

# Value of Primary Care Diabetes Management: Long-Term Cost Impacts

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Despite the existence and availability of effective clinical guidelines for treating diabetes,<sup>1,3</sup> wide variability in the treatment patterns of patients with diabetes remains,<sup>4,8</sup> resulting in adverse health outcomes and incurring avoidable care and cost.<sup>9,10</sup> Reducing unjustified and nonpatient-centered variations in care, therefore, via a comprehensively redesigned system of care tuned to deliver all of the care needed to every patient at every encounter, can lead to both improved patient health outcomes and avoid expensive “downstream” care.

An increased focus on standardization is likely to increase the reliability of care delivery. One such effort to standardize care is Geisinger’s diabetes system of care (DSC). Geisinger has redesigned its care system to allow physicians to focus on “physician work” (ie, complex medical decision making, and patient relationships and leading staff members functioning in a top-of-license team). This physician-directed, team-delivered care is facilitated and enhanced by hard-wired technology accelerators available in primary care clinics.<sup>11</sup> The care team is a standard office complement involving physicians, advanced practitioners, and front-office staff. Staffing ratios are approximately 2.25 nonproviders to 1 physician or advanced practitioner. This system of care allows the team to focus on an all-or-none bundle that consists of quantifiable measures of care based on commonly accepted clinical elements and intermediate outcome targets (summarized in **Table 1**) that can be easily implemented during routine primary care visits and are associated with improved outcomes for the patients.<sup>12-14</sup>

The DSC is a practice-level intervention that changes how care is delivered to all patients with diabetes treated within a primary care practice site. Thus, in this study, all primary care physicians and healthcare providers are employed by Geisinger, are practicing in one of the primary care sites owned by Geisinger, and are subject to the DSC. Operationally, the DSC specifies delegated accountable responsibilities for each team member, with the goal to develop work flows

## ABSTRACT

**Objectives:** To estimate long-term cost savings associated with patients’ exposure to an all-or-none bundle of measures for primary care management of diabetes.

**Study Design:** In 2006, Geisinger’s primary care clinics implemented an all-or-none diabetes system of care (DSC). Claims data from Geisinger Health Plan were used to identify those who met Healthcare Effectiveness Data and Information Set criteria for diabetes and had 2 or more diabetes-related encounters on different dates before 2006. A cohort of 1875 members exposed to the DSC was then compared against a propensity score matched non-DSC comparison cohort from January 1, 2006, through December 31, 2013.

**Methods:** A set of generalized linear models with log link and gamma distribution was estimated. The key explanatory variable was each member’s bundle exposure measured in months. The dependent variables were inpatient and outpatient facility costs, professional cost, and total medical cost excluding prescription drugs measured on a per-member-per-month basis.

**Results:** Over the study period, the total medical cost saving associated with DSC exposure was approximately 6.9% ( $P < .05$ ). The main source of the saving was reductions in inpatient facility cost, which showed approximately 28.7% savings ( $P < .01$ ) over the study period. During the first year of the DSC exposure, however, there were significant increases in outpatient (13%;  $P < .05$ ) and professional (9.7%;  $P < .05$ ) costs.

**Conclusions:** A system of care with an all-or-none bundled measure used in primary care for patients with diabetes may reduce long-term cost of care while improving health outcomes.

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that are measurable and reliable—not dependent on the diligence of individual providers. To this end, DSC emphasizes automation of routine care processes (eg, a provider decision support system built directly into patients' electronic health records [EHRs], automatically generated patient report cards [to be shared with patients during office visits], and automatic updates to the patient registry).

The DSC also includes monthly feedback, active physician leadership, and administrative leadership management of performance and incentive payments to the primary care team, based on the proportion of the team's population of patients with diabetes who achieved all of the process and intermediate outcome measures. Furthermore, these feedback reports are made available to all other physicians/teams within Geisinger to encourage improvements among lower-performing teams. One study<sup>12</sup> has shown that during the 3-year period following the first implementation of the DSC in January of 2006, patients with diabetes whose physician-led care teams had implemented the DSC experienced lower rates of myocardial infarction, stroke, and retinopathy. For more detailed descriptions of the DSC program elements and their implementation, refer to previously published studies.<sup>12,15,16</sup>

In this study, we built upon this previous work and sought to quantify the impact of these improved health outcomes by estimating any cost saving associated with patients' exposure to the DSC. More specifically, we tested the following 2 hypotheses: 1) during the first year of the DSC exposure, the cost of care will be higher for the DSC-exposed patients than it is for the non-DSC-exposed patients, due to increased adherence to the clinical guidelines (eg, frequent testing, aggressive medication optimization); and 2) in subsequent years, cost of care for the DSC-exposed patients will be lower. In testing these hypotheses, we separately examined the association between the DSC and each of the main cost components—namely, inpatient, outpatient, and professional costs—and sought to determine the main sources of savings.

