Costs and Productivity in Patient-Centered Medical Homes: A Simulation

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Abstract

To address the fragmentation and discontinuities in health care, patient-centered medical homes (PCMHs) provide additional care coordination services for an extra management fee with the goal of saving private and public insurers money while improving the quality of care. Because empirical evidence showing PCMH financial success is unavailable, we use claims data from 312 PCMHs and a matched set of comparison practices to simulate the required reductions in hospital admissions, readmissions, and other services necessary to achieve statistically detectable savings thresholds. We also determine staff coordination time and productivity levels necessary to result in detectable savings. Our results indicate that PCMHs will have to generate annual savings between 3 percent and 30 percent depending upon the underlying cost variation per beneficiary, number of demonstration practices, and the extent of beneficiary clustering within practices. Eliminating all readmissions or most non-hospital services alone will not achieve required savings, even in larger initiatives. In order to be cost-effective, additional physician and nurse time coordinating care will have to be quite productive in reducing costly health services. If so, this likely will result in substantial profits for highly productive PCMHs.

Introduction

State and federal policy makers and private insurers have a growing interest in the cost savings and quality gains that might be achieved through patient-centered medical homes (PCMHs). An extensive literature exists on the PCMH model of care and the need to improve continuity and care coordination in a fee-for-service (FFS) health care system (AOA, 2007; Barr, 2008; Kilo & Wasson, 2010; Glasgow, Orleans, & Wagner, 2001; Wagner, 1998; Wagner, Austin, & Davis, 2001). The evidence for cost savings and quality improvements in PCMHs is growing but is still limited in certain ways (Jaen et al., 2010; O'Malley, Peikes, & Ginsburg, 2008; Peikes et al., 2012).

A number of Medicare initiatives and evaluations are underway to test the effects of PCMH initiatives that pay enhanced fees or shared savings to transform primary care practices into PCMHs. Many earlier evaluations were of small, localized pilot programs, which raises questions about their replicability and generalizability to other locations and time periods (Peikes, Chen, Schore, & Brown, 2009; Kautter, Pope, Trisolini, & Grund, 2007; McCall, 2012).

With Affordable Care Act funding, six much larger Centers for Medicare & Medicaid Services (CMS) demonstrations are underway, with CMS evaluators studying primary care responses to various payment incentives: Primary Care Redesign (PCR); Federally Qualified Health Centers (FQHCs); Independence at Home (IAH); Multi-Payer Advanced Primary Care Practice; State Innovation Models (SIMs); and the Comprehensive Primary Care (CPC) Initiative.

Evaluators are trying to determine whether reduced utilization of costly hospital and other services can both reduce expenditures and improve Medicare beneficiaries' quality of care. "Success" for these programs is based on standard levels of statistical significance, which raises a thorny question for policy makers: Can care coordination and other activities in demonstration PCMHs reduce utilization enough to generate statistically significant savings that at least pay back monthly fees or any savings shared with

CMS? More specifically, what reductions in utilization and expenditures likely will be required by PCMHs to produce statistically significant, minimally detectable savings? Policy makers are also interested in what PCMH staff resources and productivity levels are necessary for success.

To address these questions, we developed a simulation model of the minimally detectable savings per beneficiary (MDS$) and associated reductions in utilization required to be considered statistically significant. In writing this paper, we have four goals:

1. Determine the MDS$ that needs to be achieved under certain conditions to ensure that a PCMH initiative's success was not due to chance.

2. Quantify the reductions in utilization of selected services necessary to achieve these MDS$ thresholds.

3. Determine the levels and costs of physician and nurse care coordination inputs that could be purchased if MDS$ are achieved.

4. Assess the reasonableness of productivity gains from physician and nurse care coordination time that would be required to achieve savings.

Our simulation focuses on the Medicare fee-for-service population, but the model can also be applied to other insurers.

The paper begins with a detailed presentation of the simulation's algorithmic structure, including the key simulation parameters and data sources. In line with our goals, we present results in four sections:

- minimally detectable savings
- required utilization reductions
- physician and nurse care coordination time
- care coordination productivity resulting from providing fewer services.

We conclude with a discussion of policy implications and methodological limitations.

Simulation Model Structure

The simulation model is based on the following premises:

- Medicare will compensate practices for providing care coordination services with a per-beneficiary-per-month (PBPM) fee or through a shared savings arrangement.[1]

- Medicare will allow PCMHs to retain all of their extra fees if they achieve their minimally detectable savings.

- Minimally detectable savings depends on the variation in monthly beneficiary expenditures, the number of included PCMHs, and the level of statistical confidence required.

- Medicare will not continue to pay fees or share any savings from lower spending if they are not offset by statistically significant reductions in expenditures from more efficient use of health care services.[2]

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[1] The simulation model applies equally to monthly fees or shared savings payment arrangements.

[2] Previous CMS demonstrations have generally required pilot initiatives to demonstrate statistically significant savings to be eligible for expansion. Section 3021 of the 2010 Affordable Care Act grants the Secretary of Health and Human Services the authority to expand a pilot initiative to a national program if it "improve[s] the quality of patient care without increasing spending" (Sec 3021(c)(1)(B)).

The model has four domains: (1) minimally detectable savings, (2) patient utilization, (3) staff care coordination time, and (4) care coordination productivity. As shown in Figure 1, the model is driven by the size of minimally detectable savings (MDS$), which is determined by the reduction in costs a practice must achieve to meet a predetermined statistical level of confidence. To meet this savings goal, a practice must reduce the expenditure-weighted average number of services provided per beneficiary. The amount of savings achieved depends on the types, costs, quantities, and mix of health care services reduced. For example, reducing hospital admissions saves far more money than reducing utilization of most other health care services, as we show later. A practice can use the fees paid by Medicare for generating savings by investing them in more care coordination activities and staff time.

We model two staffing scenarios in our simulation. In the first, the practice could spend all its savings on extra coordination time and "break even" with more staff but end up with no profits from the investment. Under the second simulation scenario, the practice may limit its investment in staff time given availability constraints; we refer to this as the "feasible" scenario. Under both scenarios we assume that the practice has reduced utilization sufficiently to achieve its minimal savings target.

