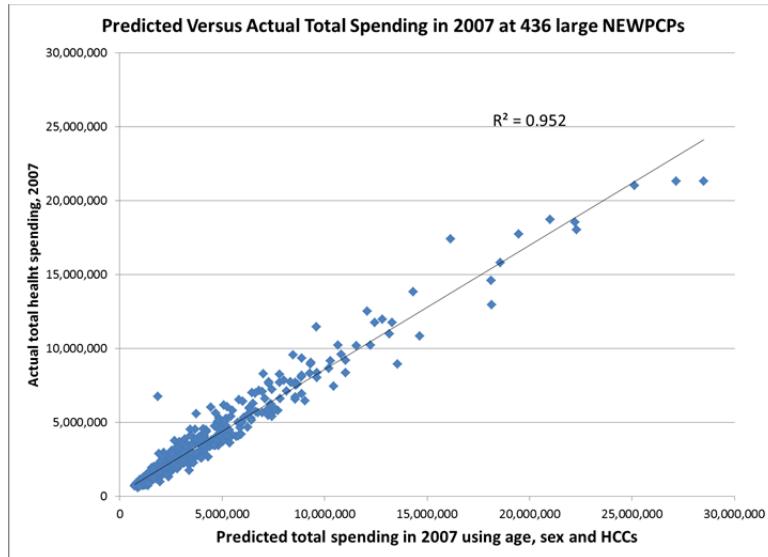


Figure 5

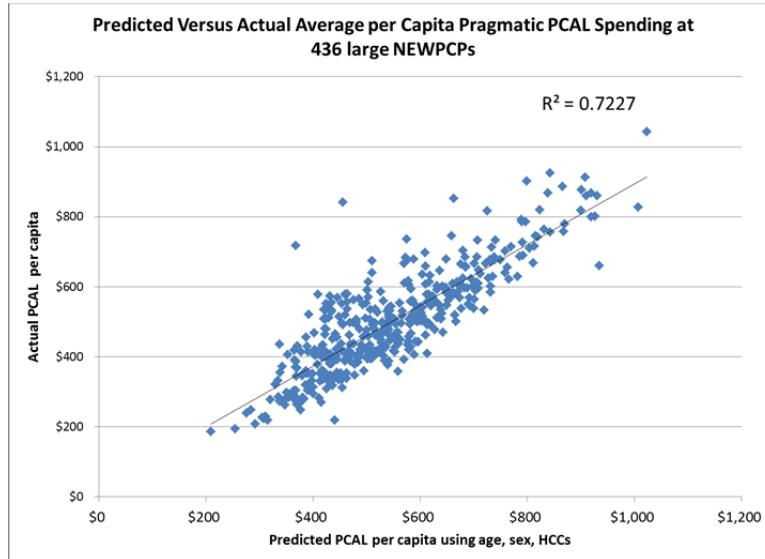
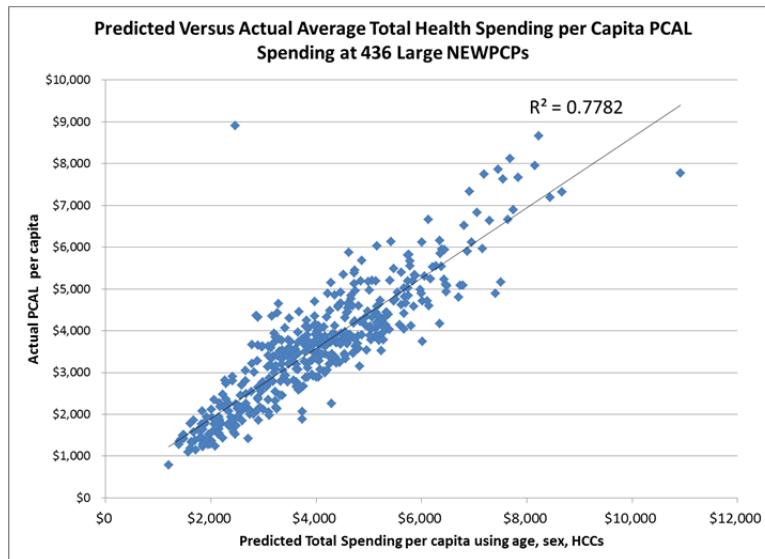


Figure 6



Correlations between the various measures.

For the payment system to work, it is important that payments be relatively stable over time, and that they have face validity to providers. One metric of face validity is that they are relatively insensitive to alternative definitions used for the PCAL measures. Tables 9 through 12 provide

correlation coefficients for our set of eleven measures at the NEWPCP and PSEUDO PCP levels. These correlations show that all of the measures are highly correlated at the NEWPCP and PSEUDO PCP levels. IN particular the correlations between the PREDCITED VALUES of the three alternative PCAL measures are all .98 or better for both ways of simulating large PCPs. This means that for all intents and purposes it does not matter which definition of PCAL is used for payment, since payments will be the same regardless. There is little point in customizing the PCAL measure for a specific purpose since the aggregate predictions of the various PCAL models are virtually indistinguishable. The results also suggest that even models designed to predict only professional services, or only PC core services will also make essentially the same paymewnts to PCPs. In this important sense, ANY of the nine measures that are shown in these tables will be "Good Enough" for use, as is, for the purpose of approximating the relative resources of diverse patients seeing PCPs.