## METHODS

### Data

Claims data from Geisinger Health Plan (GHP) covering the period from January 1, 2005, through December 31, 2013, were obtained. We used claims data rather than encounter-based EHR data because claims data provide the comprehensive summary of all types of care used by patients

### Take-Away Points

Despite the availability of evidence-based clinical guidelines, unwarranted variation in diabetes care remains.

- Since 2006, Geisinger's primary care clinics have implemented an all-or-none diabetes bundled system of care. A recent study has shown that the intervention was associated with improved health outcomes. This study examines its impact on cost of care.
- The first year of the system exposure was associated with higher outpatient and professional costs. Subsequent years of exposure were associated with lower total cost, driven by reductions in inpatient costs.
- Standardization of care process may simultaneously improve patient health outcomes while reducing cost.

during the coverage period, whereas the EHR data may omit certain types of care (eg, emergency department visits, inpatient visits) if they occurred outside of the Geisinger Health System. Moreover, claims data provided "allowed" amounts (ie, health plan payments to providers plus member out-of-pocket expenses via co-payments, coinsurance, and deductibles). For the purposes of this study, we defined "cost of care" as the allowed amounts incurred by each member in each month of the study period. To the extent that the allowed amounts represent the "price" of the care rendered by the provider for the member, we believe the allowed amounts serve as a reasonable proxy for the true cost of care.

The date of the first full implementation of the DSC across all Geisinger primary care clinics was January 1, 2006. The study population was, therefore, confined to those who had GHP coverage for at least 6 months before and after January 1, 2006, to ensure that care experiences both before and after the DSC implementation were captured. To define the diabetes patient population, the Healthcare Effectiveness Data and Information Set criteria were used.<sup>17</sup> The study population was then further restricted to those 18 years or older between 2006 and 2013 and who had at least 2 claims with an *International Classification of Diseases, Ninth Revision, Clinical Modification* code for diabetes (250.x) on different dates before 2006 to ensure that the study sample consisted only of those who were eligible for the DSC intervention. Within the study population, GHP members were grouped into either the intervention group (defined as those who received primary care from a physician office that used the DSC as of January 2006) or the comparison group (defined as those whose physician office did not).

Over the study period, some members moved in and out of the sample depending on their GHP enrollment in each year. Also, some members switched between the intervention group and the comparison group. In cases where a member had switched from a primary care practice using the DSC to one not using it, such members were excluded from the analysis because they were assumed

■ **Table 1. Diabetes Bundle Elements**

Bundle Element	Quality Standard	Measure Type
A1C measurement	Every 6 months	Process
A1C control patient-specific goal	<7%	Clinical
LDL measurement	Annually	Process
LDL control patient-specific goal	<100 mg/dL	Clinical
Blood pressure measurement	<140 SBP, <80 DBP	Clinical
Urine protein testing	Annually	Process
Influenza immunization	Annually	Process
Pneumococcal immunization	Once before age 65, once after age 65	Process
Smoking status assessment	Nonsmoker	Clinical

A1C indicates glycated hemoglobin; DBP, diastolic blood pressure; LDL, low-density lipoprotein; SBP, systolic blood pressure.

to have been contaminated by the DSC intervention. In other cases where a member had switched from a practice not using the DSC to one using it, the month that switching occurred was considered as the first month that he or she was exposed to the DSC intervention.