Figure 1. Schematic of medical home simulation model
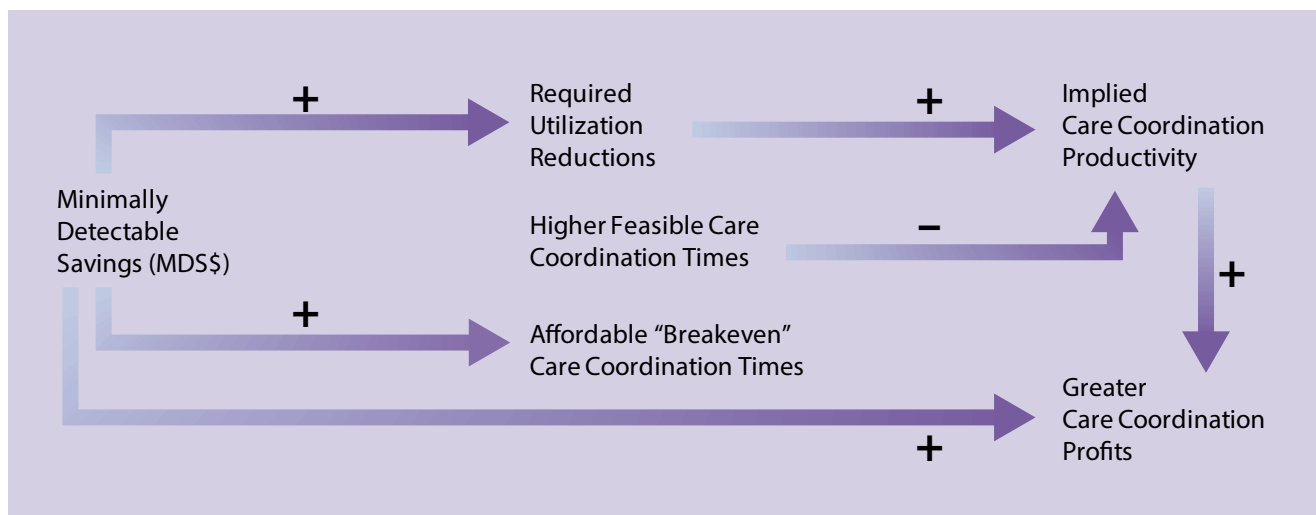
Together with required utilization reductions, the extra care coordination time spent per beneficiary is associated with an implied increase in staff care coordination productivity, which could be thought of as avoided beneficiary health services per extra staff hour. Enhanced staff productivity, along with the extra fees the practice receives when it achieves MDS$, produces the profits, if any, from coordination services. These profits augment those generated from billing for patient services under the usual fee-for-service payment system. The following sections discuss the four domains of the simulation model.

Minimally Detectable Savings

MDS$ in dollar terms is the product of the minimum required reduction in expenditures in percentage terms, MDE%, times the per beneficiary per month (quarter, year) expenditures in a previously matched comparison group. This percentage usually is derived from a difference-in-differences regression model using individuals as the unit of observation (Imbens & Wooldridge, 2009; Cromwell & Smith, 2011).

Because the analytic units are hierarchically identified within a preselected set of participating PCMHs, the resulting clustering gives a false impression of the truly independent degrees of freedom in the regression, which can be many fewer. As shown in equation 1, adjustments for clustering and the underlying variation in beneficiary expenditures interact in a complex way to produce the required expenditure reduction percentage (taken from Bloom, 2005, as modified in Peikes, Dale, Lundquist, & Genevro, 2011, p. 31):[3]

$$\text{MDE\%} = CV \bullet \text{sqrt}(1 - R^2) \bullet M_{H\text{-}2} \qquad (1)$$
$$\bullet \text{ sqrt}[1/P(1 - P)] \bullet \text{sqrt}\{(1/H)$$
$$\bullet [ICC/(1 - ICC) + (1/B)] \}$$

The minimally detectable percentage requirement in equation 1 begins with the coefficient of variation (CV), which is the underlying variation in beneficiary expenditures divided by the overall comparison group beneficiary mean expenditure per month

(quarter, year). This puts the variation in percentage terms. Next, the CV is scaled downward by the square root of $(1 - R^2)$ to account for a vector of regression patient and practice characteristics that increases the model's explanatory power and reduces unexplained variation. For example, if CV = 1.5 and the regression model explains 25 percent of the variation in beneficiary expenditures, then the adjusted CV = 1.5 • sqrt$(1 - R^2)$ = 1.125. H represents the number of practices, and B represents the average number of beneficiaries per practice.

The $M_{H\text{-}2}$ term (= $t_\alpha + t_{1\text{-}\beta}$) based on *t*-tests raises the standard error and savings percentage and ensures that a true PCMH savings effect will avoid both a Type I error of accepting false savings (t_α) and a Type II error of rejecting true savings ($t_{1\text{-}\beta}$) (Bloom, 2005, p. 129). In all simulations, we use a one-tailed *t*-test with α = .05, with $(1 - \beta)$ = 80 percent power following Bloom's (2005, p. 130) argument that "it usually makes sense to support a program only if it produces beneficial effects."[4] The $M_{H\text{-}2}$ adjustment is 2.5(1.65 + .85), which more than doubles required savings.

The regression-based savings estimate has a standard error that is sensitive to the relative size of the intervention and comparison groups. In the simulation, we assume equal numbers of practices (H) in both groups for a total H overall. This requires setting the proportion of all practices in one group P equal to 0.50 and adjusting the MDE% by the sqrt[1/P(1 − P)] equal to 2.

The last two elements in equation 1, (1/H) • [ICC/(1 − ICC) + (1/B)], adjust for the variance bias inherent in clustered sampling using beneficiaries instead of practices as the unit of analysis. The interclass correlation coefficient (ICC) is the ratio of the between-practice variance to the total cost variance in the entire sample of beneficiaries.

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3 The complete MDE% adjustment for clustering also includes a multiplicative, square root term [1 + 1/(H • B − 4)], which produces an upward adjustment in required savings when including beneficiary-specific covariates in the regression model. It is trivial for any reasonably sized sample and can be set equal to 1.0.

4 It seems unreasonable in "social" experiments, as opposed to clinical trials, to require estimates of financial success to be true 97.5 percent of the time (i.e., α = 0.025) given the lack of complete control over the intervention, its environment, and available data sources. It seems unreasonable to reject a demonstration "success" from demonstrable quality improvements only if positive savings estimates could have occurred by chance only 2.5 percent of the time.

When all between-practice mean expenditures per beneficiary are alike, then ICC = 0, and no variance bias exists in selecting beneficiaries within practices. If mean expenditures differed among practices, even after controlling for beneficiary characteristics, then it clearly made a difference which practices were actually selected for study. The ICC is a measure of strength of the "unique nature" of the analytic samples and their generalizability to other practices. Sample ICCs greater than zero raise the MDE% in recognition of one or more unique practice characteristics.[5]

A crucial policy conclusion from the upward ICC adjustment is that increasing the number of practices reduces the required level of savings considerably more than increasing the number of beneficiaries in each practice does. The relative effects of adding one entire practice to the initiative versus one more beneficiary to each practice can be evaluated by taking the derivative of MDE% with respect to H (the number of homes) and B (the average number of beneficiaries per practice) and forming the ratio of the two:

$$[dMDE\%/dH] \mathbin{/\mkern-6mu/} [dMDE\%/dB] \qquad (2)$$
$$= (B^2/H) [ICC/(1 - ICC) + 1/B].$$

For ICC = 0, H = 50, and B = 400, the addition of another practice has eight times the effect on the MDE% that adding one more beneficiary to each of 50 practices would have. The relative effectiveness of adding practices over beneficiaries rises to 90-to-1 when ICC = 0.025. The advantage of adding practices versus adding beneficiaries comes from the baseline ratio of practices to beneficiaries being so low (50 to 400). Peikes et al. (2011) provides extensive simulations of the tradeoff between more beneficiaries and practices in reducing threshold savings.