TABLE 4: Correlation Matrix of Actual Values at the New PCP Level

	1	2	3	4	5	6	7	8	9
1. PC Core Services by Assigned PCP	1.00	0.97	0.91	0.91	0.91	0.88	0.90	0.96	0.90
2. PC Core Services by PCPs	0.97	1.00	0.95	0.88	0.93	0.92	0.95	0.99	0.94
3. All PC Core Services	0.91	0.95	1.00	0.81	0.87	0.98	1.00	0.96	0.99
4. All Services by Assigned PCP	0.91	0.88	0.81	1.00	0.98	0.83	0.81	0.92	0.82
5. All Services by PCPs	0.91	0.93	0.87	0.98	1.00	0.87	0.86	0.96	0.88
6. All Services	0.88	0.92	0.98	0.83	0.87	1.00	0.98	0.95	0.99
7. PCAL _Def 1	0.90	0.95	1.00	0.81	0.86	0.98	1.00	0.95	0.99
8. PCAL _Def 2	0.96	0.99	0.96	0.92	0.96	0.95	0.95	1.00	0.96
9. PCAL _Def 3	0.90	0.94	0.99	0.82	0.88	0.99	0.99	0.96	1.00

TABLE 5: Correlation Matrix of Predicted Values - Basic HCC Model - at the New PCP Level

	1	2	3	4	5	6	7	8	9
1. PC Core Services by Assigned PCP	1.00	1.00	0.99	1.00	1.00	0.97	0.99	1.00	0.98
2. PC Core Services by PCPs	1.00	1.00	0.99	1.00	1.00	0.97	0.99	1.00	0.98
3. All PC Core Services	0.99	0.99	1.00	0.99	0.99	0.99	1.00	1.00	1.00
4. All Services by Assigned PCP	1.00	1.00	0.99	1.00	1.00	0.98	0.99	1.00	0.99
5. All Services by PCPs	1.00	1.00	0.99	1.00	1.00	0.98	0.99	1.00	0.99
6. All Services	0.97	0.97	0.99	0.98	0.98	1.00	0.99	0.99	1.00
7. PCAL _Def 1	0.99	0.99	1.00	0.99	0.99	0.99	1.00	1.00	1.00
8. PCAL _Def 2	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.99
9. PCAL _Def 3	0.98	0.98	1.00	0.99	0.99	1.00	1.00	0.99	1.00

TABLE 6: Correlation Matrix of Actual Values at the Pseudo PCP Level

	1	2	3	4	5	6	7	8	9	10	11
1. PC Core Services by Assigned PCP	1.00	0.96	0.90	0.90	0.90	0.86	0.89	0.95	0.84	0.81	0.82
2. PC Core Services by PCPs	0.96	1.00	0.95	0.88	0.93	0.91	0.94	0.99	0.91	0.88	0.88
3. All PC Core Services	0.90	0.95	1.00	0.80	0.86	0.98	1.00	0.95	0.99	0.96	0.94
4. All Services by Assigned PCP	0.90	0.88	0.80	1.00	0.98	0.81	0.80	0.92	0.77	0.73	0.79
5. All Services by PCPs	0.90	0.93	0.86	0.98	1.00	0.86	0.86	0.96	0.83	0.79	0.85
6. All Services	0.86	0.91	0.98	0.81	0.86	1.00	0.98	0.94	0.99	0.97	0.97
7. PCAL_Def 1	0.89	0.94	1.00	0.80	0.86	0.98	1.00	0.95	0.99	0.96	0.94
8. PCAL_Def 2	0.95	0.99	0.95	0.92	0.96	0.94	0.95	1.00	0.94	0.90	0.93
9. PCAL_Def 3	0.84	0.91	0.99	0.77	0.83	0.99	0.99	0.94	1.00	0.95	0.95
10. Drug Expenditures	0.81	0.88	0.96	0.73	0.79	0.97	0.96	0.90	0.95	1.00	0.96
11. All Expenditures (I+O+D)	0.82	0.88	0.94	0.79	0.85	0.97	0.94	0.93	0.95	0.96	1.00

TABLE 7: Correlation Matrix of Predicted Values - Basic HCC Model - at the Pseudo PCP Level