A logistic regression model was developed to estimate a propensity score for each member, in which member age, gender, and Charlson comorbidity index score<sup>18</sup> (as of December 2005) were included as covariates. These pre-DSC period data were obtained from the members' GHP claims data for calendar year 2005. We then used the nearest-neighbor propensity score–matching method with a caliper of 0.2 ( $\pm$  0.2 of the standard deviation of the propensity score) to find 1-to-1 matched cohorts. The final sample included 1875 members in the DSC intervention cohort and the same number of members in the comparison cohort. Also, there were 454 members who could not be matched to the intervention cohort and, therefore, were not included in the analysis. These members tended to be younger, have fewer chronic conditions, and were more likely to be male than the matched cohorts. See the [eAppendix](#) (available at [www.ajmc.com](http://www.ajmc.com)) for a comparison across these 3 groups using the available pre-DSC data (2005). Moreover, there were 59 primary care practices that had adopted the DSC and 564 that never adopted the DSC in the final sample. The latter number was higher than the former because the comparison cohort was drawn mostly from smaller independent practices not owned by Geisinger.

### Statistical Analysis

A set of generalized linear models with log link and gamma distribution was estimated. In all models, the key explanatory variable was each member's length of exposure to the DSC at a given month during the study pe-

riod, measured in terms of the number of months during which the member had received care from any of the primary care practices using the DSC since January 2006. Other covariates included in the model were member age, gender, case management status, plan types (Medicare health maintenance organization [HMO]/preferred provider organization [PPO], commercial HMO/PPO), comorbidities (chronic kidney disease, end-stage renal disease, asthma, congestive heart failure, chronic obstructive pulmonary disease, coronary artery disease, hypertension, cancer, and depression), GHP prescription drug coverage status (ie, whether

the member has drug coverage through GHP or not), and year and month indicator variables.

Case management in this context refers to GHP's nurse-based management of a high-risk patient population, which may confound the DSC effect because some of the members in the sample were also enrolled in the case management program. The drug coverage status variable accounts for the fact that not all members in the sample obtained drug coverage through GHP. To the extent that access and utilization of prescription drugs affect utilization of other medical care, the DSC effect may also be confounded by the drug coverage status. Additionally, another potential confounder is the impact of Geisinger's advanced medical home model known as ProvenHealth Navigator (PHN), which has been shown to be associated with lower cost of care.<sup>19</sup> To capture this confounding medical home effect, the regression model also includes a PHN exposure variable, as previously defined and used in the analysis by Maeng and colleagues.<sup>19</sup>

The dependent variables were inpatient and outpatient facility costs, professional cost, and total medical cost (excluding prescription drugs), measured on a per-member-per-month (PMPM) basis. Cost of care in this case was defined as the "allowed" amount (ie, the sum of GHP's payment to providers plus member out-of-pocket cost sharing). Prescription drug costs were not separately considered because, as noted above, not all members in the sample obtained drug coverage through the GHP; therefore, drug cost data were incomplete. A small positive value (0.0001) was added to all the dependent variables to ensure that the 0 values were not dropped from the analysis due to log transformation.

To translate the regression model coefficients into actual dollar amounts, regression-adjusted mean PMPM costs

were calculated based on the actual data (ie, “observed” cost). Then, the DSC exposure variable was set to 0 for all members in the intervention cohort and the corresponding regression-adjusted mean PMPM costs were again calculated (ie, “expected” cost). The difference between the observed and expected costs, therefore, represented the cost impact of the DSC. Standard errors around the estimated values were adjusted to reflect the fact that the members were clustered within primary practices. Thus, clustered standard errors were obtained and used to perform statistical significance tests.<sup>20</sup> Furthermore, to isolate the impact of the DSC exposure on cost, the year and month indicator variables were set to 0 to remove the effects of secular trends (eg, inflation) and seasonality. The full regression outputs are shown in the eAppendix.

## RESULTS

**Table 2** highlights the post DSC intervention (2006-2013) descriptive statistics of the analytic sample. Note that the unit of analysis is member-month; as such, the sample size corresponds to the number of member-month combinations in the data, rather than the number of unique members. Table 2 suggests that the distributions of age, gender, and plan type are similar between the diabetes bundle exposure and nonexposure member-month observations. However, the prevalence of some of the comorbid conditions, particularly chronic kidney disease (8.4% vs 21.9%) and depression (5.9% vs 11.4%), appears to be higher among the DSC-exposed member-month observations. Furthermore, the proportion of the member-month observations that were enrolled in case management (10.2% vs 29.3%) and the mean exposure to medical homes, were also higher (1.2 months vs 21.7 months) among the DSC-exposed observations. Reflecting these differences, the unadjusted average PMPM costs also appear to be higher among the DSC-exposed observations.