If a Medicare PCMH met its overall required savings percentage, then we assume that the practice would receive all savings or be allowed to retain all coordination fees it had received. In actual practice,

the Medicare program also requires that practices meet predetermined quality performance criteria. Failure to meet one or more criteria could result in a substantial reduction in the savings shared with a practice. In all simulations, we assume that the practice meets all quality requirements and savings are allocated equally on a per-physician basis.

Patient Utilization

Reducing utilization of health services is the primary way that PCMHs can achieve their savings requirement (Linden, 2006). Equation 3 simulates the average reduction in utilization of service *s* (e.g., hospitalizations) that is required per intervention beneficiary to achieve MDS$:

$$\Delta U_s = -S_s[(MDS\$ \bullet B)/CST_s)] \qquad (3)$$

where

ΔU_s = the required reduction in utilization of service *s* to achieve detectable savings;

S_s = the assumed share (proportion) of MDS$ generated through reductions in utilization of service *s*; and

CST_s = the average cost of service *s*.

For example, if all savings come from a reduction in the number of hospitalizations, S = 1, and MDS$ = $100, B = 400, and CST = $10,000, then the PCMH must reduce admissions by 4 per beneficiary-month.

Required reductions in the simulation can come from a single source, such as hospital admissions, in which case S_s = 1.0, or from two or more types of services, each with S_s < 1.0 and summing to 1.0.

Staff Care Coordination Time and Profits

We simulated the number of minutes that physicians (*g* = 1) and nurses (*g* = 2) provide care coordination services to a beneficiary ($CCMIN_g$) under the feasible scenario and under a break-even staffing scenario.

Scenario 1: Feasible (Predetermined) Coordination Staffing Levels. Unfortunately, to our knowledge there are no verified estimates of actual care coordination times in a sample of PCMHs. Therefore, in our baseline simulation we have assumed that a Medicare beneficiary needing care coordination

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5   The cluster effect multiplier (CEM), or ratio of the clustered to unclustered standard error, is equal to the sqrt{1 + ICC(B-1)}, where ICC = intraclass correlation coefficient and B = the average number of beneficiaries per practice (Bloom, 2005, p. 126). If B = 400 and ICC = 0.025, then CEM = 3.31.

services uses 45 (predetermined) minutes per month of physician time (CCMIN_{MD}) and 120 minutes of nurse time (CCMIN_{RN}), on average, in 2 out of 12 months (see Table 1).[6] We also assumed that each physician in a practice has an annual caseload of

400 fee-bearing Medicare beneficiaries assigned to the practice, and that 80 percent (λ) receive care coordination services for 2 months ($\mu = 0.17$) sometime during the year. This results in 13.3 percent $= 100 \times [0.80 \times (2/12)]$ of 400 Medicare beneficiaries, or $= 53.3$ beneficiaries, on average, per physician, who receive coordination services each month (CCB).

With staffing times predetermined independent of savings levels, intervention PCMHs can earn profits

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6　Many PCMHs may already be providing additional, unreimbursed care coordination services that save insurers money. Zuckerman and colleagues (October 2009) did not find evidence of additional costs incurred at higher levels of PCMH services.

Table 1. Medicare baseline simulation parameters

Demonstration Practice Characteristics	
MDs/practice	1
RNs/practice	1
% savings kept by Medicare (γ)	0
Yearly unique patients/MD[a]	2,400
% Medicare beneficiaries	0.333
% beneficiaries assigned	0.5
Net beneficiaries assigned (B)	400

Labor	MD[b]	RN[b]
Total hours worked/week	54	40
Total weeks worked/year	47	48
Staff hourly wages (W)	$95.97	$33.91
Staff minutes/care coordination beneficiary	45	120

Statistics	
Number of demonstration homes practices (H)	100
% homes in study group (P)	0.5
R^2	0.25
Significance (one-tail) (in M)	1.65
Coefficient of variation (CV)	2.0
Power (in M)	0.80
Intraclass correlation (ICC)	0

CareCoordination Parameters	
% Medicare beneficiaries with care coordination (λ)	0.8
% months with care coordination (μ)	0.17
Care coordination admissions/non–care coordination admissions	3
Medicare spending/beneficiary-month	$675

Service Utilization and Spending/Use	Use/Patient-Year (U)	Spending/Use[c] (CST)
Acute hospital		
Total	0.279	$10,564
Readmissions	0.041	$7,078
Ambulatory care–sensitive conditions	0.098	$10,620
Long-term care hospital[d]	0.0009	$31,797
Rehabilitation hospital[d]	0.0093	$14,145
Psychiatric hospital[d]	0.0123	$5,496
Skilled nursing facility[e]	0.072	$7,174
Home health visits	0.17	$2,415
Durable medical equipment	NA	$252
Outpatient	NA	$1,193
Physician	NA	$2,703
Annual total		$8,106
IT costs/MD/year[a] (IT$)		$9,464

MD = physician; RN = registered nurse; IT = information technology.

a　Unique beneficiaries per MD and costs per IT component for medical homes are based on an American Medical Association/Specialty Society Relative Value Scale Update Committee (AMA/RUC) Medicare Medical Home Workgroup report, "Medicare Medical Home Demonstration Project: April 25, 2008" (AMA/RUC Medicare Medical Home Workgroup, 2008).

b　MD and RN hours worked and wages are from Bureau of Labor Statistics Occupational Employment Statistics, Occupational Employment and Wages, May 2010; average hourly employee earnings in physicians' offices for 2007 are taken from the Statistical Abstract of the United States: 2009 (US Census Bureau, 2009).

c　Medicare costs per use (e.g., cost per admission) are based on claims from a set of 312 control practices matched to 312 practices responding to RTI's survey of all recognized National Committee for Quality Assurance (NCQA) medical homes (NCQA, 2008).

d　Annual use rates per beneficiary for long-term care hospitals, rehabilitation hospitals, and skilled nursing facilities were taken from MedPAC's 2011 Report to the Congress: Medicare Payment Policy (MedPAC, 2011).

e　Psychiatric annual use rates come from MedPAC's 2010 Report to the Congress: Aligning Incentives in Medicare (MedPAC, 2010).

on their care coordination services per assigned beneficiary if they achieve statistically significant savings. Profit per assigned beneficiary-month, π, is the difference between the MDS$ generated per beneficiary after first sharing any savings, γ, with Medicare, minus the wage-weighted cost of actual minutes per coordination beneficiary. The simulated profit algorithm is

$$\pi = [(1 - \gamma) \bullet \text{MDS\$}] - [(\text{CCB/B}) \bullet \Sigma_g W_g \bullet \text{CCMIN}_g] - \text{IT\$} \qquad (4)$$

where γ = the share of savings kept by the insurer (i.e., Medicare);

and W_g = the average effective wage per minute of clinician g.