	1	2	3	4	5	6	7	8	9	10	11
1. PC Core Services by Assigned PCP	1.00	1.00	0.99	1.00	1.00	0.97	0.99	0.99	0.97	0.95	0.93
2. PC Core Services by PCPs	1.00	1.00	0.99	1.00	1.00	0.97	0.99	0.99	0.97	0.95	0.93
3. All PC Core Services	0.99	0.99	1.00	0.99	0.99	0.99	1.00	1.00	0.99	0.98	0.96
4. All Services by Assigned PCP	1.00	1.00	0.99	1.00	1.00	0.98	0.99	1.00	0.98	0.95	0.96
5. All Services by PCPs	1.00	1.00	0.99	1.00	1.00	0.97	0.99	1.00	0.97	0.95	0.95
6. All Services	0.97	0.97	0.99	0.98	0.97	1.00	0.99	0.98	1.00	0.99	0.99
7. PCAL_Def 1	0.99	0.99	1.00	0.99	0.99	0.99	1.00	1.00	0.99	0.98	0.96
8. PCAL_Def 2	0.99	0.99	1.00	1.00	1.00	0.98	1.00	1.00	0.99	0.97	0.97
9. PCAL_Def 3	0.97	0.97	0.99	0.98	0.97	1.00	0.99	0.99	1.00	0.98	0.98
10. Drug Expenditures	0.95	0.95	0.98	0.95	0.95	0.99	0.98	0.97	0.98	1.00	0.98
11. All Expenditures (I+O+D)	0.93	0.93	0.96	0.96	0.95	0.99	0.96	0.97	0.98	0.98	1.00

6. Concusions

Reliable, valid, practical risk-adjustment is essential to payment reform for primary care. We have built predictive models using readily available and usable administrative claims that predict large differences in resource utilization across primary care patient panels. These models accurately predict observed differences in actual resource utilization by panels of different physicians.

It may be desirable to augment diagnosis based models with other types of information, such as the income, education, home ownership, and insurance status. This can be done on top of an existing, well designed diagnosis based model.

There is little point to customizing risk adjustment models to specific needs of different regions or insurance groups since the resulting models will be extremely similar regardless of the minor variations in the dependent variables. One caveat is that we have not presented here the evaluation of spending totals that may include or exclude service or diagnosis specific subsets of spending, such as with and without behavioral health carve outs. Still, the high correlations in predicted average payments

even for such divers measures as total spending, total spending on procedures, and PCAL spending is informative.

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Appendix Table A1 Analysis of actual spending on eleven measures for NEW PCPs, which include patients not seeing any PCP during the year.

TABLE 1B: New PCPs, Including those not seeing a PCP (Actual Values)

	Analysis at the New PCP Level (N=53,192)			
	Mean	Std_Error	Max	Mean # of Patients
Professional and Outpatient Services				
1. PC Core Services by Assigned PCP	4,708	32,792	3,468,055	31.4
2. PC Core Services by PCPs	6,507	42,551	3,647,330	31.4
3. All PC Core Services	13,036	79,364	6,477,087	31.4
4. All Services by Assigned PCP	7,373	62,519	6,705,677	31.4
5. All Services by PCPs	9,645	73,578	6,931,003	31.4
6. All Services	39,711	243,464	18,176,417	31.4
PCAL				
7. PCAL_Def 1	14,113	84,348	6,412,675	31.4
8. PCAL_Def 2	9,324	60,234	4,901,910	31.4
9. PCAL_Def 3	17,140	101,753	7,732,149	31.4
Others				
10. Drug Expenditures	26,082	167,997	13,990,826	31.4
11. All Expenditures (I+O+D)	133,202	786,626	64,463,041	31.4

Appendix Table A2 Analysis of actual spending on eleven measures for PSEUDO PCPs, which include patients not seeing any PCP during the year.

TABLE 1C: Pseudo PCPs (Actual Values)

	Analysis at the Pseudo PCP Level (N=1,764)			
	Mean	Std_Error	Max	Mean # of Patients
Professional and Outpatient Services				
1. PC Core Services by Assigned PCP	264,718	198,972	3,610,090	1,086.0
2. PC Core Services by PCPs	365,854	250,455	3,869,173	1,086.0
3. All PC Core Services	733,008	454,204	6,857,365	1,086.0
4. All Services by Assigned PCP	414,571	410,098	6,904,813	1,086.0
5. All Services by PCPs	542,350	466,778	7,231,835	1,086.0
6. All Services	2,232,878	1,420,642	19,468,161	1,086.0
PCAL				
7. PCAL_Def 1	793,537	478,245	6,842,047	1,086.0
8. PCAL_Def 2	524,297	355,847	5,211,148	1,086.0
9. PCAL_Def 3	963,761	582,557	8,287,795	1,086.0
Others				
10. Drug Expenditures	1,466,543	996,429	14,728,160	1,086.0
11. All Expenditures (I+O+D)	7,489,740	4,594,750	64,658,286	1,086.0