**Table 3** shows the regression-adjusted mean total medical PMPM costs of care. The estimated total medical cost savings associated with any DSC exposure during the study period (ie, months of DSC exposure >0) was \$47

■ **Table 2. Descriptive Statistics**

	DSC Exposure = 0 (N = 158,693) <sup>a</sup>	DSC Exposure >0 (N = 178,612) <sup>a</sup>
Age, years (SD)	72.7 (11.8)	72.3 (11.8)
Female, %	57.5	53.3
Has GHP Rx coverage, %	76.3	72.6
Average medical home exposure, months (SD)	1.2 (6.1)	21.7 (23.4)
Average diabetes bundle exposure, months (SD)	0 (0)	46.5 (27.6)
Enrolled in case management, %	10.2	29.3
Plan type, %		
Commercial HMO	19.3	19.9
Commercial PPO	1.9	0.6
Medicare with HMO	77.2	78.5
Medicare without PPO	1.5	1.1
Chronic condition-related claims, %		
CKD	8.4	21.9
ESRD	0.7	0.6
Asthma	5.3	8.0
CHF	10.1	12.3
COPD	9.1	9.8
CAD	37.1	37.8
Hypertension	80.9	78.8
Cancer	8.4	10.2
Depression	5.9	11.4
Cost of care, unadjusted mean \$PMPM (SD)		
Medical allowed	648 (2739)	738 (3345)
IP allowed	219 (2061)	237 (2592)
OP allowed	185 (903)	233 (1077)
Pro allowed	201 (569)	224 (614)

CAD indicates coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DSC, diabetes system of care; ESRD, end-stage renal disease; GHP, Geisinger Health Plan; HMO, health maintenance organization; IP, inpatient; PPO, preferred provider organization; Pro, professional; OP, outpatient; Rx, prescription; \$PMPM, cost per member per month.  
<sup>a</sup>Sample size (N) denotes the number of member-month observations rather than the number of members in the data.

PMPM or 6.9% ( $P < .05$ ). In particular, there were statistically significant cost savings during the third (\$73 PMPM; 12.5%), fifth (\$124 PMPM; 18.8%), and sixth (\$104 PMPM; 14.7%) years.

**Table 4** breaks down the total medical cost estimates shown in Table 3 in terms of its main components—specifically, inpatient, outpatient, and professional costs. The most significant source of the savings appears to be the inpatient costs, which largely follow the same pattern as that of the total medical cost shown in Table 3. Table 4 also suggests that during the first year of the DSC expo-

■ **Table 3.** Diabetes Bundle Exposure Impact on Total Medical Cost of Care (\$PMPM)

Diabetes Bundle Exposure (months)	Medical: Observed	Medical: Expected	Difference	% Difference	P
>0 <sup>a</sup>	630	677	-47	-6.9%	<.05
1-12	551	551	0	0.0%	.99
13-24	520	562	-42	-7.4%	.21
25-36	513	586	-73	-12.5%	<.05
27-48	603	620	-17	-2.7%	.69
49-60	538	662	-124	-18.8%	<.01
61-72	602	706	-104	-14.7%	<.01
>72	804	834	-31	-3.7%	.54

\$PMPM indicates cost per member per month.  
<sup>a</sup>The average of all the categories below.

sure, there were statistically significant increases in the outpatient (\$20 PMPM; 13%;  $P < .05$ ) and professional (\$15 PMPM; 9.7%;  $P < .01$ ) costs.

## DISCUSSION

The DSC is designed to create an environment in which every care provider team member can help the patient succeed in achieving reliably better care. Clearly, the increased monitoring that this engenders raises short-term costs; additionally, more reliable eye screenings, immunizations, and laboratory work, as well as support for medication adherence, all increase the immediate cost of care. Not only did the greater focus on process measures increase the initial cost, but the focus on the intermediate outcome measures of control of blood pressure, blood sugar, and blood cholesterol is also likely to have increased the short-term costs. The increased monitoring may have also led to accelerated care, which would have increased costs for medications and led to earlier disease identification. This, and the necessary management of emerging complications, led to higher costs at the outset of the program, but also earlier in the course of disease. This is supported by the increased professional costs as closer monitoring of the diabetic population created more frequent visits and increased the use of more office-based interventions.