We assume $\gamma = 0$ in the baseline model. We also debit from profits an estimate of information technology costs per beneficiary-month (IT$; see the appendix for our calculation of IT$). For example, if MDS$ = $100, $\gamma = 0$, CCB = 53, B = 400, W_{MD} = $1.67, W_{RN} = $0.58, CCMIN_{MD} = 45, CCMIN_{RN} = 120, and IT$ = $2, then the monthly extra coordination care costs would be $145 per beneficiary, CCB/B = 0.133, and the per-assigned-beneficiary profit would be about $80 per beneficiary-month. Total practice profits per month for 400 assigned beneficiaries would be $32,000 per physician-month.

Scenario 2: Break-Even Coordination Staffing Levels.
The alternative break-even savings scenario assumes that practices invest all fees or shared savings ($\gamma = 0$) in care coordination services when they achieve the exact statistically significant savings threshold. Factors affecting how much coordination time the fees or shared savings will buy per beneficiary with services are shown in equation 5:

$$\text{CCMIN}_g = \{(1 - \gamma) \bullet \alpha_g[\text{B} \bullet \text{MDS\$}/W_g]\}/\text{CCB} \qquad (5)$$

where α_g = the share of savings allocated to physicians or nurses to support care coordination activities.

The term $[\text{B} \bullet \text{MDS\$}/W_g]$ in equation 5 is the monthly number of care coordination minutes of the physician or nurses that could be purchased in a single physician practice with MDS$ savings. In the simulation, we allocated savings to support physician

and nurse care coordination times (α_g) according to their own care coordination cost shares incurred in the feasible savings scenario (i.e., 52 percent physician; 48 percent nurse).[7] Each provider's monthly break-even care coordination times are most meaningful when scaled to the number of beneficiaries each month receiving these services.

If monthly savings allocated to practices were $40,000 on average (400 beneficiaries × $100 per beneficiary savings), and the physician's hourly wage was $95.97 ($1.60/min), then physicians could afford a maximum of 400 hours, or 25,000 = $40,000/$1.60 minutes, of extra care coordination time, assuming none was provided by nurses. This would amount to 469 physician minutes with each of 53.3 care coordination beneficiaries each month (compared with 1,328 minutes for nurses alone). Distributing care coordination times based on each provider's care coordination cost shares would fund 244 physician (469 × 0.52) and 637 nurse (1,328 × 0.48) minutes for each coordination beneficiary each month. No care coordination–related profits result from the break-even scenario as all savings are reinvested in coordination efforts.

Care Coordination Productivity

Labor productivity is usually expressed as the ratio of output to the number of hours of labor input. However, in our model, PCMH *productivity* is defined as "the avoided use of health services (e.g., hospitalizations, CT scans) per care coordination staff minute or hour." Productivity (PROD) is calculated as the ratio of required percentage reductions in monthly utilization of beneficiaries receiving coordination services (in absolute terms), $|\% \Delta U_s|$,[8] to percentage increases

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[7] Each clinician's share of total monthly care coordination costs reflects the clinician's marginal products and shares in production (Denison, 1979; Kendrick, 1961; Cromwell & Pope, 1989).

[8] $|\% \Delta U_s|$ = the ratio of the absolute value of the required CCB volume reduction divided by the average monthly utilization of service s only by care coordination beneficiaries, $\text{AVOL}_{s,cc}$. The denominator of this ratio is derived from the following formula for acute inpatient admissions: $\text{AVOL}_{s,cc} = 0.0232 /[\%\text{CCB-mn} + (1 - \%\text{CCB-mn}) \bullet 1/3]$ and 0.0232 implies 232 hospital discharges per 10,000 beneficiaries each month. If CCBs make up 13.3 percent of all eligible beneficiaries in a given month, AVOL only for CCB acute admissions equals 0.055.

in physician and nurse work minutes ($\%\Delta CCMIN_g$) due to increased care coordination:

$$PRODs = RED\%_s \bullet |\% \Delta U_s| / \Sigma_g \, \alpha_g \bullet \%\Delta CCMIN_g \quad (6)$$

where $RED\%_s$ = the percentage of savings expected to come from service s.

Staff productivity from care coordination can be focused on a single service, such as hospital admissions, as shown later, or reducing several types of services simultaneously. For example, if achieving the minimum savings threshold requires a 30 percent reduction in acute hospitalizations per beneficiary receiving care coordination and the feasible increase in staffing time is 40 percent, then the productivity rate for this one service alone would be 30 percent/40 percent, or three-quarters (i.e., 75 percent). Therefore, every 1 percent increase in staff time must translate into a 0.75 percent reduction in hospitalizations. Productivity will generally have to be fairly high for the limited number of beneficiaries the staff contact each month given that the practice is receiving fees on a presumably much larger set of assigned beneficiaries.

Furthermore, care coordination productivity can be quite different in the feasible (predetermined) and break-even scenarios due to differing levels of care coordination hours for the assumed same level of MDS\$. Were the practice to achieve detectable savings with a modest, fixed amount of extra coordination time, then staff productivity per hour providing coordination services could be quite high. Of course, staffing productivity in a break-even scenario does not change because required percentage reductions in service use are exactly offset by percentage increases in staff time spent on coordination (see equation 6).

Simulation Parameters and Data Sources

Table 1 summarizes the parameters for the baseline simulation model along with their sources. Medicare cost and use data were derived from a special survey of practices recognized by the National Committee for Quality Assurance, NCQA. By the end of 2012, some 1,247 physician practices had received NCQA

recognition (NCQA, 2008), 312 of which agreed to participate in our PCMH study.

We identified a similar-sized comparison set of unrecognized practices using a multi-step process. We first selected all physician practices in the same zip codes as the 312 PCMHs. A logistic model then identified the subset of practices and beneficiaries that were most similar to the PCMHs in terms of practice and beneficiary demographic and health status characteristics (Rosenbaum & Rubin, 1983). We excluded PCMH and comparison practices if they had fewer than 30 assigned beneficiaries. Medicare FFS beneficiaries were assigned to PCMHs and comparison practices based on where they received a plurality of primary care evaluation and management services. The entire beneficiary sample consisted of 268,873 Medicare FFS beneficiaries.

The sources for parameters such as physician and nurse hours worked and wages are the US Bureau of Labor Statistics (BLS), the Medicare Payment Assessment Commission (MedPAC), the US Census Bureau, and the American Medical Association (AMA). Beneficiary utilization and cost parameters are based on the comparison group data and remain fixed in the simulations. Parameters that vary in the simulation tables include (a) number of PCMHs, (b) intraclass correlations (ICCs), (c) percentage of beneficiaries needing coordination services, (d) physician and nurse time (hours or minutes) providing care coordination, and (e) variation in monthly per-beneficiary Medicare expenditures.

We present results on a per-physician basis and assume one full-time nurse per physician. Per-physician totals can be factored up for practices with more physicians, but this has little effect on the results given the lack of scale economies in providing labor-intensive care coordination services.

Results

Minimally Detectable Savings

Table 2 simulates the effects on MDS\$ of varying levels of clustering (ICC), the underlying variation in patient costs, reflected in CVs, and the total number of PCMHs and comparison practices in the initiative.

The ICC in the baseline sample of 312 practices was 0.028 (comparable to the ICC of 0.026 in Peikes et al., 2011). This suggests a substantial amount of clustering across medical homes.