The focused attention on reliably achieving all recommended testing and treatment across the whole population, however, rapidly led to a reduction in the total cost of care in the long run. Early clinical impact is critical to driving down the longer-term total cost of care, particularly in light of the increased short-term costs. The reduction in true patient-centered outcomes, such as the reduction in heart attack and stroke, are necessary to create popu-

lation-level savings. The distribution of the cost savings demonstrated in this study supports this. The most significant reductions occurred, as expected, in the inpatient costs to offset the elevated early professional costs.

## Limitations

The limitations of this study include reliance on retrospective administrative data that lack clinical variables useful for more sophisticated risk adjustment. Another important limitation is the fact that the cost savings represent only the “gross” savings, or the return portion of the return-on-investment (ROI) quotient. That is, the savings shown above do not take into account all the expenses related to the implementation of the DSC, which would include the incentive payments to physicians associated with their all-or-none DSC bundle achievements, the expenses associated with the EHR support and data reporting, additional staff time and resources needed for provider training, patient outreach and engagement, etc. Due to the inherent difficulty of measuring and quantifying all such expenses in dollar terms, we are unable to reliably capture the ROI in this analysis. Furthermore, the DSC may also be associated with higher drug spending due to increased drug adherence. Although drug cost was not explicitly examined in this study, it is an area of future study.

Given the relatively high age of the cohorts (72 years old), some proportions of the cohorts are presumed to have deceased during the study period. To the extent that the DSC is associated with improved patient outcome as shown in the previous study,<sup>12</sup> it is reasonable to expect that the DSC cohort might have survived longer than the non-DSC cohort. Given the substantial cost associated with end-of-life care, the fact that the DSC cohort might have survived longer implies higher cost of care for

■ **Table 4.** Diabetes Bundle Exposure Impact on Individual Cost Components (\$PMPM)

Diabetes Bundle Exposure (months)	IP: Observed	IP: Expected	Difference	% Difference	P
>0 <sup>a</sup>	220	309	-89	-28.7%	<.01
1-12	187	219	-32	-14.6%	.25
13-24	167	234	-67	-28.8%	<.05
25-36	142	239	-97	-40.5%	<.01
27-48	208	237	-30	-12.4%	.50
49-60	140	264	-123	-46.8%	<.01
61-72	186	316	-131	-41.3%	<.01
>72	304	473	-169	-35.7%	<.01

Diabetes Bundle Exposure (months)	OP: Observed	OP: Expected	Difference	% Difference	P
>0 <sup>a</sup>	199	190	9	4.8%	.38
1-12	175	155	20	13.0%	<.05
13-24	158	152	6	4.0%	.57
25-36	153	160	-7	-4.1%	.51
27-48	184	175	9	5.1%	.50
49-60	172	184	-12	-6.5%	.37
61-72	196	195	1	0.7%	.93
>72	262	231	31	13.6%	.20

Diabetes Bundle Exposure (months)	Pro: Observed	Pro: Expected	Difference	% Difference	P
>0 <sup>a</sup>	181	183	-2	-1.2%	.68
1-12	170	155	15	9.7%	<.01
13-24	150	156	-6	-3.8%	.40
25-36	154	162	-9	-5.2%	.19
27-48	164	171	-7	-4.3%	.36
49-60	160	180	-20	-11.2%	<.05
61-72	174	187	-13	-6.9%	.09
>72	209	210	-1	-0.6%	.90

IP indicates inpatient; OP, outpatient; \$PMPM, cost per member per month; Pro, professional.

<sup>a</sup>The average of all the categories below.

the DSC cohort unrelated to their DSC exposure, which would lead to smaller estimated savings. The reduced magnitude of the cost savings at >72 months of the DSC exposure (shown in Tables 3 and 4) is suggestive of this phenomenon. Thus, our results may be considered to be conservative estimates, reflecting the higher costs associated with end-of-life care. Because our claims data do not accurately capture patient death, however, we are unable to test this hypothesis. The impact of DSC on mortality is an area of future research.

The creation of reliable systems to consistently deliver all the needed care for maximizing the control of

chronic disease to reduce downstream complications will be a critical element for health systems as they react to broader financial responsibility for health outcomes and the healthcare process. The DSC program described in this study provides a paradigm that can be adopted in wider settings to achieve that aim. Moreover, the fact that the DSC explicitly ties physician compensation to achievement of the all-or-none bundle is a significant move away from traditional fee-for-service toward a sustainable payment system that aligns patient outcomes with physician and team financial incentives. As discussed elsewhere,<sup>15,16</sup> up to 20% of the total cash compen-

sation for Geisinger-employed primary care physicians is based on the discrete performance metrics of the DSC and similar chronic and preventive systems of care. This system-based and population-focused compensation arrangement is a departure not only from the traditional fee-for-service model, but also from the now-popular pay-for-performance schemes that typically rely on the diligence and hard work of individual physicians rather than a reengineered system.

## CONCLUSIONS

The findings of this study support the notion that higher quality in healthcare can coexist with and be responsible for the total cost of care savings. Ensuring the success of DSC in larger contexts will require retooling both the organizational structures and the electronic systems that support and facilitate the model implementation, as well as restructuring the physical assets of medicine. For example, availability of nearby ambulatory care centers with enhanced EHR-capabilities that directly connect patients to their care providers would enhance the effectiveness of the system of care model by encouraging greater patient engagement in the decision-making process and, thereby, achieve more reliable management of their chronic conditions.

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## REFERENCES

1. Klein R. Hyperglycemia and microvascular and macrovascular disease in diabetes. *Diabetes Care*. 1995;18(2):258-268. doi:10.2337/diacare.18.2.258.
2. UK Prospective Diabetes Study Group. Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. *BMJ*. 1998;317(7160):703-713. doi:http://dx.doi.org/10.1136/bmj.317.7160.703.
3. Pyörälä K, Pedersen TR, Kjekshus J, Faergeman O, Olsson AG, Thorgeirsson G. Cholesterol lowering with simvastatin improves prognosis of diabetic patients with coronary heart disease. a subgroup analysis of the Scandinavian Simvastatin Survival Study (4S). *Diabetes Care*. 1997;20(4):614-620. doi:10.2337/diacare.20.4.614.
4. Quality/effective care. The Dartmouth Atlas of Health Care website. <http://www.dartmouthatlas.org/data/topic/topic.aspx?cat=25>. Accessed January 13, 2016.
5. Saydah SH, Fradkin J, Cowie CC. Poor control of risk factors for vascular disease among adults with previously diagnosed diabetes. *JAMA*. 2004;291(3):335-342. doi:10.1001/jama.291.3.335.
6. Malik S, Lopez V, Chen R, Wu W, Wong ND. Undertreatment of cardiovascular risk factors among persons with diabetes in the United States. *Diabetes Res Clin Pract*. 2007;77(1):126-133. doi:10.1016/j.diabres.2006.10.016.
7. Selvin E, Parrinello CM, Sacks DB, Coresh J. Trends in prevalence and control of diabetes in the United States, 1988-1994 and 1999-2010. *Ann Intern Med*. 2014;160(8):517-525. doi:10.7326/M13-2411.
8. Ali MK, Bullard KM, Saaddine JB, Cowie CC, Imperatore G, Gregg EW. Achievement of goals in U.S. diabetes care, 1999-2010. *N Engl J Med*. 2013;368(17):1613-1624. doi:10.1056/NEJMsa1213829.
9. Fitch KV, Iwasaki K, Pyenson BS. The cost and quality gap in diabetes care: an actuarial analysis. Milliman website. <http://us.milliman.com/insight/health/The-cost-and-quality-gap-in-diabetes-care-an-actuarial-analysis/>. Published January 30, 2012. Accessed January 13, 2016.
10. McGlynn EA, Asch SM, Adams J, et al. The quality of health care delivered to adults in the United States. *N Engl J Med*. 2003;348(26):2635-2645. doi:10.1056/NEJMsa022615.
11. Cebul RD, Love TE, Jain AK, Hebert CJ. Electronic health records and quality of diabetes care. *N Engl J Med*. 2011;365(9):825-833. doi:10.1056/NEJMsa1102519.
12. Bloom FJ Jr, Yan X, Stewart WF, et al. Primary care diabetes bundle management: 3-year outcomes for microvascular and macrovascular events. *Am J Manag Care*. 2014;20(6):e175-e182.
13. Maeng DD, Graf TR, Davis DE, Tomcavage J, Bloom FJ Jr. Can a patient-centered medical home lead to better patient outcomes? the quality implications of Geisinger's ProvenHealth Navigator. *Am J Med Qual*. 2012;27(3):210-216. doi:10.1177/1062860611417421.
14. Gilfillan RJ, Tomcavage J, Rosenthal MB, et al. Value and the medical home: effects of transformed primary care. *Am J Manag Care*. 2010;16(8):607-614.
15. Bloom FJ Jr, Graf T, Anderer T, Stewart WF. Redesign of a diabetes system of care using an all-or-none diabetes bundle to build teamwork and improve intermediate outcomes. *Diabetes Spectrum*. 2010;23(3):165-169. doi:10.2337/diaspect.23.3.165.
16. Lee TH, Bothe A, Steele GD. How Geisinger structures its physicians' compensation to support improvements in quality, efficiency, and volume. *Health Aff (Millwood)*. 2012;31(9):2068-2073. doi:10.1377/hlthaff.2011.0940.
17. National Committee for Quality Assurance. *HEDIS 2009. Volume 2: Technical Specifications*. Washington, DC: National Committee for Quality Assurance; 2008.
18. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373-383. doi:10.1016/0021-9681(87)90171-8.
19. Maeng DD, Graham J, Graf TR, et al. Reducing long-term cost by transforming primary care: evidence from Geisinger's medical home model. *Am J Manag Care*. 2012;18(3):149-155.
20. Cameron AC, Trivedi PK. *Microeconometrics Using Stata*. College Station, TX: Stata Press; 2009. ■