We show a range of ICC coefficients from zero (i.e., no clustering) to 0.025, which may be the low end of clustering effects. Results assume that cost drivers in the multivariate model explain 25 percent of the cost variance ($R^2 = 0.25$; see equation 1) and that an average of 400 (or 50 percent of all) unique Medicare beneficiaries are assigned to each single-physician practice. Expenditure CVs are assumed to range between 1.5 and 2.0, which is within the range of many Medicare demonstrations (see also Peikes et al., 2012, Table 1). A 5 percent one-tailed significance level is used with power to detect a significant difference 80 percent of the time.

Detectable savings rise proportionally with increases in overall CVs. Savings percentages are modest (1.0 percent to 8.6 percent) without any clustering effects (i.e., ICC = 0.00) but rapidly increase with positive ICCs). If mean costs vary between practices by even 1 percent of the variance in overall patient costs, producing an ICC = 0.01, minimally detectable thresholds increase 2.2-fold. Detectable savings thresholds are over 20 percent in smaller demonstrations if the ICC coefficient is 0.025 or higher. Achieving required statistical savings is considerably less likely in initiatives with fewer than 100 study and comparison practices combined.

Reducing the explanatory power to 10 percent would raise the MDE percentage by 10 percentage points.

Required Utilization Reductions

Volume reductions required to achieve detectable savings are shown, in percentage terms, in Tables 3 and 4. In Table 3, all savings come from a single service, and in Table 4, savings are spread across several services. Without clustering effects (ICC = 0.00), and assuming all savings are generated from reduced total hospital use, an initiative with 25 PCMH and 25 comparison practices (H = 50) would have to achieve a 17 percent reduction in Medicare acute hospital admission rates across all assigned beneficiaries to achieve statistically detectable PBPM savings of $41.22 (see Table 3). The 25 intervention PCMHs as a group could eliminate all readmissions and still fall short of required savings because readmissions constitute only 4 percent of a typical beneficiary's annual Medicare expenditures.

An initiative four times as large (200 total practices) with one-half the dollar level of required savings would have to reduce hospitalization rates by 8 percent. Even in an initiative with 100 intervention PCMHs (200 total practices), 86 percent of all readmissions would need to be avoided through care coordination if they were the sole source of savings.

With greater clustering (ICC = 0.025), eliminating all readmissions would be insufficient to achieve required savings at just about any demonstration

Table 2. Simulated minimally detectable gross savings (percent) per Medicare beneficiary per month (PBPM)

| Number of Practices (H) | Level of Clustering | | | | | |
| | ICC = 0.00 | | ICC = 0.01 | | ICC = 0.025 | |
	CV = 1.5	CV = 2.0	CV = 1.5	CV = 2.0	CV = 1.5	CV = 2.0
25	6.5	8.6	14.5	19.4	21.7	28.9
50	4.6	6.1	10.3	13.7	15.3	20.5
100	3.2	4.3	7.3	9.7	10.9	14.5
200	2.3	3.1	5.1	6.8	7.7	10.2
500	1.5	1.9	3.3	4.3	4.9	6.5
1,000	1.0	1.4	2.3	3.1	3.4	4.6

ICC = intraclass correlation coefficient within practice; CV = coefficient of variation in PBPM costs.

Notes: The number of practices (H) includes patient-centered medical homes and comparison practices combined. Minimally detectable gross savings is the percentage reduction in intervention costs PBPM necessary to achieve 95 percent 1-tail significance at 80 percent power. Other assumptions: R-squared = 0.25; 400 beneficiaries per practice.

See Table 1 for baseline parameters.

size. Ambulatory care-sensitive condition (ACSC) admission rates would need to fall 24–79 percent, even in a large initiative, depending on the degree of clustering.

Required reductions in physician services (bottom of Table 3) are similar in percentage terms to total

hospital admission reductions because of their similar expenditure shares. Eliminating all long-term care, rehabilitation, and psychiatric hospital use, as well as durable medical equipment utilization, individually, would contribute little to savings because altogether they represent only 6 percent of average Medicare spending.

Table 3. Required percentage reductions in Medicare use per single service to achieve minimally detectable savings (MDS) per beneficiary per month

Service	Expenditure Share %	Level of Clustering			
		ICC = 0.00		ICC = 0.025	
		H = 50 MDS$ = $41.22	H = 200 MDS$ = $20.61	H = 50 MDS$ = $138.23	H = 200 MDS$ = $69.11
		% Reduction		% Reduction	
Acute hospital					
Total	35	17	8	56	28
Readmissions	4	171	86	574	287
ACSCs	13	47	24	159	79
Long-term care hospital	0	1,725	863	5,785	2,893
Rehabilitation hospital	2	376	188	1,261	630
Psychiatric hospital	1	732	366	2,454	1,227
Skilled nursing facility	6	95	48	320	160
Durable medical equipment	3	196	98	659	3,29
Home health	5	121	60	404	202
Outpatient	15	41	21	139	70
Physician	33	18	9	61	31

ICC = intraclass correlation coefficient; H = PCMH and comparison practices combined; ACSCs = ambulatory care-sensitive conditions.

Notes: CV (coefficient of PBPM cost variation) = 2.0. Expenditure share = percentage of beneficiary costs incurred by type of service. Average costs per year are $8,106. See Table 1 for baseline parameters.

Table 4. Simulation of sample required utilization reductions to achieve a feasible (predetermined) savings percentage for selected services

Service	Assumed % Savings Achieved	Level of Clustering		Assumed % Savings Achieved	Level of Clustering	
		ICC = 0.01 MDS$ = $46.25	ICC = 0.025 MDS$ = $69.11		ICC = 0.01 MDS$ = $46.25	ICC = 0.025 MDS$ = $69.11
		% Reduction			% Reduction	
Acute hospital						
Total	35	7	10			
Readmissions				25	48	72
ACSCs				25	13	20
Skilled nursing facility	10	11	16	5	5	8
Outpatient	25	12	17	20	9	14
Physician	30	6	9	25	5	8

ICC = intraclass correlation coefficient; MDS$ = minimally detectable savings/beneficiary; ACSCs = ambulatory care-sensitive conditions.

Notes: Assumptions: 200 PCMH and comparison practices combined; 400 beneficiaries per practice; CV (coefficient of PBPM cost variation) = 2.0; P = 0.50; R-squared = 0.25. See Table 1 for baseline parameters.

Not all PCMH program savings are expected to come from a single service. Table 4 simulates required savings distributed across four or five major services in a 200-practice initiative with modest (ICC = 0.01) or substantial (ICC = 0.025) clustering and a CV of 2.0. If only 35 percent of savings were to come from a lower number of acute hospitalizations, see first column, admission rates would have to decline between 7 and 10 percent with modest or substantial clustering. With another 30 percent of savings coming from physicians, their volumes would also have to decline between 6 and 9 percent. Skilled nursing facility (SNF) and outpatient use would also have to decline between 11 and 17 percent each given arbitrary savings targets of 10 and 25 percent, respectively. Failure to achieve any one of these target reductions would jeopardize the chances of achieving overall required savings.

If, instead, one-half of required savings were expected to come equally from fewer readmissions and ACSC admissions, their use rates would have to decline by 48–72 percent and 13–20 percent, respectively, depending upon the level of clustering. Assuming another 25 percent of savings from physician services, their volumes would have to fall by 5–8 percent as well. SNF and outpatient use rates would also have to decline by 5–14 percent.

Physician and Nurse Care Coordination Time

This section includes simulations of the increase in staff work effort, extra staffing costs, and potential profits using either feasible or break-even ("affordable") physician and nurse care coordination time.

Table 5. Feasible medical home care coordination times, costs, and profits

	80% Care coordination beneficiaries/month = 53.3		
	MD Time: 45 min/CCB	**RN Time: 120 min/CCB**	**Total**
FTEs/practice-month	0.19	0.67	0.85
Costs/physician-month	$3,835	$3,613	$7,448
Cost/beneficiary-month	$9.60	$9.04	$18.64
	ICC = 0.01		**ICC = 0.025**	
	H = 50	**H = 200**	**H = 50**	**H = 200**
Minimally Detectable Fee (MDS$)	**$92.50**	**$46.25**	**$138.23**	**$69.11**
Profit/beneficiary-month	$71.89	$25.64	$117.62	$48.50
Profit/physician-month	$28,727	$10,245	$47,000	$19,381

	50% Care coordination beneficiaries/month = 33.3		
	MD Time: 30 min/CCB	**RN Time: 120 min/CCB**	**Total**
FTEs/practice-month	0.079	0.312	0.391
Costs/physician-month	$1,598	$1,694	$3,292
Cost/beneficiary-month	$4.00	$4.24	$8.24
	ICC = 0.01		**ICC = 0.025**	
	H = 50	**H = 200**	**H = 50**	**H = 200**
Minimally Detectable Fee (MDS$)	**$92.50**	**$46.25**	**$138.23**	**$69.11**
Profit/beneficiary-month	$71.89	$25.64	$117.62	$48.50
Profit/physician-month	$28,727	$10,245	$47,000	$19,381

FTE = full-time equivalent; CCB = coordination care beneficiary; ICC = intraclass correlation coefficient; H = the number of patient-centered medical homes and comparison practices combined; MDS$ = minimally detectable savings/beneficiary.

Notes: Assumes 400 beneficiaries per practice; MDS$ is based on CV = 2.0; MD (physician) wage = $95.97; RN (nurse) wage = $33.91. CCB profit = minimally detectable savings – care coordination time – IT costs. See Table 1 for baseline parameters.

Feasible Staffing. Table 5 shows the effects of assuming two different feasible, predetermined levels of physician and nurse care coordination times in initiatives of 50 or 200 intervention plus comparison practices. Each physician in the practice sees 400 unique Medicare beneficiaries per year. In the top panel, 53.3, or 80 percent, of beneficiaries who will require coordination services during the year receive them during a given month. These 53.3 beneficiaries represent 13.3 percent of the 400 monthly assigned beneficiaries. The bottom panel assumes that only 50 percent of 400 beneficiaries, or 33.3 beneficiaries, require 2 months of care coordination services.

If a physician spends 45 minutes with each of 53.3 beneficiaries in a month (Table 5, top panel), an increase of 0.19 (10.3 hours) in her full-time equivalent (FTE) work time is required over and above the simulation's average 54 hours per week for a physician. For nurses, the additional 2 hours of coordination time with 53.3 beneficiaries would require an added 0.67 FTE (27 hours) of a nurse each month. Total practice costs for these extra care coordination services would be $7,448 per month, or $18.64 per Medicare beneficiary receiving care coordination services.

Because care coordination times have been preset, staff costs are independent of the Medicare expenditure savings that practices would have to achieve. In a small initiative with 50 total practices, modest clustering (ICC = 0.01), and 53.3 beneficiaries receiving coordination monthly, a practice would enjoy $71.89 in monthly profits per beneficiary per physician, or $28,727 per physician per month, from the 400 assigned beneficiaries if it exactly achieved its $92.50 minimally detectable savings rate.

A higher degree of clustering in a 50-practice initiative would require substantially more savings ($138.23 PBPM versus $92.50), which, if achieved, would increase care coordination profits per physician to $47,000 each month. An initiative four times larger (200 practices) would make considerably

less profit per physician on its care coordination services because practices are assumed to achieve only one-half the savings compared with a smaller initiative.

An alternative scenario is shown in the bottom half of Table 5, with only 50 percent of beneficiaries (33.3) in need of coordination services during the year and physicians and nurses spending just 30 and 90 minutes per month on care coordination. Total costs per practice-month decline by over 50 percent to $3,292 compared with the previous scenario, but profits increase only modestly because coordination staffing costs were only a minor fraction of required savings.

Break-Even Staffing. If practices invested all of their savings in care coordination services, they would be able to afford sizable increases in physician and nurse time (Table 6). For example, with modest clustering (0.01) and 53.3 beneficiaries receiving physician and nurse coordination time each month, a practice would receive $92.50 per assigned beneficiary and could hire nearly one additional full-time physician (0.92 FTE) and more than three full-time nurses (3.2 FTEs) per physician to carry out care coordination. The extra payments would pay for 219 minutes of physician time and 583 minutes of nurse time for each beneficiary who needed coordination.

For an initiative four times as large (200 practices) achieving one-half the required savings, only one-half the increase in coordination time is affordable. With substantial clustering (ICC = 0.025) and 50 percent greater required savings if the initiative is successful, affordable care coordination staffing also increases by 50 percent to 1,206 from 801 minutes.

Detectable savings and net fees in a 10-physician practice (not shown) fall only slightly due to economies in IT costs, although the chances of savings being statistically significant are improved modestly across the entire initiative with more beneficiaries per practice (see equation 1).

Table 6. Break-even medical home "affordable" care coordination times and costs

| | ICC = 0.01; CCB = 53.3 | | | | | |
| | H = 50 | | | H = 200 | | |
	MD	**RN**	**Total**	**MD**	**RN**	**Total**
Minimally Detectable Savings (MDS$)	$92.50	$92.50	$92.50	$46.25	$46.25	$46.25
CC FTEs/practice-month	0.92	3.23	4.15	0.45	1.58	2.03
CC minutes/CCB-month	219	583	801	107	285	392
CC costs/practice-month	$18,626	$17,550	$36,176	$9,110	$8,584	$17,694
CC cost/beneficiary-month	$46.61	$43.92	$90.53	$22.80	$21.48	$44.28
	ICC = 0.025; CCB = 53.3					
	H = 50			H = 200		
	MD	**RN**	**Total**	**MD**	**RN**	**Total**
Minimally Detectable Savings (MDS$)	$138.23	$138.23	$138.23	$69.11	$69.11	$69.11
CC FTEs/practice-month	1.38	4.87	6.25	0.68	2.40	3.08
CC minutes/CCB-month	329	877	1206	162	432	594
CC costs/practice-month	$28,034	$26,414	$54,448	$13,814	$13,016	$26,830
CC cost/beneficiary-month	$70.15	$66.10	$136.26	$34.57	$32.57	$67.14

ICC = intraclass correlation coefficient; CCB = coordination care beneficiaries; H = the number of patient-centered medical homes and comparison practices combined; CC = care coordination; FTE = full-time equivalent.