## eAppendix

**Table A1.** Pre-DSC Sample Characteristics (as of December 2005)

	<b>Non-GHS PCP (N = 1875)<sup>a</sup></b>	<b>GHS PCP (N = 1875)<sup>a</sup></b>	<b>Non-Match (N = 454)<sup>a</sup></b>
Mean age, years (SD)	68.2 (12.1)	68.4 (12.1)	63.0 (12.4)
Female, %	52.6	57.2	47.8
Mean CCI score (SD)	3.4 (2.0)	3.6 (1.9)	2.5 (1.4)
Plan type, %			
Commercial with reference	14.3	15.1	24.9
Commercial without reference	4.1	5.7	16.5
Medicare with reference	79.1	74.5	55.9
Medicare without reference	2.5	4.7	2.6

CCI indicates Charlson comorbidity index; DSC, diabetes system of care; GHS, Geisinger Health System; PCP, primary care provider.

<sup>a</sup>Sample size (N) denotes the number of unique members in the data.

**Table A2. Full GLM Regression Output**

N = 337,305 (3750 unique patients)	Medical		IP		OP		Pro	
	Coef	P	Coef	P	Coef	P	Coef	P
Bundle exposure: 0 months (ref)								
Bundle exposure: 1-12 months	0.00	1.00	-0.16	.25	0.12	.04	0.09	.01
Bundle exposure: 13-24 months	-0.08	.21	-0.34	.02	0.04	.57	-0.04	.40
Bundle exposure: 24-36 months	-0.13	.01	-0.52	.00	-0.04	.51	-0.05	.19
Bundle exposure: 37-48 months	-0.03	.69	-0.13	.50	0.05	.50	-0.04	.36
Bundle exposure: 49-60 months	-0.21	.00	-0.63	.00	-0.07	.37	-0.12	.01
Bundle exposure: 61-72 months	-0.16	.00	-0.53	.00	0.01	.93	-0.07	.09
Bundle exposure: >72 months	-0.04	.54	-0.44	.01	0.13	.20	-0.01	.90
Age, years	0.01	.08	0.04	.03	0.02	.04	0.02	.00
Age squared	0.00	.01	0.00	.06	0.00	.00	0.00	.00
Female	0.01	.73	0.03	.66	-0.02	.65	0.06	.01
Has GHP Rx coverage	0.06	.05	0.10	.12	0.02	.64	0.03	.19
PHN exposure: 0 month (ref)								
PHN exposure: 1-6 month	0.09	.33	0.22	.42	0.05	.47	0.03	.45
PHN exposure: 7-12 month	0.00	.99	-0.12	.46	0.07	.24	0.02	.56
PHN exposure: 13-18 month	-0.07	.16	-0.57	.00	0.08	.14	-0.03	.34
PHN exposure: 19-24 month	-0.11	.05	-0.77	.00	0.10	.06	-0.05	.19
PHN exposure: 25-30 month	-0.07	.27	-0.39	.05	0.06	.38	-0.03	.52
PHN exposure: 31-36 month	-0.17	.02	-0.59	.02	0.00	.99	-0.09	.03
PHN exposure: 37-42 month	-0.18	.00	-0.61	.01	0.01	.89	-0.13	.00
PHN exposure: 43-48 month	-0.10	.14	-0.15	.51	-0.03	.71	-0.09	.09