Notes: Assumes 400 beneficiaries per practice; MDS$ is based on CV = 2.0; MD wage = $95.97; RN wage = $33.91. See Table 1 for baseline parameters.

Care Coordination Productivity Resulting From Providing Fewer Services

In this section, we simulate the staff productivity of greater care coordination inputs that would be required to achieve MDS$. We show this for both a break-even and a feasible staffing scenario and only for acute inpatient admissions (Figure 2). We then simulate a set of productivity requirements across several services affected by greater care coordination using the feasible (predetermined) baseline coordination times (Figure 3).

Admissions-Only Productivity. If the practice employed more care coordination staff simply to break even, every 1 percent increase in the total work time of the physician and nurse together providing coordination requires a constant 0.58 percent reduction in the acute hospital admission rate *for those receiving coordination services*

(Figure 2, bottom line). (No volume reductions are assumed to come from beneficiaries not receiving the extra care.) Simulated break-even productivity rates are independent of the number of practices

Figure 2. Required percentage reduction in acute hospitalizations alone to offset a 1 percent increase in care coordination staff time
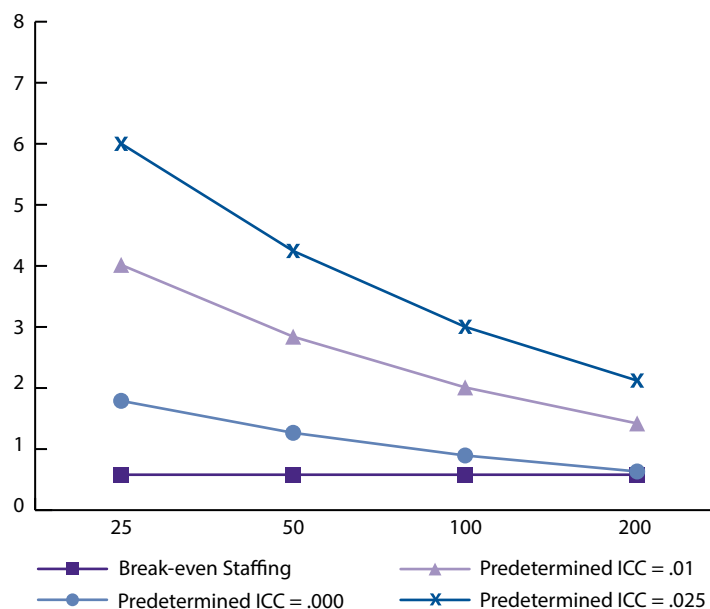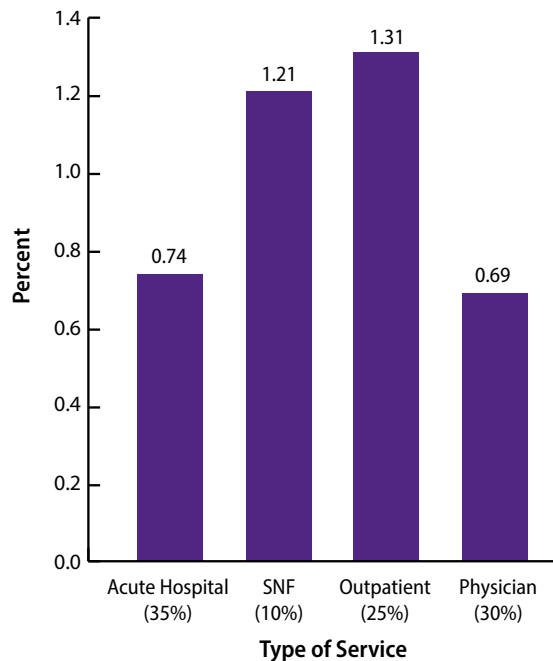
Figure 3. Required percentage reduction in utilization per beneficiary of four services together to achieve minimally detectable savings for each 1 percent increase in staff time providing care coordination services

and clustering because any successful percentage reduction in acute hospitalizations results in an equal, but opposite, percentage investment in increased staff coordination time.

With fixed coordination time per beneficiary (45 physician minutes and 120 nurse minutes), required productivity automatically rises from greater clustering or fewer practices because required savings and utilization reductions are greater as well. At the extreme, with substantial clustering and only 25 intervention and comparison practices combined (ICC = 0.025, CV = 2.0, MDS$ = $196), every 1 percent increase in total work effort from an increase in coordination care time must achieve a 6.0 percent reduction in hospital admissions (Figure 2, top line) for beneficiaries receiving coordination services. (Non-CCBs are assumed to have no volume reductions yet generate management fees.) To achieve such savings with large investments in coordination times, acute hospital use alone would have to fall an impossible 106 percent (not shown in figure).

Average monthly hospital admissions solely by CCBs is estimated to be only 2.93.[9] To achieve such savings, this requirement translates into an impossible 252 percent CCB reductions in use of services.

Even a far larger 200-practice initiative would require a roughly 89 percent reduction in hospitalizations (a 42 percent staff time increase × 2.12 productivity ratio = 0.89) for those receiving care management.

Selected Services Productivity. Volume reductions could be spread across a combination of fewer readmissions, ACSC admissions, and/or other services but would remain quite substantial. Figure 3 simulates required productivity from volume reductions spread across four services with physician and nurse coordination of 45 and 120 minutes, respectively (and H = 200, ICC = 0.025, CV = 2.0). Percentage contributions to savings are provided in parentheses under the bars next to each service.
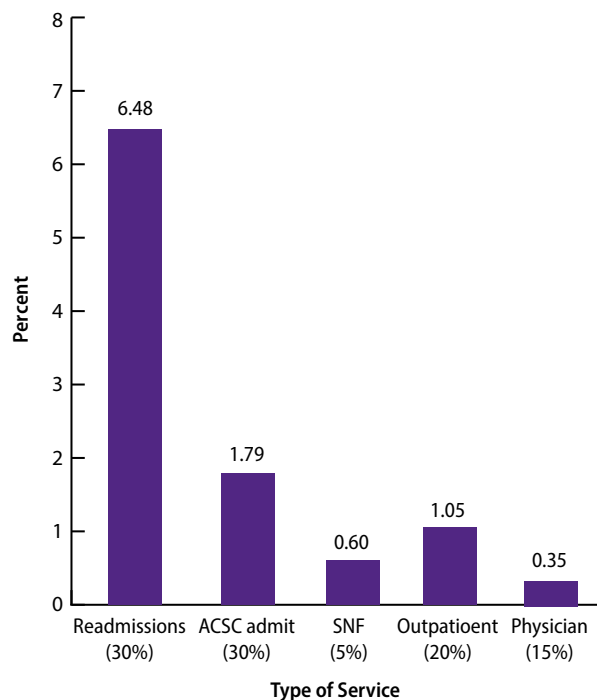
If 35 percent of savings were to come from reductions in acute hospital admissions, each 1 percent increase in overall staff time would have to produce a 0.74 percent reduction in acute admissions for those beneficiaries receiving coordination services. This is considerably less than the 2.1-fold reduction required if all savings were to come from fewer hospitalizations alone (Figure 2, top line, 200 practices), but it still implies a 31 percent decrease in hospitalizations among CCBs for a 42 percent increase in work effort. If another 30 percent were to come from reductions in physician services, the same 1 percent increase in staffing would also have to generate a 0.69 percent reduction in physician services.

Alternatively, in Figure 4, focusing on another set of services that are often the focus of PCMHs, we show the required percentage reductions in a combined group of five services. If a lower readmission rate among beneficiaries receiving care coordination was targeted for 30 percent of required savings, every 1 percent increase in feasible (predetermined) staff work effort would have to reduce the readmission rate by 6.5 percent, implying an infeasible 272 percent decline in readmissions for care coordination

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9   6.0 = 100*(7.39/2.93)/42.0, and 42.0 = the percentage increase in predetermined staffing from more care coordination services.

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beneficiaries. If an additional 30 percent was to come from fewer ACSC admissions, this rate would have to be reduced by 1.8 percent per 1 percent increase in coordination work effort, or a 75 percent overall decline in ACSC admissions for beneficiaries with coordination services.

Figure 4. Required percentage reduction in utilization per beneficiary in five services together to achieve minimally detectable savings for each 1 percent increase in staff time providing care coordination services

of 20 percent if they are the only source of savings. Reductions in total admissions would be lower when spread across several services, but achieving reductions of 10–15 percent across several services will still be challenging. For example, eliminating *all* ACSC "avoidable" admissions and *all* readmissions likely will not be enough alone to achieve required savings. Because acute hospital admissions and physician services constitute roughly 70 percent of average beneficiary costs, major reductions will be needed in both of these health services.

PCMHs face a formidable challenge in achieving required savings through care coordination. First is the asymmetry between the larger number of assigned beneficiaries in an initiative who generate monthly fees or shared savings compared with the far fewer PCMH beneficiaries receiving care coordination in any month. Based on the simulations, if fewer than one-third of assigned beneficiaries receive care coordination in a month, it is unreasonable to expect the volume reductions and staff productivity gains required to achieve minimally required savings. If, by contrast, one assumes that the majority of beneficiaries actually receive meaningful, effective care coordination in a month, the extra investment in physician and nurse time appears infeasible. Besides, even if a practice makes the requisite large investment in staffing, there still is no guarantee of financial success. In most cases, the investment risk is not worth the low likelihood of achieving the necessary savings.

Discussion

Reviewing existing literature, many questions remain about the level of cost savings achievable by PCMHs (Sidorov, 2008). Based on our simulations, savings on beneficiary expenditures will have to be substantial in modestly sized demonstrations or programs to achieve statistical significance at standard levels after accounting for the large variation in Medicare expenditures and clustering effects. Except in large initiatives, clustering of beneficiaries within practices will likely require savings of 15 percent or more and reductions in acute hospitalizations in excess

Any evaluation of PCMHs must take into consideration the clustering of beneficiaries within practices because those selected for study may be atypical in unmeasured ways. Propensity score matching of comparison subjects and multivariate regression can help, but variances in patient outcomes (e.g., expenditures, admission rates) also depend on differences in care patterns across practices selected for study. Critical to generalizing results to a larger national program is how clustered and homogeneous these beneficiaries are in the particular PCMHs selected for study. That our sample of 312 NCQA-recognized practices exhibited relatively high cross-practice clustering of ICC = 0.028 is not encouraging

and calls for very large demonstrations to produce achievable reductions in utilization and costs; otherwise, a national PCMH subsidy program could produce disappointing savings.

Achieving savings that justify fees or shared savings has been the focus of the simulations, but policy makers are also interested in whether PCMHs are more efficient than non-PCMH practices in caring for beneficiaries, even without subsidies. Most primary care practices, regardless of whether they have NCQA recognition, already provide some coordination services at varying levels. The standard difference-in-difference evaluation design that compares NCQA-recognized PCMHs with recognized comparison PCMHs may produce a null finding yet miss the real cost savings that could be achieved if "non-PCMHs" began providing more coordination services.

The effectiveness of financially incentivizing non-PCMHs to implement coordination services is yet to be determined, although CMS is actively funding PCMH transition demonstrations, such as the Comprehensive Primary Care initiative and Federally Qualified Health Centers. However, limited evidence suggests that practices can be reorganized to provide these valuable services at little or no extra cost (Zuckerman et al., 2009).

Limitations

Any simulation of PCMHs is limited to the data necessary to create parameters for the model. We have relied extensively on the utilization and cost data available to us in the form of Medicare claims for 312 NCQA-recognized PCMHs and a matched comparison group of primary care practices without NCQA recognition. These may not be nationally representative of all PCMHs or primary care practices.

Also, no studies have provided reliable information on the amount of time that PCMH clinical staff actually spend with beneficiaries managing their care in a typical month, so we assumed between 45 (physician) and 120 (nurse) minutes per "coordinated" beneficiary per month. We then simulated the effects of less staff coordination time on practice costs and profits.

In addition, we made assumptions about how many beneficiaries on average would receive care coordination services in a month. If our number of care coordination beneficiaries is underestimated, then total care coordination time will have to be greater unless staff spend less time with each beneficiary. Finally, it is possible that clustering exceeds the range simulated in our model, in which case cost reductions will have to be even greater unless staff productivity in reducing service use is raised even more.

Despite these limitations, the simulation demonstrates the large reductions in health services that are required to meet stringent mandatory levels of program savings in initiatives with fewer than 100 or so participating practices. With Affordable Care Act funding, current CMS demonstrations are considerably larger, which affords a greater opportunity to observe statistically significant savings through clinically plausible levels of lower service use.

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Appendix. Calculation of PCMH Information Technology (IT) Costs

IT costs per beneficiary-month, IT\$, shown in equation 4, are based on American Medical Association (AMA/RUC, 2008) estimates of equipment unit costs (cost/unit) summed across j different components (e.g., monitors, servers, maintenance), then amortized across machine life-years (LY) and divided by the total number of beneficiary-months per year in the practice (see also Gans et al., 2005; DesRoches et al., 2008).

$$IT\$ = \Sigma_j[(cost/unit)_j/LY_j]/12B \, ,$$

where B = the number of beneficiaries per physician per practice.

We assume that all future IT expenses are supported solely by Medicare PCMH payments and not shared by other payers.[1] Estimated IT costs per Medicare beneficiary-month would be only one-sixth this amount if costs were prorated across all unique patients in a practice (400/2,400), but the per-beneficiary estimate is still minor compared with required savings in most initiatives. Given the model's focus on utilization reductions and staff productivity, practice IT costs are debited from savings that are available for covering extra coordination services.

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[1]   This assumption excludes the IT funding that has been provided through Centers for Medicare & Medicaid Services Electronic Health Record Incentive Programs and Beacon grants. Including such funding to PCMHs should reduce intervention IT costs.