PHN exposure: 49-54 month	-0.16	.02	-0.47	.03	0.03	.72	-0.14	.01
PHN exposure: 55+ month	-0.16	.08	-0.21	.41	-0.11	.49	-0.12	.01
Commercial HMO (ref)								
Commercial PPO	0.09	.38	-0.17	.57	0.21	.15	0.07	.50
Medicare HMO	0.05	.37	0.05	.64	0.19	.02	0.10	.01
Medicare PPO	0.00	1.00	0.05	.84	0.21	.10	0.02	.82
Enrolled in case management	0.86	.00	1.72	.00	0.50	.00	0.60	.00
January (ref)								
February	-0.13	.01	-0.24	.07	-0.10	.01	-0.10	.00
March	0.01	.80	-0.01	.93	0.01	.74	0.01	.74

April	0.02	.72	0.00	.98	0.07	.09	0.00	.98
May	-0.03	.50	-0.09	.54	0.01	.87	-0.02	.43
June	-0.09	.07	-0.22	.11	-0.03	.48	-0.08	.00
July	-0.06	.21	-0.27	.06	0.01	.81	-0.04	.09
August	-0.02	.62	-0.13	.35	0.05	.17	-0.01	.74
September	-0.05	.33	-0.10	.47	-0.02	.53	-0.03	.20
October	0.05	.31	-0.15	.26	0.11	.01	0.11	.00
November	-0.05	.31	-0.13	.36	-0.02	.60	-0.02	.34
December	-0.12	.01	-0.20	.16	-0.06	.12	-0.13	.00
Year 2006 (ref)								
Year 2007	0.17	.00	0.35	.00	0.14	.00	0.24	.00
Year 2008	0.20	.00	0.38	.00	0.22	.00	0.26	.00
Year 2009	0.29	.00	0.47	.00	0.25	.00	0.36	.00
Year 2010	0.38	.00	0.69	.00	0.34	.00	0.39	.00
Year 2011	0.35	.00	0.56	.00	0.30	.00	0.39	.00
Year 2012	0.21	.00	0.30	.03	0.17	.00	0.30	.00
Year 2013	0.29	.00	0.32	.02	0.22	.00	0.36	.00
Has CKD	0.25	.00	0.35	.00	0.25	.00	0.20	.00
Has ESRD	1.47	.00	1.00	.00	2.28	.00	0.85	.00
Has asthma	0.11	.00	0.09	.42	0.17	.00	0.13	.00
Has CHF	0.32	.00	0.49	.00	0.35	.00	0.20	.00
Has COPD	0.15	.00	0.27	.00	0.12	.00	0.10	.00
Has CAD	0.34	.00	0.56	.00	0.37	.00	0.28	.00
Has hypertension	0.16	.00	0.34	.00	0.08	.04	0.14	.00
Has cancer	0.40	.00	0.16	.04	0.58	.00	0.41	.00
Has depression	0.31	.00	0.56	.00	0.28	.00	0.26	.00
Constant	5.35	.00	2.31	.00	4.32	.00	3.78	.00

CAD indicates coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; coef, coefficient; COPD, chronic obstructive pulmonary disease; ESRD, end-stage renal disease; GLM, generalized linear model; HMO, health maintenance organization; IP, inpatient; OP, outpatient; PHN, ProvenHealth Navigator; PPO, preferred provider organization; Pro, professional; ref, reference; Rx, prescription.